ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI, KOZHIKODE

(Affiliated to the University of Calicut)

CURRICULUM & SYLLABI

FOR

B.Sc. Physics Honours

UNDER FOUR YEAR UNDER GRADUATE PROGRAMME (FYUGP) SYSTEM 2024

(EFFECTIVE FROM 2024 ADMISSION)

INDEX

B.Sc. PHYSICS HONOURS

(MAJOR, MINOR AND GENERAL FOUNDATION COURSES)

SCHEME & SYLLABUS

PROGRAMME OUTCOMES (PO):

At the end of the graduate programme at Calicut University, a student would:

PO1	**Knowledge Acquisition:** Demonstrate a profound understanding of knowledge trends and their impact on the chosen discipline of study.
PO2	**Communication, Collaboration, Inclusiveness, and Leadership:** Become a team player who drives positive change through effective communication, collaborative acumen, transformative leadership, and a dedication to inclusivity.
PO3	**Professional Skills:** Demonstrate professional skills to navigate diverse career paths with confidence and adaptability.
PO4	**Digital Intelligence:** Demonstrate proficiency in varied digital and technological tools to understand and interact with the digital world, thus effectively processing complex information.
PO5	**Scientific Awareness and Critical Thinking:** Emerge as an innovative problem-solver and impactful mediator, applying scientific understanding and critical thinking to address challenges and advance sustainable solutions.
PO6	**Human Values, Professional Ethics, and Societal and Environmental Responsibility:** Become a responsible leader, characterized by an unwavering commitment to human values, ethical conduct, and a fervent dedication to the well-being of society and the environment.
PO7	**Research, Innovation, and Entrepreneurship:** Emerge as a researcher and entrepreneurial leader, forging collaborative partnerships with industry, academia, and communities to contribute enduring solutions for local, regional, and global development.

PROGRAMME SPECIFIC OUTCOMES (PSO):

At the end of the BSc Physics Honours programme at Calicut University, a student would:

PSO1	Understand concepts and applications in the field of Physics viz. Mechanics, Electrodynamics, Thermodynamics, Optics, Quantum Mechanics, Electronics etc.
PSO2	Develop the skills for experimentation to measure, analyse and interpret empirical data, and present the results in a methodical and accessible way.
PSO3	Evaluate complex real-world problems by applying principles of theoretical and applied physics, and mathematical and computational models.
PSO4	Design and execute a Project to solve real-world problems in accordance to the need of the industry and academic research, in a stipulated time frame.
PSO5	Develop understanding of the fundamental concepts of Physics needed for a deeper study of related fields of knowledge viz. Mathematics, Chemistry, Electronics, Computer Science, Geology etc.
PSO6	Develop the experimental and analytical skills in Physics that can be of useful applications in allied areas of knowledge.

MINIMUM CREDIT REQUIREMENTS OF THE DIFFERENT PATHWAYS IN THE THREE-YEAR PROGRAMME IN CUFYUGP

Sl. No.	Academic Pathway	Major	Minor/ Other Disciplines	Foundation Courses AEC: 4 MDC: 3 SEC: 3 VAC: 3	Intern-ship	Total Credits	Example
		Each course has 4 credits		Each course has 3 credits			
1	Single Major (A)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Physics + six courses in different disciplines in different combinations
2	Major (A) with Multiple Disciplines (B, C)	68 (17 courses)	12 + 12 (3 + 3 = 6 courses)	39 (13 courses)	2	133	Major: Physics + Mathematics and Chemistry

3	Major (A) with Minor (B)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Physics Minor: Mathematics
4	Major (A) with Vocational Minor (B)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Physics Minor: Data Analysis
5	Double Major (A, B)	A: 48 (12 courses) B: 44 (11 courses)	-	12 + 18 + 9	2	133	Physics and Mathematics double major
			The 24 credits in the Minor stream are distributed between the two Majors. 2 MDC, 2 SEC, 2 VAC and the Internship should be in Major A. Total credits in Major A should be 48 + 20 = 68 (50% of 133) 1 MDC, 1 SEC and 1 VAC should be in Major B. Total credits in Major B should be 44 + 9 = 53 (40% of 133)				
Exit with UG Degree / Proceed to Fourth Year with 133 Credits							

B.Sc. PHYSICS HONOURS PROGRAMME

COURSE STRUCTURE FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	PHY1CJ 101/ PHY1MN 100	Core Course 1 in Major – Fundamentals of Physics	75	5	4	30	70	100
		Minor Course 1	60/ 75	4/ 5	4	30	70	100
		Minor Course 2	60/ 75	4/ 5	4	30	70	100
	ENG1FA 101(2)	Ability Enhancement Course 1– English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75

		Multi-Disciplinary Course 1 – Other than Major	45	3	3	25	50	75
		Total		**23/ 25**	**21**			**525**
2	PHY2CJ 101/ PHY2MN 100	Core Course 2 in Major –Electronics – I	75	5	4	30	70	100
		Minor Course 3	60/ 75	4/ 5	4	30	70	100
		Minor Course 4	60/ 75	4/ 5	4	30	70	100
	ENG2FA 103(2)	Ability Enhancement Course 3– English	60	4	3	25	50	75
		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 2 – Other than Major	45	3	3	25	50	75
		Total		**23/ 25**	**21**			**525**
3	PHY3CJ 201	Core Course 3 in Major – Mechanics – I	60	4	4	30	70	100
	PHY3CJ 202/ PHY3MN 200	Core Course 4 in Major – Computational Physics	75	5	4	30	70	100
		Minor Course 5	60/ 75	4/ 5	4	30	70	100
		Minor Course 6	60/ 75	4/ 5	4	30	70	100
		Multi-Disciplinary Course 3 – Kerala Knowledge System	45	3	3	25	50	75
	ENG3FV 108(2)	Value-Added Course 1 – English	45	3	3	25	50	75
		Total		**23/ 25**	**22**			**550**
4	PHY4CJ 203	Core Course 5 in Major – Electrodynamics–I	75	5	4	30	70	100
	PHY4CJ 204	Core Course 6 in Major – Mechanics– II	75	5	4	30	70	100
	PHY4CJ 205	Core Course 7 in Major – Modern Physics	75	5	4	30	70	100
	ENG4FV 109(2)	Value-Added Course 2 – English	45	3	3	25	50	75
		Value-Added Course 3 – Additional Language	45	3	3	25	50	75

	ENG4FS 111(2)	Skill Enhancement Course 1 – English	60	4	3	25	50	75
		Total		**25**	**21**			**525**
5	PHY5CJ 301	Core Course 8 in Major – Electrodynamics – II	75	5	4	30	70	100
	PHY5CJ 302	Core Course 9 in Major – Optics	75	5	4	30	70	100
	PHY5CJ 303	Core Course 10 in Major – Quantum Mechanics – I	60	4	4	30	70	100
		Elective Course 1 in Major*	60	4	4	30	70	100
		Elective Course 2 in Major*	60	4	4	30	70	100
		Skill Enhancement Course 2	45	3	3	25	50	75
		Total		**25**	**23**			**575**
6	PHY6CJ 304/ PHY8MN 304	Core Course 11 in Major – Thermodynamics	75	5	4	30	70	100
	PHY6CJ 305/ PHY8MN 305	Core Course 12 in Major–Electronics–II	75	5	4	30	70	100
	PHY6CJ 306/ PHY8MN 306	Core Course 13 in Major – Nuclear and Particle Physics	60	4	4	30	70	100
		Elective Course 3 in Major*	60	4	4	30	70	100
		Elective Course 4 in Major*	60	4	4	30	70	100
	PHY6FS 113	Skill Enhancement Course 3 – Electrical and Photovoltaic Devices	45	3	3	25	50	75
	PHY6CJ 349	Internship in Major (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		25	25			**625**
Total Credits for Three Years					**133**			**3325**
7	PHY7CJ 401	Core Course 14 in Major – Mathematical Physics	75	5	4	30	70	100
	PHY7CJ 402	Core Course 15 in Major – Classical Mechanics	75	5	4	30	70	100
	PHY7CJ 403	Core Course 16 in Major – Quantum Mechanics – II	75	5	4	30	70	100

	PHY7CJ 404	Core Course 17 in Major – Statistical Mechanics	75	5	4	30	70	100
	PHY7CJ 405	Core Course 18 in Major – Electronics – III	75	5	4	30	70	100
		Total		**25**	**20**			**500**
8	PHY8CJ 406 / PHY8MN 406	Core Course 19 in Major – Solid State Physics	75	5	4	30	70	100
	PHY8CJ 407 / PHY8MN 407	Core Course 20 in Major – Spectroscopy	60	4	4	30	70	100
	PHY8CJ 408 / PHY8MN 408	Core Course 21 in Major – Electrodynamics – III	60	4	4	30	70	100
	OR (instead of Core Courses 19 – 21 in Major)							
	PHY8CJ 449	Project (in Honours programme)	360**	13**	12	90	210	300
	PHY8CJ 499	Project (in Honours with Research programme)	360**	13**	12	90	210	300
		Elective Course 5 in Major*** / Minor Course 7	60	4	4	30	70	100
		Elective Course 6 in Major*** / Minor Course 8	60	4	4	30	70	100
		Elective Course 7 in Major*** / Minor Course 9 / Major Course in any Other Discipline	60	4	4	30	70	100
	OR (instead of Elective Course 7 in Major, in the case of Honours with Research Programme)							
	PHY8CJ 489	Principles of Research Methodology	60	4	4	30	70	100
		Total		**25**	**24**			**600**
Total Credits for Four Years					**177**			**4425**

* Choose any two elective courses each from the course basket of seven elective courses in semester 5 and six elective courses in semester 6, as listed below in the two tables of elective courses with specialisation and elective courses with no specialisation.

** The teacher should have 13 hrs/week of engagement (the hours corresponding to the three core courses) in the guidance of the Project(s) in Honours programme and Honours with

Research programme, while each student should have 24 hrs/week of engagement in the Project work. Total hours are given based on the student's engagement.

*** Choose any three elective courses from the course basket of nine elective courses in semester 8, as listed below in the table of elective courses with no specialisation.

CREDIT DISTRIBUTION FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	Major Courses	Minor Courses	General Foundation Courses	Internship/ Project	Total
1	4	4 + 4	3 + 3 + 3	-	21
2	4	4 + 4	3 + 3 + 3	-	21
3	4 + 4	4 + 4	3 + 3	-	22
4	4 + 4 + 4	-	3 + 3 + 3	-	21
5	4 + 4 + 4 + 4 + 4	-	3	-	23
6	4 + 4 + 4 + 4 + 4	-	3	2	25
Total for Three Years	**68**	**24**	**39**	**2**	**133**
7	4 + 4 + 4 + 4 + 4	-	-	-	20
8	4 + 4 + 4	4 + 4 + 4	-	12*	24
* Instead of three Major courses					
Total for Four Years	**88 + 12 = 100**	**36**	**39**	**2**	**177**

DISTRIBUTION OF MAJOR COURSES IN PHYSICS FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	Course Code	Course Title	Hours/ Week	Credits
1	PHY1CJ 101 / PHY1MN 100	Core Course 1 in Major – Fundamentals of Physics	5	4

2	PHY2CJ 101 / PHY2MN 100	Core Course 2 in Major – Electronics – I	5	4
3	PHY3CJ 201	Core Course 3 in Major – Mechanics – I	4	4
	PHY3CJ 202 / PHY3MN 200	Core Course 4 in Major – Computational Physics	5	4
4	PHY4CJ 203	Core Course 5 in Major – Electrodynamics – I	5	4
	PHY4CJ 204	Core Course 6 in Major – Mechanics –II	5	4
	PHY4CJ 205	Core Course 7 in Major – Modern Physics	5	4
5	PHY5CJ 301	Core Course 8 in Major – Electrodynamics –II	5	4
	PHY5CJ 302	Core Course 9 in Major – Optics	5	4
	PHY5CJ 303	Core Course 10 in Major – Quantum Mechanics– I	4	4
		Elective Course 1 in Major*	4	4
		Elective Course 2 in Major*	4	4
6	PHY6CJ 304 / PHY8MN 304	Core Course 11 in Major – Thermodynamics	5	4
	PHY6CJ 305 / PHY8MN 305	Core Course 12 in Major – Electronics – II	5	4
	PHY6CJ 306 / PHY8MN 306	Core Course 13 in Major – Nuclear and Particle Physics	4	4
		Elective Course 3 in Major*	4	4
		Elective Course 4 in Major*	4	4
	PHY6CJ 349	Internship in Major	-	2

Total for the Three Years				**70**
7	PHY7CJ 401	Core Course 14 in Major – Mathematical Physics	5	4
	PHY7CJ 402	Core Course 15 in Major – Classical Mechanics	5	4
	PHY7CJ 403	Core Course 16 in Major – Quantum Mechanics–II	5	4
	PHY7CJ 404	Core Course 17 in Major – Statistical Mechanics	5	4
	PHY7CJ 405	Core Course 18 in Major – Electronics – III	5	4
8	PHY8CJ 406 / PHY8MN 406	Core Course 19 in Major – Solid State Physics	5	4
	PHY8CJ 407 / PHY8MN 407	Core Course 20 in Major – Spectroscopy	4	4
	PHY8CJ 408 / PHY8MN 408	Core Course 21 in Major –Electrodynamics–III	4	4
	OR (instead of Core Courses 19 – 21 in Major)			
	PHY8CJ 449	Project (in Honours programme)	13	12
	PHY8CJ 499	Project (in Honours with Research programme)	13	12
		Elective Course 5 in Major**	4	4
		Elective Course 6 in Major**	4	4
		Elective Course 7 in Major**	4	4
	OR (instead of Elective course 7 in Major, in Honours with Research programme)			
	PHY8CJ 489	Principles of Research Methodology	4	4
Total for the Four Years				**114**

* Choose any two elective courses each from the course basket of seven elective courses in semester 5 and six elective courses in semester 6, as listed below in the two tables of elective courses with specialisation and elective courses with no specialisation.

** Choose any three elective courses from the course basket of nine elective courses in semester 8, as listed below in the table of elective courses with no specialisation.

ELECTIVE COURSES IN PHYSICS WITH SPECIALISATION

Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		MATERIALS SCIENCE								
	1	PHY5EJ 301(1)	Properties of Solids	5	60	4	4	30	70	100
	2	PHY5EJ 302(1)	Materials Science	5	60	4	4	30	70	100
	3	PHY6EJ 301(1)	Nanoscience and Technology	6	60	4	4	30	70	100
	4	PHY6EJ 302(1)/ PHY6EJ 304(2)	Optoelectronics and Semiconductor Devices	6	60	4	4	30	70	100
2		PHOTONICS								
	1	PHY5EJ 303(2)	Photonics	5	60	4	4	30	70	100
	2	PHY5EJ 304(2)	Introductory Molecular Spectroscopy	5	60	4	4	30	70	100
	3	PHY6EJ 303(2)	Biophotonics	6	60	4	4	30	70	100
	4	PHY6EJ 304(2)/ PHY6EJ 302(1)	Optoelectronics and Semiconductor Devices	6	60	4	4	30	70	100
3	PHYSICS IN BIOLOGY									
	1	PHY5EJ 305(3)	Physics of Human Body	5	60	4	4	30	70	100
	2	PHY5EJ 306(3)	Introductory Medical Physics	5	60	4	4	30	70	100
	3	PHY6EJ 305(3)	Introductory Biophysics	6	60	4	4	30	70	100
	4	PHY6EJ 306(3)	Applied Nuclear Physics	6	60	4	4	30	70	100

4	**DATA SCIENCE AND ARTIFICIAL INTELLIGENCE**									
	1	PHY5EJ 307(4)	Foundations of Data Science	5	60	4	4	30	70	100
	2	PHY5EJ 308(4)	Exploratory Data Analysis using Python	5	60	4	4	30	70	100
	3	PHY6EJ 307(4)	Foundations of Artificial Intelligence	6	60	4	4	30	70	100
	4	PHY6EJ 308(4)	Machine Learning Using Python	6	60	4	4	30	70	100

ELECTIVE COURSES IN PHYSICS WITH NO SPECIALISATION

Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
							Internal	External	Total
1	PHY5EJ 309	Astrophysics	5	60	4	4	30	70	100
2	PHY6EJ 309	Space Physics	6	60	4	4	30	70	100
3	PHY6EJ 310	Atmospheric Physics	6	60	4	4	30	70	100
4	PHY8EJ 401	Quantum Computation and Quantum Information	8	60	4	4	30	70	100
5	PHY8EJ 402	Artificial Intelligence and Machine Learning in Physics	8	60	4	4	30	70	100
6	PHY8EJ 403	Digital Signal Processing	8	60	4	4	30	70	100
7	PHY8EJ 404	Digital Electronics	8	60	4	4	30	70	100
8	PHY8EJ 405	Communication Electronics	8	60	4	4	30	70	100
9	PHY8EJ 406	Plasma Physics	8	60	4	4	30	70	100
10	PHY8EJ 407	Nonlinear Dynamics and Chaos	8	60	4	4	30	70	100
11	PHY8EJ 408	Introductory General Relativity	8	60	4	4	30	70	100
12	PHY8EJ 409	Introductory Quantum Field Theory	8	60	4	4	30	70	100

13	PHY8EJ 410	Nuclear Physics	8	60	4	4	30	70	100

GROUPING OF MINOR COURSES IN PHYSICS

Note: The Minor courses given below should not be offered to students who have taken Physics or Applied Physics as the Major discipline. They should be offered to students from other Major disciplines only.

Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		**MATHEMATICS FOR PHYSICAL SYSTEMS** (preferable for students from Mathematics and other Major disciplines)								
	1	PHY1MN 101	Mechanics and Optics	1	75	5	4	30	70	100
	2	PHY2MN 101	Electromagnetism and Network Theorems	2	75	5	4	30	70	100
	3	PHY3MN 201	Mathematical Methods for Physics	3	75	5	4	30	70	100
2		**MATERIALS PHYSICS** (preferable for students from Chemistry and other Major disciplines)								
	1	PHY1MN 102	Properties of Matter and Thermodynamics	1	75	5	4	30	70	100
	2	PHY2MN 102	Modern Physics and Nuclear Physics	2	75	5	4	30	70	100
	3	PHY3MN 202	Solid State Physics and Spectroscopy	3	75	5	4	30	70	100
3		**SEMICONDUCTOR PHYSICS** (preferable for students from Electronics, Computer Science, Instrumentation and other Major disciplines)								
	1	PHY1MN 103	Semiconductor Physics and Electronics	1	75	5	4	30	70	100
	2	PHY2MN 103	Fundamentals of Optics	2	75	5	4	30	70	100
	3	PHY3MN 203	Electronic Communication	3	75	5	4	30	70	100
4		**OPTICAL PHYSICS** (preferable for students from Geology and other Major disciplines)								

	1	PHY1MN 104	Electricity and Magnetism	1	75	5	4	30	70	100
	2	PHY2MN 104	Optics and Lasers	2	75	5	4	30	70	100
	3	PHY3MN 204	Atomic Structure and Spectroscopy	3	75	5	4	30	70	100
5		**ENERGY PHYSICS** (preferable for students from Food Technology and other Major disciplines)								
	1	PHY1MN 105	Non-Conventional Energy Sources	1	75	5	4	30	70	100
	2	PHY2MN 105	Fluid Mechanics and Thermodynamics	2	75	5	4	30	70	100
	3	PHY3MN 205	Optics and Spectroscopy	3	75	5	4	30	70	100

GROUPING OF VOCATIONAL MINOR COURSES IN PHYSICS

Note: The Vocational Minor courses given below should not be offered to students who have taken Physics or Applied Physics as the Major discipline. They should be offered to students from other Major disciplines only.

Group No.	**Sl. No.**	**Course Code**	**Title**	**Semester**	**Total Hrs**	**Hrs/Week**	**Credits**	**Marks**		
								Internal	**External**	**Total**
1		**TECHNIQUES IN MATERIALS PHYSICS**								
	1	PHY1VN 101	Introductory Materials Science	1	75	5	4	30	70	100
	2	PHY2VN 101	Synthesis of Nanomaterials	2	75	5	4	30	70	100
	3	PHY3VN 201	Characterizations and Applications of Nanomaterials	3	75	5	4	30	70	100
	4	PHY8VN 301	Scientific Documentation	8	60	4	4	30	70	100
2		**DATA ANALYSIS IN PHYSICS**								
	1	PHY1VN 102	Python Basics	1	75	5	4	30	70	100
	2	PHY2VN 102	Data Analysis in Physics Using Python	2	75	5	4	30	70	100
	3	PHY3VN 202	Data Analysis in Physics Using Machine Learning	3	75	5	4	30	70	100

	4	PHY8VN 302	Applications of Advanced Machine Learning and Artificial Intelligence in Physics	8	60	4	4	30	70	100

(i). Students in the Single Major pathway can choose course/courses from any of the Minor/ Vocational Minor groups offered by a discipline other than their Major discipline.

(ii). Students in the Major with Multiple Disciplines pathway can choose as one of the multiple disciplines, all the three courses from any one of the Minor/ Vocational Minor groups offered by a discipline other than their Major discipline.

(iii). Students in the Major with Minor pathway can choose all the courses from any two Minor groups offered by a discipline other than their Major discipline. If the students from other Major disciplines choose any two Minor groups in Physics as given above, then the title of the Minor will be **Physics.**

(iv). Students in the Major with Vocational Minor pathway can choose all the courses from any two Vocational Minor groups offered by a discipline other than their Major discipline. If the students from other Major disciplines choose any two Vocational Minor groups in Physics as given above, then the title of the Vocational Minor will be **Physics.**

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN PHYSICS

Semester	**Course Code**	**Course Title**	**Total Hours**	**Hours/ Week**	**Credits**	**Marks**		
						Internal	**External**	**Total**
1	PHY1FM 105	Multi-Disciplinary Course 1 – Physics in Daily Life	45	3	3	25	50	75
2	PHY2FM 106	Multi-Disciplinary Course 2 – Astronomy and Stargazing	45	3	3	25	50	75
3	PHY3FV 108	Value-Added Course 1 – Renewable Energy Sources	45	3	3	25	50	75
4	PHY4FV 110	Value-Added Course 2 – Science Communication	45	3	3	25	50	75

5	PHY5FS 112	Skill Enhancement Course 2 Python for Data Analysis	45	3	3	25	50	75
6	PHY6FS 113	Skill Enhancement Course 3 – Electrical and Photovoltaic Devices	45	3	3	25	50	75

Note: The MDC1 and MDC2 courses given above should not be offered to students who have taken Physics or Applied Physics as the Major discipline.

COURSE STRUCTURE FOR BATCH A1(B2) IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in Physics (Major A) ***B1: 68 credits in Major B***

A2: 53 credits in Physics (Major A) ***B2: 53 credits in Major B***

The combinations available to the students: (A1 & B2), (B1 & A2)

Note: Unless the batch is specified, the course is for all the students of the class

Semester	**Course Code**	**Course Title**	**Total Hours**	**Hours/ Week**	**Credits**	**Marks**		
						Internal	**External**	**Total**
1	PHY1CJ 101 / PHY1MN 100	Core Course 1 in Major Physics – Fundamentals of Physics	75	5	4	30	70	100
	BBB1CJ 101	Core Course 1 in Major B –	60/ 75	4/ 5	4	30	70	100
	PHY1CJ 102 / PHY2CJ 102	Core Course 2 in Major Physics – Elements of Modern Physics (for batch A1 only)	75	5	4	30	70	100
	ENG1FA 101(2)	Ability Enhancement Course 1 – English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
	PHY1FM 105	Multi-Disciplinary Course 1 in Physics – Physics in Daily Life (for batch A1 only)	45	3	3	25	50	75
		Total		**24/ 25**	**21**			**525**

2	PHY2CJ 101 / PHY2MN 100	Core Course 3 in Major Physics – Electronics – I	75	5	4	30	70	100
	BBB2CJ 101	Core Course 2 in Major B –	60/ 75	4/ 5	4	30	70	100
	BBB2CJ 102 / BBB1CJ 102	Core Course 3 in Major B – (for batch B2 only)	60/ 75	4/ 5	4	30	70	100
	ENG2FA 103(2)	Ability Enhancement Course 3 – English	60	4	3	25	50	75
		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
	PHY2FM 106 / PHY3FM 106	Multi-Disciplinary Course 2 in Physics – Astronomy and Stargazing	45	3	3	25	50	75
		Total		**23 – 25**	**21**			**525**
3	PHY3CJ 201	Core Course 4 in Major Physics – Mechanics – I	60	4	4	30	70	100
	PHY3CJ 202 / PHY3MN 200	Core Course 5 in Major Physics – Computational Physics	75	5	4	30	70	100
	BBB3CJ 201	Core Course 4 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB3CJ 202	Core Course 5 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB3FM 106 / BBB2FM 106	Multi-Disciplinary Course 1 in B –	45	3	3	25	50	75
	PHY3FV 108	Value-Added Course 1 in Physics – Renewable Energy Sources (for batch A1 only)	45	3	3	25	50	75
		Total		**23 – 25**	**22**			**550**
4	PHY4CJ 203	Core Course 6 in Major Physics –Electrodynamics –I	75	5	4	30	70	100
		Core Course 6 in Major B	60/ 75	4/ 5	4	30	70	100

	PHY4CJ 204	Core Course 7 in Major Physics – Mechanics – II (for batch A1 only)	75	5	4	30	70	100
	PHY4FV 110	Value-Added Course 2 in Physics – Science Communications	45	3	3	25	50	75
	BBB4FV 110	Value-Added Course 1 in B –	45	3	3	25	50	75
	PHY4FS 112 / PHY5FS 112	Skill Enhancement Course 1 in Physics – Python for Data Analysis	45	3	3	25	50	75
		Total		**23/ 24**	**21**			**525**
5	PHY5CJ 302	Core Course 8 in Major Physics – Optics	75	5	4	30	70	100
		Core Course 7 in Major B –	60/ 75	4/ 5	4	30	70	100
	PHY5CJ 303	Core Course 9 in Major Physics – Quantum Mechanics –I (for batch A1 only)	60	4	4	30	70	100
		Elective Course 1 in Major Physics*	60	4	4	30	70	100
		Elective Course 1 in Major B*	60	4	4	30	70	100
	BBB5FS 112 / BBB4FS 112	Skill Enhancement Course 1 in B	45	3	3	25	50	75
		Total		**24/ 25**	**23**			**575**
6	PHY6CJ 305/ PHY8MN 305	Core Course 10 in Major Physics – Electronics – II	75	5	4	30	70	100
		Core Course 8 in Major B –	60/ 75	4/ 5	4	30	70	100
	BBB6CJ 305	Core Course 9 in Major B – (for batch B2 only)	60	4	4	30	70	100
		Elective Course 2 in Major Physics*	60	4	4	30	70	100
		Elective Course 2 in Major B*	60	4	4	30	70	100
	PHY6FS 113	Skill Enhancement Course 2 in Physics – Electrical and Photovoltaic Devices (for batch A1 only)	45	3	3	25	50	75

	PHY6CJ 349	Internship in Major Physics (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		**24/ 25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**
For batch A1(B2), the course structure in semesters 7 and 8 is the same as for pathways 1 – 4, except that the number of the core and elective courses is in continuation of the number of courses in the two categories completed at the end of semester 6.								

* Choose any one elective course each in Major Physics from the course basket of nine elective courses in physics in semester 5 and nine elective courses in physics in semester 6, as listed above in the two tables of elective courses with specialisation and elective courses with no specialisation. Choose any one elective course each in Major B from the course basket of elective courses in Major B in semester 5 and semester 6.

CREDIT DISTRIBUTION FOR BATCH A1(B2) IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in Physics	General Foundation Courses in Physics	Internship/ Project in Physics	Major Courses in B	General Foundation Courses in B	AEC	Total
1	4 + 4	3	-	4	-	3 + 3	21
2	4	3	-	4 + 4	-	3 + 3	21
3	4 + 4	3	-	4 + 4	3	-	22
4	4 + 4	3 + 3	-	4	3	-	21
5	4 + 4 + 4	-	-	4 + 4	3	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	**48**	**18**	**2**	**44**	**9**	**12**	**133**
	68			**53**		**12**	**133**
	Major Courses in Physics	Minor Courses					
7	4 + 4 + 4 + 4 + 4	-			-	-	20
8	4 + 4 + 4	4 + 4 + 4	12*		-	-	24
* Instead of three Major courses							
Total for Four Years	**88 + 12 = 100**	**12**					**177**

COURSE STRUCTURE FOR BATCH B1(A2)
IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in Physics (Major A) ***B1: 68 credits in Major B***

A2: 53 credits in Physics (Major A) ***B2: 53 credits in Major B***

The combinations available to the students: (A1 & B2), (B1 & A2)

Note: Unless the batch is specified, the course is for all the students of the class

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	PHY1CJ 101 / PHY1MN 100	Core Course 1 in Major Physics – Fundamentals of Physics	75	5	4	30	70	100
	BBB1CJ 101	Core Course 1 in Major B –	60/ 75	4/ 5	4	30	70	100
	BBB1CJ 102 / BBB2CJ 102	Core Course 2 in Major B – (for batch B1 only)	60/ 75	4/ 5	4	30	70	100
	ENG1FA 101(2)	Ability Enhancement Course 1 – English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
	BBB1FM 105	Multi-Disciplinary Course 1 in B – (for batch B1 only)	45	3	3	25	50	75
		Total		**23 – 25**	**21**			**525**
2	PHY2CJ 101 / PHY2MN 100	Core Course 2 in Major Physics – Electronics – I	75	5	4	30	70	100
	BBB2CJ 101	Core Course 3 in Major B –	60/ 75	4/ 5	4	30	70	100
	PHY2CJ 102 / PHY1CJ 102	Core Course 3 in Major Physics – Elements of Modern Physics (for batch A2 only)	75	5	4	30	70	100
	ENG2FA 103(2)	Ability Enhancement Course 3 – English	60	4	3	25	50	75

		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
	PHY2FM 106 / PHY3FM 106	Multi-Disciplinary Course 1 in Physics – Astronomy and Stargazing	45	3	3	25	50	75
		Total		**24/ 25**	**21**			**525**
3	PHY3CJ 201	Core Course 4 in Major Physics – Mechanics – I	60	4	4	30	70	100
	PHY3CJ 202 / PHY3MN 200	Core Course 5 in Major Physics – Computational Physics	75	5	4	30	70	100
	BBB3CJ 201	Core Course 4 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB3CJ 202	Core Course 5 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB3FM 106 / BBB2FM 106	Multi-Disciplinary Course 2 in B –	45	3	3	25	50	75
	BBB3FV 108	Value-Added Course 1 in B – (for batch B1 only)	45	3	3	25	50	75
		Total		**23 – 25**	**22**			**550**
4	PHY4CJ 203	Core Course 6 in Major Physics –Electrodynamics –I	75	5	4	30	70	100
		Core Course 6 in Major B	60/ 75	4/ 5	4	30	70	100
		Core Course 7 in Major B – (for batch B1 only)	60/ 75	4/ 5	4	30	70	100
	PHY4FV 110	Value-Added Course 1 in Physics – Science Communications	45	3	3	25	50	75
	BBB4FV 110	Value-Added Course 2 in B –	45	3	3	25	50	75
	PHY4FS 112 / PHY5FS 112	Skill Enhancement Course 1 in Physics – Python for Data Analysis	45	3	3	25	50	75
		Total		**22 – 24**	**21**			**525**

5	PHY5CJ 302	Core Course 7 in Major Physics – Optics	75	5	4	30	70	100
		Core Course 8 in Major B –	60/ 75	4/ 5	4	30	70	100
		Core Course 9 in Major B – (for batch B1 only)	60	4	4	30	70	100
		Elective Course 1 in Major Physics*	60	4	4	30	70	100
		Elective Course 1 in Major B*	60	4	4	30	70	100
	BBB5FS 112 / BBB4FS 112	Skill Enhancement Course 1 in B	45	3	3	25	50	75
		Total		**24/ 25**	**23**			**575**
6	PHY6CJ 305/ PHY8MN 305	Core Course 8 in Major Physics – Electronics – II	75	5	4	30	70	100
		Core Course 10 in Major B –	60/ 75	4/ 5	4	30	70	100
	PHY6CJ 306/ PHY8MN 306	Core Course 9 in Major Physics – Nuclear and Particle Physics (for batch A2 only)	60	4	4	30	70	100
		Elective Course 2 in Major Physics*	60	4	4	30	70	100
		Elective Course 2 in Major B*	60	4	4	30	70	100
	BBB6FS 113	Skill Enhancement Course 2 in B – (for batch B1 only)	45	3	3	25	50	75
	BBB6CJ 349	Internship in Major B (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		**24/ 25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**

To continue to study Physics in semesters 7 and 8, batch B1(A2) needs to earn additional 15 credits in Physics to make the total credits of 68. If this condition is achieved, and the student of batch B1(A2) proceeds to the next semesters to study Physics, then the course structure in semesters 7 and 8 is the same as for pathways 1 – 4, except that the number of the core and elective courses is in continuation of the number of courses in the two categories completed at the end of semester 6, taking into account the number of courses in Physics taken online to earn the additional 15 credits.

* Choose any one elective course each in Major Physics from the course basket of nine elective courses in physics in semester 5 and nine elective courses in physics in semester 6, as listed above in the two tables of elective courses with specialisation and elective courses with no specialisation. Choose any one elective course each in Major B from the course basket of elective courses in Major B in semester 5 and semester 6.

CREDIT DISTRIBUTION FOR BATCH B1(A2) IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in B	General Foundation Courses in B	Internship/ Project in B	Major Courses in Physics	General Foundation Courses in Physics	AEC	Total
1	4 + 4	3	-	4	-	3 + 3	21
2	4	-	-	4 + 4	3	3 + 3	21
3	4 + 4	3 + 3	-	4 + 4	-	-	22
4	4 + 4	3	-	4	3 + 3	-	21
5	4 + 4 + 4	3	-	4 + 4	-	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	**48**	**18**	**2**	**44**	**9**	**12**	**133**
	68			**53**		**12**	**133**
	Major Courses in B	Minor Courses					
7	4 + 4 + 4 + 4 + 4	-			-	-	20
8	4 + 4 + 4	4 + 4 + 4	12*		-	-	24
* Instead of three Major courses							
Total for Four Years	**88 + 12 = 100**	**12**					**177**

EQUIVALENT ONLINE COURSES

The list of equivalent online courses is appended at the end (Page 622)

EVALUATION SCHEME

1. The evaluation scheme for each course contains two parts: internal evaluation (about 30%) and external evaluation (about 70%). Each of the Major and Minor courses is of 4-credits. It is evaluated for 100 marks, out of which 30 marks is from internal evaluation and 70 marks, from external evaluation. Each of the General Foundation course is of 3-credits. It is evaluated for 75 marks, out of which 25 marks is from internal evaluation and 50 marks, from external evaluation.
2. The 4-credit courses (Major and Minor courses) are of two types: (i) courses with only theory and (ii) courses with 3-credit theory and 1-credit practical.
    - In 4-credit courses with only theory component, out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 10 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.
    - In 4-credit courses with 3-credit theory and 1-credit practical components, out of the total 5 modules of the syllabus, 4 modules are for theory and the fifth module is for practical. The practical component is internally evaluated for 20 marks. The internal evaluation of the 4 theory modules is for 10 marks.
3. All the 3-credit courses (General Foundational Courses) in Physics, except SEC3 are with only theory component. Out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 5 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks. Considering the nature of the SEC3 course, the internal evaluation for the 25 marks, including the 5 marks in the open ended module, will be entirely based on the practical examination and viva.
4. The students can write the external examinations in BSc Physics Honours programme in both English and Malayalam languages.

Sl. No.	Nature of the Course		Internal Evaluation in Marks (about 30% of the total)		External Exam on 4 modules (Marks)	Total Marks
			Open-ended module / Practical	On the other 4 modules		
1	4-credit course	only theory (5 modules)	10	20	70	100
2	4-credit course	Theory (4 modules) + Practical	20	10	70	100
3	3-credit course	only theory (5 modules)	5	20	50	75

1. MAJOR AND MINOR COURSES

1.1. INTERNAL EVALUATION OF THEORY COMPONENT

Sl. No.	Components of Internal Evaluation of Theory Part of a Major / Minor Course	Internal Marks for the Theory Part of a Major / Minor Course of 4-credits			
		Theory Only		Theory + Practical	
		4 Theory Modules	Open-ended Module	4 Theory Modules	Practical
1	Test paper/ Mid-semester Exam	10	4	5	-
2	Seminar/ Viva/ Quiz	6	4	3	-
3	Assignment	4	2	2	-
		20	10	10	20*
	Total	30		30	

* Refer the table in section 1.2 for the evaluation of practical component

1.2. EVALUATION OF PRACTICAL COMPONENT

The evaluation of practical component in Major and Minor courses is completely by internal evaluation.

- Continuous evaluation of practical by the teacher-in-charge shall carry a weightage of 50%.
- The end-semester practical examination and viva-voce, and the evaluation of practical records shall be conducted by the teacher in-charge and an internal examiner appointed by the Department Council.

- The process of continuous evaluation of practical courses shall be completed before 10 days from the commencement of the end-semester examination.
- Those who passed in continuous evaluation alone will be permitted to appear for the end-semester examination and viva-voce.

The scheme of continuous evaluation and the end-semester examination and viva-voce of practical component shall be as given below:

Sl. No.	Evaluation of Practical Component of Credit-1 in a Major / Minor Course	Marks for Practical	Weightage
1	Continuous evaluation of practical/ exercise performed in practical classes by the students	10	50%
2	End-semester examination and viva-voce to be conducted by teacher-in-charge along with an additional examiner arranged internally by the Department Council	7	35%
3	Evaluation of the Practical records submitted for the end semester viva–voce examination by the teacher-in-charge and additional examiner	3	15%
	Total Marks	20	

1.3. EXTERNAL EVALUATION OF THEORY COMPONENT

External evaluation carries 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the University based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR MAJOR AND MINOR COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
2 Hours	Short Answer	10	8 – 10	3	24
	Paragraph/ Problem	8	6 – 8	6	36
	Essay	2	1	10	10
				Total Marks	70

2. INTERNSHIP

- All students should undergo Internship of 2-credits during the first six semesters in a firm, industry or organization, or training in labs with faculty and researchers of their own institution or other Higher Educational Institutions (HEIs) or research institutions.

- Internship can be for enhancing the employability of the student or for developing the research aptitude.
- Internship can involve hands-on training on a particular skill/ equipment/ software. It can be a short project on a specific problem or area. Attending seminars or workshops related to an area of learning or skill can be a component of Internship.
- A faculty member/ scientist/ instructor of the respective institution, where the student does the Internship, should be the supervisor of the Internship.

2.1. GUIDELINES FOR INTERNSHIP

1. Internship can be in Physics or allied disciplines.
2. There should be minimum 60 hrs. of engagement from the student in the Internship.
3. Summer vacations and other holidays can be used for completing the Internship.
4. In BSc. Physics Honours programme, institute/ industry visit or study tour is a requirement for the completion of Internship. Visit to minimum one national research institute, research laboratory and place of scientific importance should be part of the study tour. A brief report of the study tour has to be submitted with photos and analysis.
5. The students should make regular and detailed entries in to a personal log book through the period of Internship. The log book will be a record of the progress of the Internship and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Internship supervisor should periodically examine and countersign the log book.
6. The log book and the typed report must be submitted at the end of the Internship.
7. The institution at which the Internship will be carried out should be prior-approved by the Department Council of the college where the student has enrolled for the UG Honours programme.

2.2. EVALUATION OF INTERNSHIP

- The evaluation of Internship shall be done internally through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG Honours programme.
- The credits and marks for the Internship will be awarded only at the end of semester 6.
- The scheme of continuous evaluation and the end-semester viva-voce examination based on the submitted report shall be as given below:

<table>
<tr><th>Sl. No.</th><th colspan="2">Components of Evaluation of Internship</th><th>Marks for Internship 2 Credits</th><th>Weightage</th></tr>
<tr><td>1</td><td rowspan="3">Continuous evaluation of internship through interim presentations and reports by the committee internally constituted by the Department Council</td><td>Acquisition of skill set</td><td>10</td><td rowspan="3">40%</td></tr>
<tr><td>2</td><td>Interim Presentation and Viva-voce</td><td>5</td></tr>
<tr><td>3</td><td>Punctuality and Log Book</td><td>5</td></tr>
<tr><td>4</td><td colspan="2">Report of Institute Visit/ Study Tour</td><td>5</td><td>10%</td></tr>
<tr><td>5</td><td rowspan="3">End-semester viva-voce examination to be conducted by the committee internally constituted by the Department Council</td><td>Quality of the work</td><td>6</td><td rowspan="3">35%</td></tr>
<tr><td>6</td><td>Presentation of the work</td><td>5</td></tr>
<tr><td>7</td><td>Viva-voce</td><td>6</td></tr>
<tr><td>8</td><td colspan="2">Evaluation of the day-to-day records, the report of internship supervisor, and final report submitted for the end semester viva–voce examination before the committee internally constituted by the Department Council</td><td>8</td><td>15%</td></tr>
<tr><td></td><td colspan="2">Total Marks</td><td>50</td><td></td></tr>
</table>

3. PROJECT

3.1. PROJECT IN HONOURS PROGRAMME

- In Honours programme, the student has the option to do a Project of 12-credits instead of three Core Courses in Major in semester 8.
- The Project can be done in the same institution/ any other higher educational institution (HEI)/ research centre/ training centre.

- The Project in Honours programme can be a short research work or an extended internship or a skill-based training programme.
- A faculty member of the respective institution, where the student does the Project, should be the supervisor of the Project.

3.2. PROJECT IN HONOURS WITH RESEARCH PROGRAMME

- Students who secure 75% marks and above (equivalently, CGPA 7.5 and above) cumulatively in the first six semesters are eligible to get selected to Honours with Research stream in the fourth year.
- A relaxation of 5% in marks (equivalently, a relaxation of 0.5 grade in CGPA) is allowed for those belonging to SC/ ST/ OBC (non-creamy layer)/ Differently-Abled/ Economically Weaker Section (EWS)/ other categories of candidates as per the decision of the UGC from time to time.
- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits instead of three Core Courses in Major in semester 8.
- The approved research centres of University of Calicut or any other university/ HEI can offer the Honours with Research programme. The departments in the affiliated colleges under University of Calicut, which are not the approved research centres of the University, should get prior approval from the University to offer the Honours with Research programme. Such departments should have minimum two faculty members with Ph.D., and they should also have the necessary infrastructure to offer Honours with Research programme.
- A faculty member of the University/ College with a Ph.D. degree can supervise the research project of the students who have enrolled for Honours with Research. One such faculty member can supervise maximum five students in Honours with Research stream.
- The maximum intake of the department for Honours with Research programme is fixed by the department based on the number of faculty members eligible for project supervision, and other academic, research, and infrastructural facilities available.
- If a greater number of eligible students are opting for the Honours with Research programme than the number of available seats, then the allotment shall be based on the existing rules of reservations and merits.

3.3. GUIDELINES FOR THE PROJECT IN HONOURS PROGRAMME AND HONOURS WITH RESEARCH PROGRAMME

1. Project can be in Physics or allied disciplines.
2. Project should be done individually.
3. Project work can be of experimental/ theoretical/ computational in nature.
4. There should be minimum 360 hrs. of engagement from the student in the Project work in Honours programme as well as in Honours with Research programme.
5. There should be minimum 13 hrs./week of engagement (the hours corresponding to the three core courses in Major in semester 8) from the teacher in the guidance of the Project(s) in Honours programme and Honours with Research programme.
6. The various steps in project works are the following:
    - Wide review of a topic.
    - Investigation on a problem in systematic way using appropriate techniques.
    - Systematic recording of the work.
    - Reporting the results with interpretation in a standard documented form.
    - Presenting the results before the examiners.
7. During the Project the students should make regular and detailed entries in to a personal log book through the period of investigation. The log book will be a record of the progress of the Project and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Project supervisor should periodically examine and countersign the log book.
8. The log book and the typed report must be submitted at the end of the Project. A copy of the report should be kept for reference at the department. A soft copy of the report too should be submitted, to be sent to the external examiner in advance.
9. It is desirable, but not mandatory, to publish the results of the Project in a peer reviewed journal.
10. The project report shall have an undertaking from the student and a certificate from the research supervisor for originality of the work, stating that there is no plagiarism, and that the work has not been submitted for the award of any other degree/ diploma in the same institution or any other institution.

11. The project proposal, institution at which the project is being carried out, and the project supervisor should be prior-approved by the Department Council of the college where the student has enrolled for the UG Honours programme.

3.4. EVALUATION OF PROJECT

- The evaluation of Project will be conducted at the end of the eighth semester by both internal and external modes.
- The Project in Honours programme as well as that in Honours with Research programme will be evaluated for 300 marks. Out of this, 90 marks is from internal evaluation and 210 marks, from external evaluation.
- The internal evaluation of the Project work shall be done through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG Honours programme. 30% of the weightage shall be given through this mode.
- The remaining 70% shall be awarded by the external examiner appointed by the University.
- The scheme of continuous evaluation and the end-semester viva-voce of the Project shall be as given below:

Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research)	Weightage
Continuous evaluation of project work through interim presentations and reports by the committee internally constituted by the Department Council	90	30%
End-semester viva-voce examination to be conducted by the external examiner appointed by the university	150	50%
Evaluation of the day-to-day records and project report submitted for the end-semester viva–voce examination conducted by the external examiner	60	20%
Total Marks	300	

INTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research)
1	Skill in doing project work	30
2	Interim Presentation and Viva-Voce	20
3	Punctuality and Log book	20
4	Scheme/ Organization of Project Report	20
	Total Marks	90

EXTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research) 12 credits
1	Content and relevance of the Project, Methodology, Quality of analysis, and Innovations of Research	50
2	Presentation of the Project	50
3	Project Report (typed copy), Log Book and References	60
4	Viva-Voce	50
	Total Marks	210

4. GENERAL FOUNDATION COURSES

- All the General Foundation Courses (3-credits) in Physics are with only theory component.

4.1. INTERNAL EVALUATION

Sl. No.	Components of Internal Evaluation of a General Foundation Course in Physics	Internal Marks of a General Foundation Course of 3-credits in Physics	
		4 Theory Modules	Open-ended Module
1	Test paper/ Mid-semester Exam	10	2
2	Seminar/ Viva/ Quiz	6	2
3	Assignment	4	1
		20	5
	Total	25	

4.2. EXTERNAL EVALUATION

External evaluation carries about 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the University based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR GENERAL FOUNDATION COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
1.5 Hours	Short Answer	10	8 – 10	2	16
	Paragraph/ Problem	5	4 – 5	6	24
	Essay	2	1	10	10
				Total Marks	50

5. LETTER GRADES AND GRADE POINTS

- Mark system is followed for evaluating each question.
- For each course in the semester letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below.
- The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester.
- The Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.
- Only the weighted grade point based on marks obtained shall be displayed on the grade card issued to the students.

LETTER GRADES AND GRADE POINTS

Sl. No.	Percentage of Marks (Internal & External Put Together)	Description	Letter Grade	Grade Point	Range of Grade Points	Class
1	95% and above	Outstanding	O	10	9.50 – 10	First Class with Distinction
2	Above 85% and below 95%	Excellent	A+	9	8.50 – 9. 49	
3	75% to below 85%	Very Good	A	8	7.50 – 8.49	
4	65% to below 75%	Good	B+	7	6.50 – 7.49	First Class
5	55% to below 65%	Above Average	B	6	5.50 – 6.49	

6	45% to below 55%	Average	C	5	4.50 – 5.49	Second Class
7	35% to below 45% aggregate (internal and external put together) with a minimum of 30% in external valuation	Pass	P	4	3.50 – 4.49	Third Class
8	Below an aggregate of 35% or below 30% in external evaluation	Fail	F	0	0 – 3.49	Fail
9	Not attending the examination	Absent	Ab	0	0	Fail

- When students take audit courses, they will be given Pass (P) or Fail (F) grade without any credits.
- The successful completion of all the courses and capstone components prescribed for the three-year or four-year programme with 'P' grade shall be the minimum requirement for the award of UG Degree or UG Degree Honours or UG Degree Honours with Research, as the case may be.

5.1. COMPUTATION OF SGPA AND CGPA

- The following method shall be used to compute the Semester Grade Point Average (SGPA):

  The SGPA equals the product of the number of credits (Ci) with the grade points (Gi) scored by a student in each course in a semester, summed over all the courses taken by a student in the semester, and then divided by the total number of credits of all the courses taken by the student in the semester,

  i.e. SGPA (Si) = Σi (Ci x Gi) / Σi (Ci)

  where Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course in the given semester. Credit Point of a course is the value obtained by multiplying the credit (Ci) of the course by the grade point (Gi) of the course.

$$SGPA = \frac{Sum\ of\ the\ credit\ points\ of\ all\ the\ courses\ in\ a\ semester}{Total\ credits\ in\ that\ semester}$$

ILLUSTRATION – COMPUTATION OF SGPA

Semester	Course	Credit	Letter Grade	Grade point	Credit Point (Credit x Grade)
I	Course 1	3	A	8	3 x 8 = 24
I	Course 2	4	B+	7	4 x 7 = 28
I	Course 3	3	B	6	3 x 6 = 18
I	Course 4	3	O	10	3 x 10 = 30
I	Course 5	3	C	5	3 x 5 = 15
I	Course 6	4	B	6	4 x 6 = 24
	Total	20			139
	SGPA				139/20 = 6.950

- The Cumulative Grade Point Average (CGPA) of the student shall be calculated at the end of a programme. The CGPA of a student determines the overall academic level of the student in a programme and is the criterion for ranking the students.

  CGPA for the three-year programme in CUFYUGP shall be calculated by the following formula.

$$CGPA = \frac{Sum\ of\ the\ credit\ points\ of\ all\ the\ courses\ in\ six\ semesters}{Total\ credits\ in\ six\ semesters\ (133)}$$

  CGPA for the four-year programme in CUFYUGP shall be calculated by the following formula.

$$CGPA = \frac{Sum\ of\ the\ credit\ points\ of\ all\ the\ courses\ in\ eight\ semesters}{Total\ credits\ in\ eight\ semesters\ (177)}$$

- The SGPA and CGPA shall be rounded off to three decimal points and reported in the transcripts.
- Based on the above letter grades, grade points, SGPA and CGPA, the University shall issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

BSc PHYSICS HONOURS
MAJOR CORE COURSES

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**FUNDAMENTALS OF PHYSICS**				
Type of Course	**Core in Major**				
Semester	**I**				
Academic Level	**100 – 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Fundamentals of vectors, calculus and kinematics.				
Course Summary	This course explores Newton's Laws of Motion and how they can be applied to solve different mechanical systems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts of Newton's Laws of Motion	U	C	Instructor-created exams / Quiz
CO2	Apply Newton's Laws of Motion to solve different mechanical systems	Ap	P	Instructor-created exams / Home Assignments
CO3	Apply work-energy theorem to solve different mechanical systems	Ap	P	Instructor-created exams / Home Assignments
CO4	Analyse conservative systems and solve them using the	An	P	Instructor-created exams / Home

	conservation of mechanical energy.			Assignments
CO5	Demonstrate critical thinking and problem-solving skills by applying the concepts and techniques learned to solve an extended set of real-world problems.	Ap	P	Seminar Presentation / Group Tutorial Work
CO6	Demonstrate skills to set up and perform experiments to test Newton's Laws of Motion and related concepts.	Ap	P	Practical Assignment / Observation of Practical Skills / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**NEWTON'S LAWS OF MOTION**		**12**	**18**
	1	Review of units, physical quantities and vectors	3	
	2	Force and Interactions	2	
	3	Newton's First Law	2	
	4	Newton's Second Law	2	
	5	Mass and Weight	1	
	6	Newton's Third Law	1	
	7	Free-Body Diagrams	1	
	Relevant topics of chapter 1 of Book 1; sections 4.1 – 4.6 of chapter 4 of Book 1 Self-Study: Chapters 1 – 3 of Book 1			

II	**APPLYING NEWTON'S LAWS**		**14**	**20**
	8	Using Newton's First Law: Particles in Equilibrium	3	
	9	Using Newton's Second Law: Dynamics of Particles	3	
	10	Apparent Weight and Apparent Weightlessness	1	
	11	Friction Forces	2	
	12	Fluid Resistance and Terminal Speed	1	
	13	Dynamics of Circular Motion	3	
	14	The Fundamental Forces of Nature	1	
	Sections 5.1 – 5.5 of chapter 5 of Book 1			
III	**WORK AND KINETIC ENERGY**		**8**	**14**
	15	Work	1	
	16	Kinetic Energy and the Work – Energy Theorem	3	
	17	Work and Energy with Varying Forces	3	
	18	Power	1	
	Sections 6.1 – 6.4 of chapter 6 of Book 1			
IV	**POTENTIAL ENERGY AND ENERGY CONSERVATION**		**11**	**18**
	19	Gravitational Potential Energy	3	
	20	Elastic Potential Energy	2	
	21	Conservative and Nonconservative Forces	2	
	22	Force and Potential Energy	2	
	23	Energy Diagrams	2	

	Sections 7.1 – 7.5 of chapter 7 of Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6^{th} experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	● Error Analysis: Lecture/ Tutorial/ Seminar: 2 hrs. ● Theory of experiments 1 and 2 can be given as Assignment/ Seminar. ● Plot the graphs using GeoGebra. FitLine function may be used to get the slope. ● Smartphones are exclusively intended for educational lab use. Necessary care should be taken to safeguard them during the experiments. ● Smartphone experiments primarily serve demonstration purposes, with result accuracy contingent upon the precision of phone sensors and experimental setups.			
	1	**Young's Modulus of the Material of a Given Bar: Uniform Bending** ● Use an optic lever and telescope. Take measurements for a minimum of two lengths. Obtain the elevation (e) from the shift (s) in the telescope reading and calculate Y from it. ● For each length of the bar, plot the load-elevation graph (using GeoGebra) and obtain m/e, and then calculate Y from it. ● Estimate the random error in the measurements and the error of the result using propagation of the error formulae.		
	2	**Young's Modulus of the Material of a Given Bar: Non-Uniform Bending** ● Use a pin and a microscope. Take measurements for a minimum of two lengths. Obtain the depression (e) from the shift in the microscope reading and calculate Y from it.		

		• For each length of the bar, plot the load-depression graph (using GeoGebra) and obtain m/e, and then calculate Y from it. • Estimate the random error in the measurements and the error of the result using propagation of the error formulae.		
	3	**Verification of Newton's First Law: Equilibrium of a Particle** • Analyze the two dimensional equilibrium problems using spring / digital force gauges. • Hang a weight from a chain that is linked at the ring to two other chains, one fastened to the ceiling and the other to the wall. Example 5.3 of Book 1. • Measure the angle between the chain from the ceiling and the horizontal and the tension in each of the three chains using spring/digital force gauges and verify with the theoretical predictions. • https://www.youtube.com/watch?v=XI7E32BROp0		
	4	**Coefficient of Static Friction.** • Determine the coefficient of static friction between a wooden block and a wooden plane. • Measure the angle at which the wooden block just starts to slide down an inclined wooden plane and hence calculate the static friction coefficient. • https://www.youtube.com/watch?v=gt8mr6pFSFE **OR** • Place the wooden block on a wooden plane surface and add mass to the pan attached to the block using a string through a frictionless pulley. • Find the mass required to initiate the sliding of the block. • Different trials can be done by adding mass on the top of the block and hence determine the coefficient of static friction. • Example 5.13 of Book 1. • https://www.youtube.com/watch?v=MSV6VafiUF4&t=443s		
	5	**Acceleration of a Freely Falling Body** • Use the smartphone acoustic stopwatch to determine the duration of a free fall. • Measure the time of flight of a steel ball for different heights and plot a graph of distance versus. time squared (s vs. t^2). Determine g from the graph. • Experiment 2 of Book 2. • Phyphox app may be used. https://phyphox.org/experiment/free-fall-2/		

		OR ● Use ExpEyes kit, electromagnet, and contact sensor to determine the duration of a free fall. https://expeyes.in/experiments/mechanics/tof.html		
	6	**Verification of the Relation of Angular Velocity and Centrifugal Acceleration** ● Use the smartphone gyroscope and the accelerometer. ● Attach the smartphone to some rotating arrangements and record the data from the gyroscope and accelerometer. ● Plot angular velocity versus acceleration and verify the relation. ● Experiment 18 of Book 2. ● Phyphox app may be used. https://phyphox.org/experiment/centrifugal-acceleration/		
	7	**Analysis of Bouncing Balls to Determine Gravitational Acceleration and Coefficient of Restitution.** ● After doing the experiment, the student should be able to understand the concept of inelastic collision. ● Measure the time interval between successive bounces using a digital acoustic stopwatch and hence calculate g and coefficient of restitution ● Experiment 12 of Book 2 and section 3.3 of Book 1 ● Phyphox app may be used. https://phyphox.org/experiment/inelastic-collision/		
	8	**The Nearly Parabolic Trajectories of a Bouncing Ball** ● Perform Experiment 7 using Tracker tool. ● Track the ball and plot the time versus position graph. ● Measure the time interval between successive bounces and hence calculate g and coefficient of restitution. ● Experiment 12 of Book 2 and section 3.3 of Book 1 ● Tracker Autotracker Tutorial: https://www.youtube.com/watch?v=Dn0Zz7rtkZw		
	9	**Verification of Newton's Second Law: Atwood's Machine** ● Determine the relationship between the vertical acceleration and the mass difference, using a smartphone accelerometer. ● The vertical acceleration is registered using the built-in accelerometer of the smartphone. ● By redistributing the masses of the supports, a linear relationship between the mass difference and the vertical acceleration is obtained.		

		● Experiment 8 of Book 2. ● https://phyphox.org/experiment/acceleration-without-g/		
	10	**Analysis of Air Resistance and Terminal Speed to Determine the Drag Coefficient.** ● Record the motion of a light weight paper cup and analyse it with Tracker tool (https://physlets.org/tracker/). ● Plot acceleration, velocity, and position with time. ● Repeat the experiment with different mass (by simply stacking the paper cups) ● Determine the Drag Coefficient ● Experiment 27 of Book 2. ● https://www.youtube.com/watch?v=iujzK3uH1Yc		
	11	**Projectile Motion: Kinematics** ● Analyse projectile motion as a combination of horizontal motion with constant velocity and vertical motion with constant acceleration. ● Drop two balls from a height, one from rest, and other simultaneously projected horizontally. ● Analyse the motion of both in the Tracker tool. ● Section 3.3 of Book 1 ● https://www.youtube.com/watch?v=zMF4CD7i3hg ● https://www.youtube.com/watch?v=Mi01anodoDE ● https://www.youtube.com/watch?v=5I0NLNthJGc		
	12	**Projectile Motion: Energy Conservation** ● Analyse the motion of the tossing ball / projectile in the Tracker tool. ● Plot time versus the x-and y-components of velocity and acceleration. ● Also plot the kinetic energy, potential energy (build data using define tool) and total energy. ● https://www.youtube.com/watch?v=x0AWRLvgB28 ● https://www.youtube.com/watch?v=i07HeUWo8xc		

Books and References:

1. University Physics with Modern Physics (Edn.15) by Young & Freedman (Book 1)
2. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 2)
3. https://phyphox.org/
4. https://physlets.org/tracker/
5. B.Sc Practical Physics by C L Arora
6. Practical Physics by S L Gupta & V Kumar

7. Fundamentals of Physics by David Halliday, Robert Resnick and Jearl Walker
8. Physics for Scientists and Engineers by Paul A. Tipler and Gene Mosca
9. Fundamentals of Physics by J. Richard Christman and William J. Francis
10. NPTEL video lectures: https://nptel.ac.in/courses/115106090

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PS O6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	0	2	0	2	1	3	3	1	1	2	2	1
CO 2	3	2	2	0	1	2	3	3	3	1	3	3	3
CO 3	3	2	2	0	1	2	3	3	3	1	3	3	3
CO 4	3	2	2	3	1	2	3	3	3	1	3	3	3
CO 5	3	2	3	0	3	3	3	3	3	1	3	3	3
CO 6	3	3	3	3	1	3	3	3	3	1	3	3	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

IMPORTANT: This course is for the Double Major pathway only. It should not be offered for the other four pathways.

Programme	**B. Sc. PhysicsHonours**				
Course Title	**ELEMENTS OF MODERN PHYSICS**				
Type of Course	**Core in Major**				
Semester	**I or II (depending upon the batch in the Double Major)**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary Physics				
Course Summary	The course integrates key principles of modern physics, including the Special Theory of Relativity, wave-particle duality, and the Bohr Atom Model, to provide students with a comprehensive understanding of fundamental concepts and their applications in diverse scientific fields.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the principles of the Special Theory of Relativity	Comprehension	Conceptual	Written exams, quizzes
CO2	Explain the dual nature of particles and waves	Comprehension	Conceptual	Problem sets, essays
CO3	Apply relativistic principles to solve problems	Application	Procedural	Problem-solving exams, simulations
CO4	Analyse experimental evidence supporting wave-particle duality	Analysis	Conceptual	Laboratory reports, case studies

CO5	Compare and contrast classical and quantum mechanical models	Analysis	Conceptual	Research papers, presentations
CO6	Critically evaluate the limitations of the Bohr atom model	Evaluation	Conceptual	Research projects, discussions
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**THE SPECIAL THEORY OF RELATIVITY**	**16**	**22**
	1	Classical Relativity	1	
	2	The Michelson – Morley Experiment	1	
	3	Einstein's Postulates and Its Consequences– Relativity of Time, Relativity of Length, Relativistic Velocity Addition	4	
	4	The Lorentz Transformation and Derivations of Relativistic Effects from Lorentz Transformations	2	
	5	Length Contraction, Velocity Transformation, Time Dilation, Simultaneity and Clock Synchronization	2	
	6	The Twin Paradox	1	
	7	Relativistic Dynamics – Relativistic Momentum	2	
	8	Relativistic Kinetic Energy, Total Energy and Rest Energy	2	
	9	Experimental Tests of Special Relativity	1	
	Sections 2.1 –2.7, 2.9 of chapter 2 of Book 1			
II		**THE PARTICLE – LIKE PROPERTIES OF ELECTROMAGNETIC RADIATION**	**10**	**16**
	10	Review of Electromagnetic Waves, Interference and Diffraction, Crystal Diffraction of X-Rays	2	
	11	The Photoelectric Effect	2	

	12	Thermal Radiation	2	
	13	The Compton Effect	2	
	14	Other Photon processes	1	
	15	Particles or Waves	1	
	Sections 3.1 – 3.6 of chapter 3 of Book 1.			
III	**THE WAVE – LIKE PROPERTIES OF PARTICLES**		**10**	**16**
	16	De Broglie's Hypothesis	1	
	17	Experimental Evidences for De Broglie waves	3	
	18	Uncertainty Relationships for Classical waves	1	
	19	Heisenberg Uncertainty Relationships	2	
	20	Wave Packets and the Motion of a Wave Packet	2	
	21	Probability and Randomness, and the Probability Amplitude	1	
	Sections 4.1 – 4.7 of chapter 4 of Book 1			
IV	**THE RUTHERFORD – BOHR MODEL OF THE ATOM**		**9**	**16**
	22	Basic Properties of Atoms ,The Rutherford Nuclear Atom – Rutherford Scattering Formula and Its Experimental Verification – The Closest Approach of a Projectile to the Nucleus	2	
	23	Line Spectra	1	
	24	The Bohr Model	3	
	25	The Franck – Hertz Experiment	1	
	26	The Correspondence Principle	1	
	27	The Failure of the Bohr Model	1	
	Sections 5.1 – 5.8 of chapter 5 of Book1. Excluded: sections 5.2.1, 5.3.1, derivation of Rutherford scattering formula			
V	**PRACTICALS**		**30**	
	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			

	1	**Determination of Plank's constant using LEDs** ● Observe the turn-on voltage, V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing) ● Plot $\frac{1}{\lambda} - V_0$ graph using Python, fit a straight line to get the slope and estimate the value of h. ● Calculate the %error. ● Programmable voltage source of ExpEYES may be used to find the turn-on voltage.		
	2	**Continuous and line spectra- Determination of the wavelengths and photon energy.** ● Familiarize the initial adjustments and measurements in the spectrometer. ● Mount the grating at normal incidence on the spectrometer. ● Determine the wavelengths of the sodium vapor lamp and calculate the associated photon energy. ● Determine the approximate range of the wavelengths of the continuous spectrum of incandescent/white LED lamp or any one coloured LED and calculate the associated photon energy. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating can be given.		
	3	**Mercury spectrum- Determination of wavelength and photon energy.** ● Determine wavelength of any four prominent lines and associated photon energy of the mercury spectrum using a spectrometer with grating at normal incidence. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	4	**Hydrogen spectrum - Determination of wavelengths and calculation of the Rydberg's constant.** ● Determine the wavelengths and photon energy in eV of the prominent lines of the Balmer series of the Hydrogen spectrum using a spectrometer with grating at normal incidence. ● Calculate the Rydberg's constant and estimate the % error. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	5	**Wave Packets - Analysis of beats in sound.** ● The experiment is intended to understand the concept of wave packet, phase and group velocities. ● Generate sounds waves of two near frequencies using smartphone/ExpEYES/Function generator and the		

		superimposed wave can be recorded and analysed using smartphone/ExpEYES/CRO ● Change the separation between the frequencies and compare the results with the theoretical values. ● https://expeyes.in/experiments/sound/beats.html ● Multi Tone generator and Audio scope tools of Phyphox may be used https://phyphox.org/experiment/tone-generator/		
	6	**Analysis of Hydrogen spectra using the Tracker Video Analysis tool**. ● Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant. ● Estimate the %error. ● Pre recorded video of the Hydrogen spectra can be used. ● https://physlets.org/tracker/. ● https://www.youtube.com/watch?v=UCCPkJpUQEw		
	7	**Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.** ● Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity, get λ_{max} and using Wein's law calculate the surface temperature. ● Pre recorded video of the solar spectra can be used.		
	8	**Verification of Wein's displacement law and Stefan's law using incandescent bulb.** ● Calibrate the video of the spectra of the incandescent bulb in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity and note λ_{max} . ● Repeat the experiment by increasing the operating voltage of the incandescent bulb(hence increasing the temperature of the source) ● From the plots, verify the Wein's displacement law and Stefan's law.		
	9	**Black body radiation- total energy output.** ● Plot Planck's radiation formula. ● Evaluate the area under the curve and x- axis(total radiance over all wavelengths) by numerical integration and hence verify Stephan's law		

Books and References:

1. Modern Physics (Fourth Edition, an Indian Adaptation) by Kenneth S. Krane (Book 1)
2. https://phyphox.org/
3. https://physlets.org/tracker/

4. https://expeyes.in/
5. Modern Physics for Scientists and Engineers" by John Morrison
6. Concepts Of Modern Physics By Arthur Beiser
7. Modern Physics by Raymond A. Serway
8. Modern physics by Randy Harris

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	0	0	0	0	0	2	0	0	0	0	0	0
CO 2	0	3	2	0	0	0	0	2	0	0	0	0	0
CO 3	0	0	3	2	0	0	0	0	2	0	0	0	0
CO 4	0	0	0	3	2	0	0	0	0	2	0	0	0
CO 5	0	0	0	0	3	2	0	0	0	0	2	0	0
CO 6	0	0	0	0	0	3	0	0	0	0	0	2	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**ELECTRONICS I**				
Type of Course	**Core in Major**				
Semester	**II**				
Academic Level	**100 – 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	The course usually encompasses proficiency in mathematics, physics, and basic circuit theory, alongside computer literacy and potentially some laboratory experience, ensuring students have the foundational knowledge needed for the course material.				
Course Summary	The course provides students with a comprehensive introduction to fundamental concepts in electronics, including circuit analysis, semiconductor devices and digital logic, equipping them with the essential skills and knowledge needed to understand and work with electronic systems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define the basic concepts of semiconductor physics, including energy bands, charge carriers, and doping.	Remember	Definitions and basic concepts	Quizzes
CO2	Explain the operating principles of semiconductor diodes, including forward and reverse bias conditions.	Understand	Laws and theories of semiconductor physics	Problem sets, concept maps
CO3	Analyse the applications of semiconductor diodes in rectification, clipping, and clamping circuits.	Analyse	Semiconductor device applications	Research papers, case studies
CO4	Explain the principles of operation of bipolar junction transistors (BJTs) and field-effect transistors (FETs), including their modes of operation and characteristics.	Understand	Laws and theories of semiconductor physics	Problem sets, concept maps
CO5	Apply transistor models to analyse amplifier circuits.	Apply	Application of principles	Laboratory experiments, simulations
CO6	Define the basic concepts of digital electronics, including binary number systems, hexadecimal number systems	Remember	Definitions and basic concepts	Quizzes
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**SEMICONDUCTOR PHYSICS**		**10**	**15**
	1	Semiconductor	3	
	2	P N Junction	2	
	3	Break down and Knee Voltage	2	
	4	Special Purpose diodes: LED and Photodiode	3	
	Sections : 5.1 – 5.19, 7.2 – 7.10 of Book 1			
II	**SEMICONDUCTOR DIODE APPLICATIONS**		**10**	**20**
	5	Rectifier	2	
	6	Half Wave and Full Wave Rectifiers	2	
	7	Filter Circuits	2	
	8	Voltage Multipliers	2	
	9	Zener Diode as Voltage Stabiliser	2	
	Sections : 6.8 – 6.28, Book 1			
III	**TRANSISTORS**		**15**	**25**
	10	Transistor	2	
	11	Transistor Connections	3	
	12	Transistor as an amplifier	3	
	13	Faithful Amplification and transistor biasing	3	

	14	Methods of Transistor Biasing – Base resistor method, Voltage Divider method, Design of transistor biasing circuits	4	
	Sections: 8.1 – 8.14, 8.16 – 8.23, 9.1 – 9.16, 9.18, Book 1			
IV	**DIGITAL FUNDAMENTALS**		**10**	
	18	Analog and Digital Signals	2	**10**
	19	Binary Number System	2	
	20	Decimal to Binary Conversion	2	
	21	Hexadecimal Number System	2	
	22	Binary-Coded Decimal Code	2	
	Sections: 26.1 – 26.6, 26.8 – 26.9, Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Study the V-I characteristics of diodes.** ● Characteristics of Ge, Si diodes, LEDs and photodiode. ● Reverse characteristics - Germanium diode; AO79 may give better results. ● ExpEYES may be used. https://expeyes.in/experiments/electronics/diodeIV.html ● Optional: Plot and fit the experimental data with the diode equation in GeoGebra or any other application and calculate the value of the ideality factor of the PN junction.		
	2	**Study the characteristics of Zener diode and construct a voltage regulator.** ● Study the V-I characteristics of zener diode and hence determine the breakdown voltage. ● https://expeyes.in/experiments/electronics/zenerIV.html ● Construct a voltage regulator using a zener diode and determine the percentage of voltage regulation.		

	3	**Study the V-I characteristics of solar cell and find the open circuit voltage, short circuit current and maximum power point.** ● Plot the V-I characteristics of solar cell under dark and illuminated conditions and get the open circuit voltage and short circuit current. ● Plot voltage-power graph and get the maximum output power point. ● Optional: find the efficiency of the solar cell, if a standardized light source is available. ● ExpEYES may be used. Solar cell of voltage rating 3V and current rating of the order of 100mA is desirable for the study. ● https://expeyes.in/experiments/electronics/diodeIV.html		
	4	**Construction of the Half Wave Rectifier.** ● Construct a half wave rectifier. Breadboard may be used for the easy replacement of the filters. ● Observe the waveforms without filter and with filter capacitors of four different values (4.7uF, 10uF, 47uF, 100uF) using CRO/ExpEYES. Measure the voltages and calculate the ripple factor. ● Observe the variation of the ripple factor when filters of different values are used, by maintaining a low value of the load resistance.		
	5	**Construction of the center tapped full wave rectifier and regulated power supply.** ● Construct a center tapped full wave rectifier without filter and with a filter. ● Connections may be realized through soldering, to get an experience of soldering. ● Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter. ● Observe the variation of the ripple factor with load resistance, when filter is used. ● Construct 5V/12V regulated power supply using 78XX IC.		
	6	**Construction of the Bridge rectifier.** ● Construct a bridge rectifier. Breadboard may be used for the easy replacement of the filters. ● Observe the waveforms without filter and with filter capacitors of four different values (4.7uF, 10uF, 47uF, 100uF) using CRO. Measure the voltages and calculate the ripple factor. ● Observe the variation of the ripple factor when filters of different values are used, by maintaining a low value of the load resistance.		
	7	**Realize clipping and clamping circuits using diodes and observe the waveforms.**		

		• Construct circuits using ordinary and zener diodes to clip the top, or bottom, or both of a waveform at a particular dc level. • Construct positive and negative clamper circuits and analyse the waveforms using CRO/ExpEYES. • https://expeyes.in/experiments/electronics/clipping.html https://expeyes.in/experiments/electronics/clamping.html		
	8	**Transistor input, output & transfer characteristics in CE configuration.** • Draw the static characteristics of the transistor in common emitter configuration and calculate input/output resistance and the current gain. • ExpEYES may be used https://expeyes.in/experiments/electronics/npn.html		
	9	**Construction of voltage multiplier (Doubler and Tripler).** • Construct the voltage doubler and tripler using diodes and capacitors and study the variation of ripple factor with respect to the capacitance values.		
	10	**Study the characteristics of LDR.** • Measure the dark resistance of LDR • Place LDR at different distances from an electric lamp and measure its resistance. Plot light intensity ($E \alpha \frac{1}{r^2}$) vs LDR resistance. • Optional: Construct a dark sensor using LDR and transistor. In order to turn on the LED in the desired light intensity, an adjustable resistor can be used in the circuit.		

Books and References:

1. Principles of Electronics by V K Mehtha and Rohith Mehtha (Book 1)
2. Electronics lab manual by K A Navas (vol 1 & 2)
3. Electronic Devices and Circuit Theory by Robert L. Boylestad and Louis Nashelsky
4. Electronic Principles by Albert Malvino and David J. Bates
5. Analog Electronics: Devices, Circuits, and Techniques by Chitralekha Mahanta
6. Basic Electrical and Electronics Engineering by R.K. Rajput
7. Semiconductor Devices: Physics and Technology by S. M. Sze

.Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	1	0	0	3	0	1	0	0	1	0	0	0

CO 2	3	1	0	0	3	0	1	0	0	1	0	0	0
CO 3	3	2	3	0	3	0	1	0	1	1	2	0	0
CO 4	3	1	3	0	3	0	1	0	0	1	0	0	0
CO 5	3	2	3	1	2	1	1	0	2	2	3	0	0
CO 6	3	1	0	0	2	1	1	0	0	1	0	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**MECHANICS -I**				
Type of Course	**Core in Major**				
Semester	**III**				
Academic Level	**200 – 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY1CJ101: Fundamentals of Physics				
Course Summary	This course explores Newton's Laws of Motion and how they can be applied to solve different mechanical systems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts of linear and angular momentum, and dynamics of linear and rotational motion	U	C	Instructor-created exams / Quiz
CO2	Understand the concepts of the conservation laws of linear and angular momentum	U	C	Instructor-created exams / Quiz
CO3	Analyse collisions of particles using the conservation of linear momentum	An	P	Instructor-created exams / Home Assignments

CO4	Analyse rotating systems using the conservation of angular momentum	An	P	Instructor-created exams / Home Assignments
CO5	Demonstrate critical thinking and problem-solving skills by applying the concepts and techniques learned to solve an extended set of real-world problems.	Ap	P	Seminar Presentation / Group Tutorial Work
CO6	Demonstrate computational skills to solve an extended set of computational projects based on real-world problems	Ap	P	Seminar Presentation / Group Tutorial Work / Group Project
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**MOMENTUM, IMPULSE AND COLLISIONS**	**11**	**16**
	1	Momentum and Impulse	2	
	2	Conservation of Momentum	2	
	3	Momentum Conservation and Collisions	2	
	4	Elastic Collisions	2	
	5	Centre of Mass	1	
	6	Rocket Propulsion	2	
		Sections 8.1 – 8.6 of chapter 8 of Book 1		
II		**ROTATION OF RIGID BODIES**	**12**	**18**
	7	Angular Velocity and Acceleration	2	

	8	Rotation with Constant Angular Acceleration	2	
	9	Relating Linear and Angular Kinematics	2	
	10	Energy in Rotational Motion	2	
	11	Parallel-Axis Theorem	1	
	12	Moment of Inertia Calculations	3	
	Sections 9.1 – 9.6 of chapter 9 of Book 1			
III	**DYNAMICS OF ROTATIONAL MOTION**		**12**	**18**
	13	Torque	1	
	14	Torque and Angular Acceleration for a Rigid Body	2	
	15	Rigid Body Rotation about a Moving Axis	3	
	16	Work and Power in Rotational Motion	1	
	17	Angular Momentum	2	
	18	Conservation of Angular Momentum	2	
	19	Gyroscopes and Precession	1	
	Sections 10.1 – 10.7 of chapter 10 of Book 1			
IV	**THE GRAVITATIONAL FIELD**		**13**	**18**
	19	Newton’s Law of Universal Gravitation	2	
	20	The Gravitational Field and Field of an Extended Body	3	
	21	The Gravitational Potential	3	
	22	Field Lines and Equipotential Surfaces	1	
	23	The Newtonian Gravitational Field Equations	3	

	24	The Equations of Poisson and Laplace	1	
	Sections 9.1 – 9,7 of chapter 9 of Book 2			
V	**OPEN-ENDED MODULE: COMPUTATIONAL PROJECTS**		**12**	
	Manageable number of selected computational projects from the list given may be assigned and evaluated. Any other computational projects related to the content of the course may be chosen by the teacher.			
	• Computational Projects 1.1 – 1.4, 2.1 – 2.6, 3.1 – 3.3, 5.1 – 5.2, 6.1 – 6.6, 7.1, 9.1 – 9.4			
	Sections from References: Computational Projects in chapters 1, 2, 3, 5, 6, 7, 9 of Book 2			

Books and References:

1. University Physics with Modern Physics (Edn.15) by Young & Freedman (Book 1)
2. Intermediate Dynamics (Edn.2) by Patrick Hamill (Book 2)
3. An Introduction to Mechanics by Daniel Kleppner and Robert J. Kolenkow
4. Mechanics by Keith R. Symon
5. Mechanics: Berkeley Physics Course, Volume 1 by Charles Kittel, Walter D. Knight and Malvin A. Ruderman
6. Mechanics: From Newton's Laws to Deterministic Chaos by Florian Scheck
7. NPTEL video lectures: https://nptel.ac.in/courses/115106090

Mapping of COs with PSOs and POs :

	PSO1	PSO 2	PSO 3	PS O4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	1	0	3	1	3	0	0	1	3	0	0
CO 2	3	1	1	0	3	1	3	0	0	1	3	0	0
CO 3	3	2	3	0	3	1	3	0	1	1	3	0	0
CO 4	3	2	3	0	3	1	3	0	1	1	3	0	0
CO 5	3	0	3	1	2	1	3	2	1	1	3	0	0
CO 6	3	3	1	2	2	2	3	0	1	2	3	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**COMPUTATIONAL PHYSICS**				
Type of Course	**Core in Major**				
Semester	**III**				
Academic Level	**200-299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic computer knowledge.				
Course Summary	This course aims to equip students with computational and simulation methods in physics using Python programming. Numerical methods for differentiation, integration, solving differential equations, interpolation and curve fitting are introduced.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand computational thinking by learning Logical and algorithmic thinking.	U	F	Instructor-created exams.
CO2	Understand python syntax and write basic python programs using loops, several data types etc	U, Ap	F, P	Instructor-created exams / Practical Assignment

CO3	Understand Numpy and matplotlib modules and apply them to matrix manipulation and graphing data.	U, Ap	P	Instructor-created exams / Practical Assignment
CO4	Understand the significance of computational methods in physics.	U	F	Instructor-created exams / Seminar Presentation
CO5	Understanding the concepts of interpolation, curve fitting, numerical differentiation, integration and ODEs in physics using python	U, Ap	P	Instructor-created exams / Practical Assignment
CO6	Applying the computational and simulation methods to several branches of physics using python.	Ap	P	Instructor-created exams / Practical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**THE COMPUTATIONAL THINKING**	**6**	**10**
	1	Approach, Logical thinking, Algorithmic thinking	4	
	2	Writing algorithm - Sum of Two Numbers, Factorial Calculation, Bubble Sort, Fibonacci series up to a given term [More algorithms other than listed here can be given as assignments and can be asked for examination as application level questions].	2	
		Relevant Sections of Chapter 2 of Book 1		
II		**THE PROGRAMMING LANGUAGE : PYTHON**	**19**	**20**
	3	Print command, Data types in Python, Variables, Input statements, eval() and type casting, String operations.	1	
	4	Operators and Operator precedence, Expressions and Statements, Formatted printing,	2	
	5	List, Set, Tuple, Dictionary	2	
	6	Flow of Control : Sequential, Selective (simple if, if-else, nested	3	

		if, ladder if), Iterative (While, For), Continue, Break		
	7	File Input and Output, Pickling, User defined function. Built-in Functions.	2	
	8	Numpy : Arrays - creation, operations, eigenvalues solvers, dot, determinant, transpose, inverse, random number generation.	4	
	9	Matplotlib : Simple plot, Labelling axes, Title, Multiple plots, Subplots, Pie chart, Hist(), Polar plot, 3D plot - introduction	3	
	Relevant Sections of Book 2 and Book 3			
III	**COMPUTATIONAL TECHNIQUES FOR EXPERIMENTAL PHYSICS**		**10**	**20**
	10	Importance of Numerical Methods in experiments, Discretisation, Accuracy considerations.	1	
	11	Interpolation - Forward Difference Method - Newton's Formula for Interpolation.	2	
	12	Programs : Interpolation using experimental data*	1	
	13	Curve Fitting - Method of Least Squares : Linear, Linearization of Nonlinear Laws.	2	
	14	Programs : Curve fitting using experimental data*	1	
	15	Numerical Differentiation - 1st & 2nd order finite difference differentiation. Numerical Integration - Trapezoidal, Simpson's 1/3 Methods.	2	
	16	Root Finding Methods - Bisection, Newton-Raphson.	1	
	Sections : 3.1, 3.3.1, 3.6, 4.1, 4.2.1, 4.2.3, 6.2.3, 6.4.1, 6.4.2, 2.2, 2.5 of Book 4			
IV	**COMPUTATIONAL TECHNIQUES FOR THEORETICAL PHYSICS**		**10**	**20**
	17	Importance of Simulation in Physics. Solving First order ODE - Euler Method, Second Order Range-Kutta Method	2	
	18	Programs : Radioactive Decay*, Newton's Law of Cooling*	1	
	19	Solving 2nd Order ODE - Euler Method, Numerov's method	3	

	20	Programs : Configuration and Phase Space Plots of Simple and Damped Harmonic Oscillator*	2	
	21	Monte Carlo Method : Simple Integration - Hit or Miss Method, Mean-value Method (only)	1	
	22	Programs : Value of Pi*, Radioactive Decay*	1	
	Sections 8.4, 8.5 of Book 4 and 14.1, 14.2 of Book 5 [* Programs must be done using Python 3]			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7^{th} experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Solution of equations by bisection and Newton-Raphson methods** ● Implement the bisection method in Python from scratch. ● Provide at least 4 functions with a specific mathematical equation and find the root using their implementation. ● Analyze and explain the conditions under which the bisection method converges and discuss any potential pitfalls. ● Similarly, implement the Newton-Raphson method in Python. ● Provide the same or different functions and find the root using their implementation. ● Compare the convergence speed of the Newton-Raphson method with the bisection method for different functions.		
	2	**Least square fitting – straight line fitting** ● Write a code that fits a straight line to the data given and calculates the slope and intercept. ● Plots the regression line along with the data points by giving, labels, title, legends and different colors ● A real-world scenario or dataset can be used to apply linear regression to solve a practical problem.		
	3	**Numerical Integration – Trapezoidal and Simpson's 1/3 rd rule** ● Implement the Trapezoidal and Simpson's 1/3 Rule in Python for a function given. ● A physics scenario can be provided, where quantities like displacement, work, or energy are needed to calculate		

		through integration. Use both methods to perform the integration and interpret the results. ● Visualize the integration process by plotting the function and the areas under the curve corresponding to the Trapezoidal and Simpson's 1/3 Rule.		
	4	**Simulation of projectile using Euler Method** ● Implement projectile motion simulation using the Euler method in Python. ● Simulate the trajectory/ Plot using matplotlib (y vs x, y vs t and x vs t) ● Compare with the theoretical values of range, maximum height and time of flight. ● Change initial conditions such that the projectile is now a freely falling body. Plot y vs t. ● Extend the simulation to include air resistance and compare the projectile motion with and without air resistance.		
	5	**Simulation of simple and damped pendulums using RK2 Method** ● Simulates the damped pendulum and stores phase space coordinates to arrays using second order Runge-Kutta method. ● Provide initial conditions and damping parameters for the damped pendulum scenario. ● Plot the motion of the pendulum and phase space trajectories. ● Change the Initial conditions and damping factor and analyse the results. Make sure turning the damping off reproduces the simple pendulum result.		
	6	**Numerical differentiation using difference table.** ● Implement numerical differentiation using a difference table in Python. ● Provide a function y = f(x) and a set of data points. Compute the numerical derivative at specific points using the forward difference method. ● Discuss the sensitivity of numerical differentiation to the choice of step size. ● Present physics problems like compute the velocity or acceleration of a particle based on position data.		
	7	**Monte- Carlo simulation of radioactive decay**		

		• Implement a simulation of radioactive decay in Python. • Provide initial conditions (number of particles, decay constant) and analyze the results, including plotting the decay curve over time. • Calculate the half-life of the radioactive substance based on the simulation results and check how it compares to the theoretically expected half-life. • Provide information about a specific radioactive isotope with a known half-life to simulate the decay of this isotope and compare the simulation results with the expected decay.		
	8	**Estimation of value of pi using Monte-Carlo Simulation** • Implement a Monte Carlo simulation to estimate the value of pi in Python. • Analyze how the estimated value of pi converges as the number of samples increases. • Create visualizations of the simulation results. Plot the points used in the simulation and visually demonstrate how the estimation of pi improves as more points are sampled.		
	9	**Solution system of linear equations and calculation of eigenvalues** • Solve a system of linear equations with three variables. • Diagonalize a 3x3 matrix and verify that by evaluating the eigenvalues. Also evaluate the eigenvectors for the matrix. • For better understanding, use Python (interactive mode) to verify that the eigenvector for an eigenvalue satisfies the eigenvalue equation: matrix times eigenvector equals eigenvalue times eigenvector.		
	10	**Least square fitting to an exponential function** • Take the data of transient effect in RC circuit (growth / decay) and write a code that fits an exponential function to the data and calculates the time constant. • ExpEYES may be used to record the data. • https://expeyes.in/experiments/electrical/rctransient.html • https://expeyes.in/experiments/electrical/rltransient.html		
	11	**Taylor series- evaluation of sine and cosine** • Evaluate sine and cosine of a given angle, using Taylor expansion about zero. • Print the difference with the built-in sine function. • Analyse how the error reduces with the number of terms. • Modify the program to calculate for higher angles to observe the effect of accuracy.		

Books and References:
1. Computational Thinking by Karl Beecher (Book 1)
2. A Student's Guide to Python for Physical Modeling by Jesse M. Kinder, Philip Nelson. Second Edition-Princeton University Press 2021 (Book 2)
3. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from https://scischool.in/python/index.html (Book 3)
4. Introductory Methods of Numerical Analysis by S.S. Sastry, Fifth Edition (Book 4)
5. Basic Concepts in Computational Physics by Benjamin A. Stickler and Ewald Schachinger, Springer International Publishing Switzerland 2014 (Book 5)

Mapping of COs with PSOs and POs :

	PSO1	PSO 2	PSO 3	PSO 4	PSO5	PSO6	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	1	2	0	3	1	0	0	0	1	3	0
CO 2	0	3	2	0	0	3	0	3	0	0	0	3	0
CO 3	0	3	2	0	0	3	0	3	0	0	0	3	0
CO 4	0	2	3	0	0	3	0	3	0	0	0	3	0
CO 5	0	2	3	0	0	3	0	3	0	0	0	3	0
CO 6	0	3	3	0	0	3	0	2	1	2	3	0	0

Correlation Levels

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">ELECTRODYNAMICS I</td></tr>
<tr><td>Type of Course</td><td colspan="5">Core in Major</td></tr>
<tr><td>Semester</td><td colspan="5">IV</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 – 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">A strong foundation in mathematics, including algebra, trigonometry, and calculus. Additionally, a basic understanding of physics concepts such as electricity, magnetism, and mechanics would be beneficial for grasping the principles covered in the course.</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course provides a foundational exploration of electromagnetism, encompassing topics like electric fields, magnetic fields and electromagnetic induction. Through simplified explanations, illustrative examples, and conceptual exercises, students gain insight into the behavior and interactions of electric and magnetic fields, preparing them for more advanced studies in physics or related fields at the undergraduate level.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply vector analysis techniques to solve problems in electromagnetics	Application	Conceptual Understanding	Problem-solving assignments, quizzes
CO2	Analyze and calculate electric fields and potentials for various charge distributions	Analysis	Procedural Knowledge	Homework assignments, exams, simulation exercises
CO3	Investigate the behavior of magnetic fields and solve problems involving magnetostatics	Evaluation	Conceptual Understanding	Laboratory reports, group projects, exams
CO4	Utilize electrical measurement instruments to quantify electric and magnetic phenomena	Application	Procedural Knowledge	Laboratory experiments, instrument operation tests, practical assessments
CO5	Demonstrate an understanding of Maxwell's equations and their implications in electromagnetism	Comprehension	Conceptual Understanding	Concept maps, oral presentations, written exams
CO6	Apply theoretical knowledge to analyze and design simple electromagnetic systems	Synthesis	Procedural Knowledge	Design projects, case studies, final projects
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**VECTOR ANALYSIS**	**12**	**20**
	1	Vector Algebra	2	
	2	Differential Calculus	4	
	3	Integral Calculus	4	

	4	Curvilinear Coordinates	2	
	Sections 1.1.1 – 1.1.4, 1.2.1 – 1.2.7, 1.3.1 – 1.3.6, 1.4.1 – 1.4.2 of chapter 1 of Book 1			
II		**ELECTROSTATICS**	**15**	**20**
	5	The Electric Field	3	
	6	Divergence and Curl of Electrostatic Field	4	
	7	Electric Potential; Electrostatic Boundary Conditions	4	
	8	Work and Energy in Electrostatics	2	
	9	Conductors	2	
	Sections 2.1.1 – 2.1.4, 2.2.1, 2.2.3, 2.2.4, 2.3.1 – 2.3.5, 2.4.1 – 2.4.4, 2.5.1 – 2.5.4 of chapter 2 of Book 1 (section 2.2.2 is excluded)			
III		**MAGNETOSTATICS**	**9**	**15**
	10	The Lorentz Force Law	2	
	11	The Biot – Savart Law	2	
	12	The Divergence and Curl of B (up to the derivation of Eqn. 5.50); Ampere's Law	2	
	13	Magnetic Vector Potential; Magnetostatic Boundary Conditions	3	
	Sections 5.1.1 – 5.1.3, 5.2.1, 5.2.2, 5.3.1 – 5.3.4, 5.4.1, 5.4.2 of chapter 5 of Book 1			
IV		**ELECTRICAL MEASUREMENTS**	**9**	**15**
	14	Kirchoff's laws and Wheatstone's Bridge	1	
	15	Carey Foster Bridge	1	
	16	Potentiometer	1	
	17	Network Analysis: Superposition Theorem	1	
	18	Thevenin's Theorem, Norton's theorem	1	
	19.	Maximum power transfer theorem	1	
	20	Maxwell's Loop Current Method	1	
	21	Torque on a Current loop in a Unifor, Magnetic field	1	
	22	Moving Coil Ballistic Galvanometer	1	

	Sections 6.6 – 6.8, 6.12 – 6.17 of chapter 6, and sections 10.10, 10.11 of chapter 10 of Book 2			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list (two from experiment 1-4 and four from 5-16) and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Plotting of the 2D functions using Python** ● Plot the 2D function in Problem 1.12 of Book 1 and find the maximum value and the location of maxima from the plot. ● Simulations of section 1.2 of Book 3 can be referred.		
	2	**Mapping of 2D vector fields using Python** ● Map the vector fields in Example 1.4 and 1.5 of Book 1. ● Map $\frac{\hat{r}}{r}$ and $\frac{\hat{r}}{r^2}$ ● Simulations of section 3.1 of Book 3 can be referred.		
	3	**Mapping of electric and magnetic field lines using Python** ● Plot the field of an electric charge, dipole and magnetic dipole. ● Simulations of section 4.1, 4.2 and Appendix D of Book 3 can be referred.		
	4	**Simulation of particle trajectory under Lorentz force law using Python** ● Simulate the trajectory of charged particle moving under Lorentz force law. ● Problem 5.66 of Book 1 and Chapter 6 of Book 3 can be referred		
	5	**Mapping of the magnetic field lines of a bar magnet.** ● Fix a paper on a drawing board kept on a table and place the bar magnet at the center along the magnetic meridian. ● Using a small compass needle, map the magnetic field lines of the magnet placed with (a) north pole pointing south and (b) north pole pointing north. ● Mark the null points (where the horizontal component of Earth's magnetic field, Bh cancels the field due to magnet) along the axial/equatorial line and measure the distance, 2d, between them. ● Calculate the moment of the magnet. (a) $m = \frac{4\pi}{\mu_0}\frac{(d^2-l^2)^2}{2d}B_h$ (b) $m = \frac{4\pi}{\mu_0}(d^2+l^2)^{3/2}B_h$		

	6	**Study the variation of the magnetic field strength of a bar magnet using a smartphone magnetometer.** ● Using a smartphone magnetometer, measure the strength of the magnetic field of a bar magnet, along the axial and equatorial lines and plot the data. ● Magnetometer in the Phyphox app may be used to get the data after locating the approximate position of the magnetometer sensor. https://phyphox.org/wiki/index.php?title=Sensor:_Magnetic_field ● Fit the theoretical formulae to the data and obtain magnetic dipole moment. Along the axial line $B = \frac{\mu_0}{4\pi}\frac{2md}{(d^2-l^2)^2}$ and along the equatorial line $B = \frac{\mu_0}{4\pi}\frac{m}{(d^2+l^2)^{3/2}}$		
	7	**Determine the moment of a bar magnet and Bh using a deflection magnetometer and a box type vibration magnetometer.** ● Determine m/Bh using deflection magnetometer in Tan A position and mBh using box type vibration magnetometer. Hence calculate the moment of the magnet and Bh. ● If the same magnet was used, compare the dipole moment with that of experiment 2 and 3.		
	8	**Circular coil- Verification of Biot Savart's law and determination of Bh.** ● Move a compass through a platform along the axis of the coil carrying a study current. Note the deflection of the needle and plot magnetic flux density ($B = B_h tan\theta$) as a function of distance. ● Optional: Smartphone magnetometer may be used to measure the strength of the magnetic field along the axial line and plot the data. https://phyphox.org/experiment/magnetic-field/ ● By varying current and (or) distance of the compass box along the axial line of the coil, note the deflection and hence determine the value of Bh.		
	9	**Reduction factor of TG using potentiometer.** ● Standardize the given potentiometer using a Danial cell or any other constant voltage source and use the standardized potentiometer to find the current through the TG. ● By observing the deflection in the TG for different currents, calculate the reduction factor. ● From the magnetic field at the center of a circular coil, deduce the value Bh.		
	10	**Verification of Kirchoff's laws / Superposition theorem.**		

		● Verify Kirchoff's current law at a junction where a minimum of three branches meet. ● Verify Kirchoff's current law for a network with two loops. **OR** ● Verify the superposition theorem for a network with two sources, S1 and S2. ● First set particular voltage values in S1 and S2 and note down the ammeter reading. ● Set the same voltage in S1 and short circuit S2 and vise versa, note down the ammeter readings and verify the superposition theorem.		
	11	**Verification of Thevenin's theorem and maximum power transfer theorem** **Thevenin's theorem** ● Measure the current through the load resistance of the network. ● Estimate the values of R_{TH} and V_{TH}, construct the Thevenin's equivalent circuit and measure the current through load resistance and compare the two results with the theoretical values. **Maximum power transfer theorem** ● Measure the current through load resistance and estimate the power. Plot $R_L - P$ graph and find the R_L corresponding to the maximum power. ● Calculate the % of error with the theoretical value.		
	12	**Determination of resistivity of a thin wire using Carey-Foster's Bridge** ● Find the resistance per unit length of the bridge wire. ● Determine resistance of the thin wire using the bridge, thickness of the wire using screw gauge and hence determine the resistivity.		
	13	**Calibrate the ammeter using potentiometer** ● Standardize the potentiometer using a Danial cell or any other standard voltage source. ● Determine the current for at least 8 trials and draw the calibration graph.		
	14	**Conversion of Galvanometer to voltmeter and calibration using potentiometer** ● Determine the value of high resistance required to connect in series with the galvanometer so as it can read 0.1V or 0.2V per scale division. ● Standardize the potentiometer using a Danial cell or any other standard voltage source. ● Determine the voltage for at least 6 trials and draw the calibration graph.		

	15	**BG-Determination of the figure of merits for current** ● Determine the figure of merits for current of the given ballistic galvanometer. ● Measure a small current using BG and verify with ammeter.		
	16	**BG-Comparison of capacitance- Desauty's method** ● Compare the capacitance of two given capacitors by forming De-Sauty bridge.		

Book for Reference:

1. Introduction to Electrodynamics (5th Edn.) by David J Griffiths, Cambridge University Press (Book 1)
2. Electricity and Magnetism (10 Edn.) by R Murugeshan, S. Chand and Company (Book 2)
3. Electrodynamics Tutorials with Python Simulations by Taejoon Kouh, Minjoon Kouh -CRC Press 1st Edition (Book 3)
4. Electricity and Magnetism, Berkeley Physics Course Vol.2, by E M Purcell, Mc Graw Hill Edn.
5. Electricity and Magnetism, by D C Pandey, Arihand Prakashan Series
6. Classical Electromagnetism by H C Verma, Bharathi Bhavan Publishers and Distributers
7. The Feynman Lectures on Physics, Vol-2, Pearson Education India
8. NPTEL lectures on Electrodynamics/ Classical Electrodynamics https://archive.nptel.ac.in/courses/115/105/115105132/

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO 4	PSO 5	PSO 6	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	1	3	2	3	0	2	3	3	2	3	2	0
CO 2	1	3	2	3	3	0	2	3	3	2	3	2	0
CO 3	3	2	3	1	3	0	3	3	3	2	3	2	0
CO 4	1	3	2	3	2	1	2	3	3	2	3	2	0
CO 5	2	2	3	1	3	0	3	3	3	2	3	2	0
CO 6	3	1	3	3	3	0	3	3	3	2	3	2	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP) BSc
PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**MECHANICS -II**				
Type of Course	**Core in Major**				
Semester	**IV**				
Academic Level	**200 – 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	PHY3CJ201: Mechanics -I				
Course Summary	This course explores Newton's Laws of Motion and how they can be applied to solve different mechanical systems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts of Newton's Laws of Motion	U	C	Instructor-created exams / Quiz
CO2	Apply Newton's Laws of Motion to solve different mechanical systems	Ap	P	Instructor-created exams / Home Assignments
CO3	Apply work-energy theorem to solve different mechanical systems	Ap	P	Instructor-created exams / Home Assignments
CO4	Analyse conservative systems and solve them using the	An	P	Instructor-created exams / Home

	conservation of mechanical energy.			Assignments
CO5	Demonstrate critical thinking and problem-solving skills by applying the concepts and techniques learned to solve an extended set of real-world problems.	Ap	P	Seminar Presentation / Group Tutorial Work
CO6	Demonstrate skills to set up and perform experiments to test Newton's Laws of Motion and related concepts.	Ap	P	Practical Assignment / Observation of Practical Skills / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**CENTRAL FORCE MOTION: THE KEPLER PROBLEM**		**14**	**20**
	1	Kepler's Laws	1	
	2	Central Forces	2	
	3	The Equation of Motion	2	
	4	Energy and the Effective Potential Energy	2	
	5	Solving the Radial Equation of Motion	1	
	6	The Equation of the Obit	2	
	7	The Equation of an Ellipse	2	
	8	Kepler's Laws Revisited	2	
	Sections 10.1 – 10.9 of chapter 10 of Book 1			

II	**HARMONIC MOTION**		**13**	**20**
	9	Springs and Pendulums	1	
	10	Solving the Differential Equation – Undamped Harmonic Oscillator	2	
	11	Damped Harmonic Oscillator – Underdamped, Overdamped and Critically Damped Oscillators	4	
	12	The Forced Harmonic Oscillator – Forced Undamped and Forced Damped Oscillators	4	
	13	The Q Factor	1	
	14	Resonance in Electrical Circuits	1	
	Sections 11.1 – 11.4 of chapter 11 of Book 1			
III	**WAVES**		**8**	**14**
	15	A Wave in a Stretched String	1	
	16	Direct Solution of the Wave Equation	1	
	17	Fourier Series	1	
	18	Standing Waves and Traveling Waves	2	
	19	Standing Waves as a Special Case of Traveling Waves	1	
	20	Energy and Energy Flow	2	
	Sections 13.1 – 13.6 of chapter 13 of Book 1			
IV	**ACCELERATED REFERENCE FRAMES**		**10**	**16**
	21	A Linearly Accelerating Reference Frame	1	
	22	A Rotating Coordinate Frame	1	
	23	Fictitious Forces	2	

	24	Centrifugal Force and the Plumb Bob	1	
	25	The Coriolis Force – A Falling Body and A Projectile	3	
	26	The Foucault Pendulum	2	
	Sections 15.1 – 15.6 of chapter 15 of Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. ● The necessary theory of the experiments can be given as an Assignment/ Seminar. ● Calculate the percentage error and standard deviation in each experiment. ● Plot the graphs using Python. ● Smartphones are exclusively intended for educational lab use. Necessary care should be taken to safeguard them during the experiments. ● Smartphone experiments primarily serve demonstration purposes, with result accuracy contingent upon the precision of phone sensors and experimental setups.			
	1	**Flywheel- Determination of the Moment of Inertia.** ● This experiment aims to help students grasp the concept of energy conservation and the dynamics of rotation. ● Do at least 9 trials for different masses and number of turns wound on the axil.		
	2	**Torsion Pendulum- Determination of the Moment of Inertia and Rigidity Modulus.** ● Using identical masses on the disc, determine the moment of inertia of the disc. ● Verify the moment of inertia by direct method, $I = \frac{1}{2}MR^2$ ● Using I, calculate rigidity modulus of the material of the wire, $n = \frac{8\pi I}{r^4}\frac{L}{T^2}$		
	3	**Compound Pendulum- Acceleration Due to Gravity and Moment of Inertia and Verification of Parallel Axis Theorem.**		

		● Plot a graph of distance of knife edge from one end Vs period of oscillations. Using the measurement from the graph, calculate g. ● Calculate the radius of gyration and hence the moment of inertia about CM. Compare the result obtained by the direct calculation $I_{CM} = \frac{ML^2}{12}$ ● Measure the period of oscillation about an arbitrary pivot point which is at a distance d from the CM. Calculate $I_{pivot} = mgd\frac{T^2}{4\pi^2}$. ● Verify the result using parallel axes theorem, $I_{pivot} = I_{CM} + md^2$		
	4	**Kater's Pendulum- Determination of Earth's Gravity.** ● To determine g for both the cases (a) T1 ≈ T2 and (b) T1 ≠ T2 and discuss the relative merits of both cases by estimation of error in the two cases.		
	5	**Melde's String - Determination of the Frequency of the Turing Fork** ● Determine the frequency of electrically maintained tuning fork by means of Melde's apparatus in longitudinal and transverse mode of vibration. ● Verify $\lambda^2 - T$ law.		
	6	**Sonometer - Determine the Frequency of AC.** ● Estimate the linear mass density of the wire. ● Draw $L^2 - m$ graph and from the slope calculate the frequency.		
	7	**Fourier Analysis of the Modes of Vibration in a Stretched String.** ● Record the sound produced by guitar string (or similar arrangement) using a microphone and analyze the spectrum by taking Fast Fourier Transform (FFT). ● Audio Spectrum in the Pyphox, Audacity, ExpEYES or any other tools can be used to record the sound and get the FFT. ● Vary the length and tension of the string and analyze the harmonics. ● https://phyphox.org/experiment/audio-spectrum/ ● https://www.youtube.com/watch?v=bl7jf2myEvM ● https://expeyes.in/experiments/sound/beats.html		
	8	**Determination of the Velocity of Sound in Air.** ● Sound wave of known frequency is generated using a wave generator(WG) and piezo buzzer and are recorded using a microphone(MIC).		

		● Phase differences between the WG and MIC waveforms were analyzed in a CRO and the distance between them were adjusted to make both of them in phase and hence calculate velocity of sound. ● Phase difference can be analyzed from the Lissajous figure obtained by X-Y plotting of WG and MIC waves. ● ExpEYES may be used. ● https://expeyes.in/experiments/sound/velocity.html ● https://expeyes.in/experiments/electrical/xyplot.html		
	9	**Transformation of Energy from One Form to Another.** ● Roll a hollow cylinder from a height, in an inclined plane, without pushing. ● Measure radius of the cylinder and record the velocity of the cylinder using the gyroscope of the phone inserted into the cylinder. ● Calculate the total energy before the cylinder starts to roll (Potential Energy, mgh) ● Calculate the total energy (Translational KE + Rotational KE) when the cylinder reaches the bottom of the plane. ● Estimate the energy lost as heat and sound. Repeat the experiment for different heights. ● Experiment 23 for Book 2 ● https://phyphox.org/experiment/roll/#more-509		
	10	**Pendulum- Limits on Angular Displacement and Study of Damped Oscillations.** ● Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM. Example 12.1 of Book 1. ● Study damped oscillations. Plot amplitude as a function of time and determine the damping coefficient and Q factor. ● Digitized data can be used for the study. ● https://www.youtube.com/watch?v=jcpvm95bhXw ● https://expeyes.in/experiments/school-level/sr04.html ● https://phyphox.org/experiment/pendulum/		
	11	Realize the computational Projects in chapters 10, 11, 12, 13, 15 of Book 1 or any other related projects using Python		

Books and References:

1. Intermediate Dynamics (Edn.2) by Patrick Hamill (Book 1)
2. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 2)

3. An Introduction to Mechanics by Daniel Kleppner and Robert J. Kolenkow
4. Mechanics by Keith R. Symon
5. Mechanics: Berkeley Physics Course, Volume 1 by Charles Kittel, Walter D. Knight and Malvin A. Ruderman
6. Mechanics: From Newton's Laws to Deterministic Chaos by Florian Scheck
7. NPTEL video lectures: https://nptel.ac.in/courses/115106090

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	0	2	0	0	0	2	0	0	0	0	0	0
CO 2	2	2	2	0	0	0	2	2	0	0	0	0	0
CO 3	0	2	2	0	0	0	0	2	0	0	0	0	0
CO 4	0	2	2	2	0	0	0	2	2	0	0	0	0
CO 5	0	0	2	0	0	0	0	0	2	0	0	0	0
CO 6	0	2	2	2	0	2	0	2	2	0	0	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">MODERN PHYSICS</td></tr>
<tr><td>Type of Course</td><td colspan="5">Core in Major</td></tr>
<tr><td>Semester</td><td colspan="5">IV</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 – 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Foundation in classical mechanics and electromagnetism. Additionally, students should have a solid understanding of calculus and differential equations to effectively engage with the mathematical concepts presented in the course.</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course integrates key principles of modern physics, including the Special Theory of Relativity, wave-particle duality, and the Bohr Atom Model, to provide students with a comprehensive understanding of fundamental concepts and their applications in diverse scientific fields. Through theoretical discussions and experimental investigations, students develop critical thinking skills and the ability to analyse complex physical phenomena at both macroscopic and microscopic levels.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the principles of the Special Theory of Relativity	Comprehension	Conceptual	Written exams, quizzes
CO2	Explain the dual nature of particles and waves	Comprehension	Conceptual	Problem sets, essays
CO3	Apply relativistic principles to solve problems	Application	Procedural	Problem-solving exams, simulations
CO4	Analyse experimental evidence supporting wave-particle duality	Analysis	Conceptual	Laboratory reports, case studies
CO5	Compare and contrast classical and quantum mechanical models	Analysis	Conceptual	Research papers, presentations
CO6	Critically evaluate the limitations of the Bohr atom model	Evaluation	Conceptual	Research projects, discussions
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**THE SPECIAL THEORY OF RELATIVITY**	**16**	**22**
	1	Classical Relativity	1	
	2	The Michelson – Morley Experiment	1	
	3	Einstein's Postulates and Its Consequences– Relativity of Time, Relativity of Length, Relativistic Velocity Addition, Relativistic Doppler Effect	4	
	4	The Lorentz Transformation and Derivations of Relativistic Effects from Lorentz Transformations – Length Contraction, Velocity	3	

		Transformation, Time Dilation, Simultaneity and Clock Synchronization		
	5	The Twin Paradox	1	
	6	Relativistic Dynamics – Relativistic Momentum	1	
	7	Relativistic Kinetic Energy, Total Energy and Rest Energy	2	
	8	Conservation Laws in Relativistic Decays and Collisions	2	
	9	Experimental Tests of Special Relativity	1	
	Sections 2.1 – 2.9 of chapter 2 of Book 1			
II	**THE PARTICLE – LIKE PROPERTIES OF ELECTROMAGNETIC RADIATION**		**10**	**16**
	10	Review of Electromagnetic Waves, Interference and Diffraction, Crystal Diffraction of X-Rays	2	
	11	The Photoelectric Effect	2	
	12	Thermal Radiation	2	
	13	The Compton Effect	2	
	14	Other Photon processes	1	
	15	Particles or Waves	1	
	Sections 3.1 – 3.6 of chapter 3 of Book 1.			
III	**THE WAVE – LIKE PROPERTIES OF PARTICLES**		**10**	**16**
	16	De Broglie’s Hypothesis	1	
	17	Experimental Evidences for De Broglie waves	3	
	18	Uncertainty Relationships for Classical waves	1	
	19	Heisenberg Uncertainty Relationships	2	
	20	Wave Packets and the Motion of a Wave Packet	2	

	21	Probability and Randomness, and the Probability Amplitude	1	
	Sections 4.1 – 4.7 of chapter 4 of Book 1			
IV		**THE RUTHERFORD – BOHR MODEL OF THE ATOM**	**9**	**16**
	22	Basic Properties of Atoms – Scattering Experiments and the Thomson Model – The Rutherford Nuclear Atom – Rutherford Scattering Formula and Its Experimental Verification – The Closest Approach of a Projectile to the Nucleus	2	
	23	Line Spectra	1	
	24	The Bohr Model	3	
	25	The Franck – Hertz Experiment	1	
	26	The Correspondence Principle	1	
	27	The Failure of the Bohr Model	1	
	Sections 5.1 – 5.8 of chapter 5 of Book1. Excluded: sections 5.2.1, 5.3.1, derivation of Rutherford scattering formula			
V		**PRACTICALS**	**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Determination of Plank's constant using LEDs** ● Observe the turn-on voltage, V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing) ● Plot $\frac{1}{\lambda} - V_0$ graph using Python, fit a straight line to get the slope and estimate the value of h. ● Calculate the %error. ● Programmable voltage source of ExpEYES may be used to find the turn-on voltage.		

	2	**Continuous and line spectra- Determination of the wavelengths and photon energy.** ● Familiarize the initial adjustments and measurements in the spectrometer. ● Mount the grating at normal incidence on the spectrometer. ● Determine the wavelengths of the sodium vapor lamp and calculate the associated photon energy. ● Determine the approximate range of the wavelengths of the continuous spectrum of incandescent/white LED lamp or any one coloured LED and calculate the associated photon energy. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating can be given.		
	3	**Mercury spectrum- Determination of wavelength and photon energy.** ● Determine wavelength of any four prominent lines and associated photon energy of the mercury spectrum using a spectrometer with grating at normal incidence. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	4	**Hydrogen spectrum - Determination of wavelengths and calculation of the Rydberg's constant.** ● Determine the wavelengths and photon energy in eV of the prominent lines of the Balmer series of the Hydrogen spectrum using a spectrometer with grating at normal incidence. ● Calculate the Rydberg's constant and estimate the % error. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	5	**Thomson's e/m experiment - Determination of the specific charge of the electron.** ● Measure the ratio of the electron charge-to-mass ratio (e/m) by studying the electron trajectories in a uniform magnetic field.		
	6	**Wave Packets - Analysis of beats in sound.** ● The experiment is intended to understand the concept of wave packet, phase and group velocities. ● Generate sounds waves of two near frequencies using smartphone/ExpEYES/Function generator and the superimposed wave can be recorded and analysed using smartphone/ExpEYES/CRO ● Change the separation between the frequencies and compare the results with the theoretical values. ● https://expeyes.in/experiments/sound/beats.html		

		● Multi Tone generator and Audio scope tools of Phyphox may be used https://phyphox.org/experiment/tone-generator/		
	7	**Analysis of Hydrogen spectra using the Tracker Video Analysis tool**. ● Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant. ● Estimate the %error. ● Pre recorded video of the Hydrogen spectra can be used. ● https://physlets.org/tracker/. ● https://www.youtube.com/watch?v=UCCPkJpUQEw		
	8	**Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.** ● Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity, get λ_{max} and using Wein's law calculate the surface temperature. ● Pre recorded video of the solar spectra can be used.		
	9	**Verification of Wein's displacement law and Stefan's law using incandescent bulb.** ● Calibrate the video of the spectra of the incandescent bulb in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity and note λ_{max}. ● Repeat the experiment by increasing the operating voltage of the incandescent bulb(hence increasing the temperature of the source) ● From the plots, verify the Wein's displacement law and Stefan's law.		
	10	**Black body radiation- total energy output.** ● Plot Planck's radiation formula. ● Evaluate the area under the curve and x- axis(total radiance over all wavelengths) by numerical integration and hence verify Stephan's law		

Books and References:

1. Modern Physics (Fourth Edition, an Indian Adaptation) by Kenneth S. Krane (Book 1)
2. https://phyphox.org/
3. https://physlets.org/tracker/
4. https://expeyes.in/
5. Modern Physics for Scientists and Engineers by John Morrison

6. Concepts Of Modern Physics By Arthur Beiser
7. Modern Physics by Raymond A. Serway
8. Modern physics by Randy Harris

Mapping of COs with PSOs and POs :

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CO 2	0	3	2	0	0	0	0	2	0	0	0	0	0
CO 3	0	0	3	2	0	0	0	0	2	0	0	0	0
CO 4	0	0	0	3	2	0	0	0	0	2	0	0	0
CO 5	0	0	0	0	3	2	0	0	0	0	2	0	0
CO 6	0	0	0	0	0	3	0	0	0	0	0	2	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**ELECTRODYNAMICS II**				
Type of Course	**Core in Major**				
Semester	**V**				
Academic Level	**300-399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	PHY4CJ203- Electrodynamics I				
Course Summary	The course emphasizes the development of mathematical techniques such as vector calculus and differential equations to solve complex problems in electromagnetism. Through theoretical discussions, problem-solving sections, and possibly laboratory experiments, students gain a deep understanding of electromagnetic phenomena and their applications in various fields such as optics, electronics, and telecommunications.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the fundamental principles of electromagnetism and Maxwell's equations	Understanding	Conceptual Knowledge	Written exams, quizzes
CO2	Apply mathematical techniques such as vector calculus and differential equations to solve electromagnetic problems	Applying	Procedural Knowledge	Problem sets, simulations
CO3	Analyze the behavior of electromagnetic fields in various media and under different boundary conditions	Analyzing	Conceptual Knowledge	Homework assignments, exams
CO4	Derive and interpret the electromagnetic wave equation and its solutions	Understanding	Conceptual Knowledge	Class discussions, presentations
CO5	Predict and analyze the behavior of electromagnetic waves in different contexts, such as optics and antenna theory	Applying	Procedural Knowledge	Laboratory experiments, projects
CO6	Design and analyze complex electromagnetic systems and devices using advanced electrodynamics principles	Creating	Procedural Knowledge	Research papers, presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**ELECTRIC AND MAGNETIC FIELDS IN MATTER**	**12**	**16**
	1	Polarization	2	
	2	The Field of a Polarised Object	2	
	3	The Electric Displacement; Boundary Conditions; Susceptibility, Permittivity, Dielectric Constant of Linear Dielectrics	3	
	4	Magnetisation	2	
	5	The Field of a Magnetised Object, Physical Interpretation of Bound Currents (Physical concept only), Ampère's Law in Magnetized Materials, Magnetic susceptibility and Permeability; Ferromagnetism	3	
		Sections 4.1.1 – 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.3, 4.4.1 of chapter 4; sections 6.1.1 – 6.1.4, 6.2.1 – 6.2.3, 6.3.1, 6.4.1, 6.4.2 of chapter 6 of Book 1		
II		**ELECTRODYNAMICS**	**12**	**18**
	6	Ohm's Law; Electromotive Force; Motional emf	3	
	7	Electromagnetic Induction: Faraday's Law; The Induced Electric Field; Inductance; Energy in Magnetic Fields	4	
	8	Maxwell's Equations: Electrodynamics before Maxwell; How Maxwell Fixed Ampere's Law; Maxwell's Equations; Maxwell's Equations in Matter; Boundary Conditions	5	
		Sections 7.1.1 – 7.1.3, 7.2.1 – 7.2.4, 7.3.1 – 7.3.3, 7.3.5 – 7.3.6 of chapter 7 of Book 1		

III	**ELECTROMAGNETIC WAVES**		**8**	**18**
	9	Waves in One Dimension, Sinusoidal waves, Polarization of Waves	2	
	10	The Wave Equations for E and B	1	
	11	Monochromatic Plane Waves	1	
	12	Poynting's Theorem	2	
	13	Energy and Momentum in Electromagnetic Waves	1	
	14	Propagation of Waves in Linear Media	1	
	Sections 9.1.1, 9.1.2, 9.1.4, 9.2.1, 9.2.2, 8.1.2, 9.2.3, 9.3.1 of Book 1			
IV	**TRANSIENT CIRCUITS AND ALTERNATING CURRENTS**		**13**	**18**
	15	Growth of Current in Series L-R, C-R, and L-C Circuits (Relevant portions)	2	
	16	Decay of Current in L-R, C-R and L-C Circuits (Relevant portions)	2	
	17	Alternating Current: EMF in a Coil Rotating in a Magnetic Field	2	
	18	AC Circuit Containing: R only, Inductance only, Capacitance only	2	
	19	Use of j Operator in Study of A.C. Circuits (Relevant concepts)	1	
	20	AC Circuit Containing: L and R, C and R, Parallel L and C	2	
	21	Series LCR Circuit	1	
	22	Power in AC	1	
		Sections 12.1, 12.3, 12.5, 13.1, 13.2, 13.3, 13.5 of Book 2		
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list (one from experiments 1-4 and 5 from 5-14) and 1 additional experiment, decided by the			

	teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Verification of Faraday's law and Lenz's law of electromagnetic induction** ● Verify Faraday's law and Lenz's law by measuring the induced voltage across a coil subjected to the varying magnetic field. (section 7.2.1 of Book 1) ● Galvanometer/ExpEYES can be used to measure the induced emf. ● In the third experiment, for better coupling between the coils, use a high permeability material like iron or ferrite core, and observe the change in the induced emf. ● https://expeyes.in/experiments/school-level/mutual-induction.html ● Simulation: https://phet.colorado.edu/sims/html/faradays-law/latest/faradays-law_all.html		
	2	**Analysis of induced emf developed in a coil as a magnet dropping through it** ● Drop a neodymium magnet through a coil, guided through a vertical tube. ● Repeat the experiment by dropping the magnet, through different heights from the coil and by changing the approaching pole. ● Capture the induced emf as a function of time using ExpEYES, note the maximum value of the emf and verify Faraday's law and Lenz's law of induced emf and flux change. ● Example 7.6 of Book 1 ● https://expeyes.in/experiments/school-level/em-induction.html		
	3	**AC three phase generator** ● Rotate a neodymium magnet about an axis perpendicular to its dipole axis and fix three coils displaced equally from each other, i.e., 120^o separated. ● Analyze the induced emf developed in the coils using CRO/ExpEYES and the phase relationship between the three induced voltages. ● Optional: Realize star connection (three phase four wire system) and verify the p.d. between the wires. section 13.10 of Book 2 ● https://expeyes.in/experiments/school-level/ac-generator.html		
	4	**Demonstration of Eddy currents** ● Mount aluminum/copper disk as a pendulum on a horizontal axis and observe the 'viscous drag' as it swings down and		

		passes between the poles of a magnet (Can be realized using two pieces of neodymium magnet. The demonstration illustrated in Fig. 7.16 of Book 1). ● https://www.youtube.com/watch?v=qTkOpprVITM OR ● Form a simple pendulum with a neodymium magnet and observe the 'viscous drag' as it swings down when an aluminium/copper sheet/block is placed under the pendulum. ● https://www.youtube.com/watch?v=VK40utGgioI ● https://www.youtube.com/watch?v=SF4xjO2RN1w OR ● Drop a neodymium magnet through an aluminium/copper tube and observe the delay in the fall of the magnet. Tubes of different gauge may be used for the demonstration. ● Keep the two probes at diametrically opposite points of the pipe and note the emf and current when a magnet is allowed to fall through the pipe. ● https://www.youtube.com/watch?v=H31K9qcmeMU		
	5	**Ballistic constant of the galvanometer using Hibbert's Magnetic Standard (HMS)** ● Give the induced current from HMS to the BG through a series resistance. Read the deflection corresponding to the resistance in the box and hence determine the ballistic constant. ● Charge a standard capacitor to its maximum capacity, with a small known voltage (using potential divider). Allow it to discharge through the BG. From the deflection in the BG, determine the charge in the capacitor and verify the relation Q = CV.		
	6	**BG-Determination of high resistance by leakage method** ● Charge the capacitor to its maximum capacity using a small known voltage and measure the charge stored q0 using the BG. ● Charge it again and allow it to discharge through a high resistance, R for a small interval of time, T. After this the remaining charge, q is measured using the BG. ● Using the values of q0, q, T and C, calculate the value of R.		
	7	**Mutual inductance and coefficient of coupling using Anderson's bridge** ● Connect the two coils of known self-inductances, L1 and L2 in series along with the resistance box in one of the arms of the Anderson's bridge. Keep one coil flat over the other so that the configuration gives maximum mutual inductance between the two. ● Determine the self-inductance L'=L1+L2+2M of the series combination using the null method. Reverse the coupling		

		between the coils by reversing the connections in one of the coils and once again determine the self-inductance L"=L1+L2-2M of the combination. ● Compute M=(L'-L")/4 and k = M/$\sqrt{L1L2}$		
	8	**Parallel plate capacitor. (a) verify the relationship between capacitance and the area of the plates (b) determination of dielectric constant of thin dielectric sheet** ● Form a parallel plate capacitor with dielectric material filled between the plates. ● Multimeter/ ExpEYES can be used to measure the capacitance. (For a significantly measurable value of the capacitance, use plates of dimension 10cmx10cm, or greater) ● Change the area of the capacitor plates and verify the relationship of the capacitance on the area (Using the same set of plates, the area can be changed by varying the overlapping region of the plates) ● By measuring the capacitance for different areas of the capacitor plates and (or) thickness of the dielectric material,determine the dielectric constant of the given material/liquid. ● https://www.youtube.com/watch?v=lKfIkUuFT-U		
	9	**Brewster's law experiment, determination of angle of polarisation and refractive index** ● Experimental arrangement- Sodium vapour lamp, Spectrometer, Polarizer (Graduated on 360° rotating) coupled in front of the spectrometer telescope, prism or glass plate. ● Get the angle of incidence corresponding to the minimum intensity of light and hence calculate the refractive index of the material. ● https://www.youtube.com/watch?v=f2A8sM1xhbQ		
	10	**RC and RL transients - determination of capacitance and inductance** ● Apply a voltage step to a series RC/RL circuit and record the resulting voltage variation across the capacitor/inductor. ● Get the value of time constant by an exponential fit to the data. ● Repeat the experiment for different resistances. ● https://expeyes.in/experiments/electrical/rctransient.html ● https://expeyes.in/experiments/electrical/rltransient.html		
	11	**RL and RC series AC circuits- Phase relationships of voltage across the elements**		

		• Using a CRO/ ExpEYES, verify the phase relationship between voltage across the inductor/capacitor and the current. • Note the phase difference between the applied voltage and current and determine the value of inductance/capacitance. **OR** • Note the peak voltage and current and determine the value of inductance/capacitance. • https://expeyes.in/experiments/electrical/rcsteady.html • https://expeyes.in/experiments/electrical/rlsteady.html • https://expeyes.in/experiments/school-level/ac-rc.html • https://expeyes.in/experiments/school-level/ac-rl.html		
	12	**Series LCR circuits-Determination of resonance frequency, quality factor and bandwidth** • The frequency of the signal generator is changed in steps and the corresponding voltage across the resistance is noted. • From the graph drawn for current against frequency, find the frequency corresponding to maximum voltage- resonant frequency. Also find the bandwidth and quality factor • CRO/Multimeter/ExpEYES can be used. • https://expeyes.in/experiments/electrical/rlcsteady.html		
	13	**Simulation of the behavior of RC and RL circuits under AC and DC** • Simulate the behavior of RC and RL circuits under AC and DC sources. • Section 8.3, 8.4 & 9.3 of Book 3 can be referred.		
	14	**Simulation of the behavior of RC and RL circuits under AC and DC** • Simulate the behavior of RC and RL circuits under AC and DC sources. • Section 9.3 of Book 3 can be referred to.		

Book for Reference:

1. Introduction to Electrodynamics (5^{th} Edn.) by David J Griffiths, Cambridge University Press (Book 1)
2. Electricity and Magnetism (10 Edn.) by R Murugeshan, S. Chand and Company (Book 2)
3. Electrodynamics Tutorials with Python Simulations by Taejoon Kouh, Minjoon Kouh -CRC Press 1st Edition (Book 3)
4. Electricity and Magnetism, Berkeley Physics Course Vol.2, by E M Purcell, McGraw Hill Edn.
5. Electricity and Magnetism, by D C Pandey, Arihand Prakashan Series
6. Electrodynamics Made Simple - e book by E D Dias and Santhosh P Jose https://store.pothi.com/book/ebook-dr-dias-e-d-electrodynamics-made-simple/

7. Classical Electromagnetism by H C Verma, Bharathi Bhavan Publishers and Distributors
8. The Feynman Lectures on Physics, Vol - 2, Pearson Education India

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7
CO 1	2	1	2	0	2	0	2	1	1	0	2	1	2
CO 2	0	2	3	0	2	0	1	3	2	0	2	2	2
CO 3	2	0	3	0	2	1	2	2	2	0	3	2	3
CO 4	2	2	2	1	3	1	2	2	2	1	3	2	3
CO 5	1	3	2	1	3	2	1	3	2	2	3	3	3
CO 6	3	2	3	2	3	2	2	3	3	3	3	3	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">OPTICS</td></tr>
<tr><td>Type of Course</td><td colspan="5">Core in Major</td></tr>
<tr><td>Semester</td><td colspan="5">V</td></tr>
<tr><td>Academic Level</td><td colspan="5">300 - 399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Fundamental understanding of basic physics principles, including optics, electromagnetic waves, and mathematical concepts such as calculus and trigonometry.</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course offers an in-depth study of light phenomena, covering polarization effects, diffraction phenomena, and their applications in optical systems and technologies.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define the basic principles of optics.	Remember	Definitions and basic concepts	Quizzes

CO2	Analyse optical phenomena using Fermat's Principle, such as reflection and refraction.	Analyse	Optical phenomena and causes	Research papers, case studies
CO3	Apply the principles of optics to design optical systems.	Apply	Application of principles	Laboratory experiments, projects
CO4	Analyse optical phenomena interference	Analyse	Optical phenomena and causes	Research papers, case studies
CO5	Apply diffraction principles to analyze patterns produced by various apertures and obstacles.	Apply	Application of principles	Laboratory experiments, simulations
CO6	Apply polarization concepts to analyze optical phenomena.	Apply	Application of principles	Laboratory experiments, simulations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**FERMAT'S PRINCIPLE**	**8**	**15**
	1	Laws of reflection and refraction from Fermat's Principle	2	
	2	Refraction and reflection at a single Spherical surface	2	
	3	The thin lens , Principal foci and focal length	2	

	4	The Newton formula, lateral magnification	2	
	Sections 3.1, 3.2, 4.1 – 4.7 of Book 1			
II	**INTERFERENCE**		**16**	**25**
	5	Superpositions of two sinusoidal waves	1	
	6	Interference division of wavefront introduction	1	
	7	Interference of light waves	3	
	8	Fresnel's two mirror and Fresnel's Biprism	2	
	9	Interference with white light , Lloyd's mirror , Phase change on reflection	3	
	10	Interference by division of amplitude -Non reflecting films	3	
	11	Colours of thin films, Newton's rings, Michelson interferometer	3	
	Sections 13.5, 14.1, 14.3 – 14.12 , 15.1 – 15.4, 15.8 – 15.11 of Book1			
III	**DIFFRACTION**		**10**	**15**
	12	Single- Slit Fraunhofer diffraction pattern	2	
	13	Two Slit Fraunhofer diffraction pattern	2	
	14	N Slit Fraunhofer diffraction pattern and Grating	2	
	15	Fresnel diffraction – Zone plate	2	
	16	Diffraction by straight edge	2	
	Sections 18.1, 18.2, 18.6 – 18.8, 20.1 – 20.3, 20.6 of Book 1			
IV	**POLARISATION**		**11**	**15**
	17	Polarisation Introduction	1	
	18	Production of linearly polarised light	2	

	19	Effects of polariser and analyser	1	
	20	Double refraction -Huygens' explanation	2	
	21	Wave plates	2	
	22	Production and analysis of different polarised light	3	
	Sections 20.1 – 20.4, 20.5, 20.6.2 – 20.6.3, 20.8.3, 20.9.1, 20.17 – 20.20 of Book 2			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Determine the refractive index of (a) given liquid and (b) the material of a lens, by forming a liquid lens.** ● Through this experiment the students are expected to get the concepts of image formation, combination of lenses and radius of curvature of the surface of lens. ● Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices.		
	2	**Determine the focal length of the combination of two lenses separated by a distance.** ● Determine the focal lengths, f1 and f2 of the two lenses using an illuminated cross-slit screen holder, nodal slide(for placing the lenses) and plane mirror arrangement. ● Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation ● $\frac{1}{F} = \frac{1}{f1}+\frac{1}{f2} - \frac{d}{f1f2}$. ● The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study. ● https://www.youtube.com/watch?v=IOlEEtyNPBg ● https://www.youtube.com/watch?v=tNo4Ipk74SU		
	3	**Determination of the dispersive power of a solid prism using a spectrometer.** ● Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer.		

		● Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths.		
	4	**Refractive indices of quartz prism using spectrometer.** ● Determine the refractive indices of quartz for the ordinary and extraordinary rays of a sodium vapour lamp by arranging the quartz prism at minimum deviation position in the spectrometer. ● Verify the polarizations of the ordinary and extraordinary rays using a polaroid.		
	5	**Determination of wavelengths of mercury spectrum using diffraction grating and spectrometer.** ● Arrange the grating at normal incidence. ● Standardize the grating using the green line of mercury and then find the wavelengths of other prominent lines of the spectrum.		
	6	**Newton's rings-determination of the wavelength of sodium light** ● Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source. ● Determine the radius of curvature by Boy's method and determine the wavelength of the source. ● Optional: In experiment 5 and 6, record a short video of the interference pattern, calibrate the video using scale marked on the glass plate, analyse the video using Tracker tool. From the intensity profile get the locations of the dark rings and calculate the wavelength of the source/thickness of the sample https://physlets.org/tracker/. https://www.youtube.com/watch?v=UCCPkJpUQEw		
	7	**Air wedge-determination of the radius of a thin wire/human hair/thin foil.** ● Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates. ● Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given.		
	8	**Single slit diffraction using laser - Determination of slit width.** ● The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper. ● From the width of the central maxima or the position of minimum intensity points, calculate the slit width. ● Verify the slit width using a traveling microscope. ● Wavelength of laser can be found using diffraction grating of known N.		

	9	**Analysis of the diffraction patterns using Tracker tool.** ● The diffracted laser light from a narrow wire/single slit/double slit/small rectangular/circular aperture is allowed to fall on a screen and record a short video of the diffraction pattern. ● Analyse the video using Tracker tool and plot the intensity profile. ● Calibrate the video using the scale marked on the screen and from the location of the intensity peaks, determine the dimension of the scattering source. ● https://physlets.org/tracker/. ● https://www.youtube.com/watch?v=UCCPkJpUQEw		
	10	**Study the specific rotation of the sugar solution using a polarimeter.** ● Determine the specific rotation corresponding to different concentrations of the sugar dissolved in water. ● Draw a graph between rotation and concentrations and verify the linear relationship.		
	11	**Verification of Malus's law using polarizer, analyzer and photo detector** ● Unpolarized light is allowed to pass through a polarizer and is observed through an analyzer. ● Vary the angle between the axes of polarizer and analyzer and measure the intensity of the light (current output of the photodetector). ● Plot $\theta - I$ and $cos^2\theta - I$ graphs and verify Malus' law.		
	12	**Spectrometer-Determination of the Cauchy's constants of the given prism** ● Find the angle of the prism, the minimum deviation angles of the prominent lines of the mercury spectrum and hence calculate the refractive indices for the colors. ● Determine A and B from the ● $\mu - \frac{1}{\lambda^2}$ graph.		

Books and References:

1. Optics by Ajoy Ghatak; 6th Edition (Book 1)
2. A Text Book of Optics by N. Subrahmanyam, Brij Lal and M.N Avadhanulu; 2018 Revised Edition (Book 2)
3. Optics by Eugene Hecht
4. Introduction to Modern Optics by Grant R. Fowles
5. Introduction to optics by Frank L. Pedrotti, Leno M. Pedrotti
6. Fundamentals of Optics by Jenkins F

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO 5	PSO 6	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	0	0	0	2	0	2	1	0	0	1	1	1
CO 2	2	2	0	2	2	0	2	1	1	0	1	1	1
CO 3	2	1	0	3	2	1	2	1	1	1	1	1	1
CO 4	2	2	0	2	2	0	2	1	1	0	1	1	1
CO 5	2	1	0	2	2	1	2	1	1	1	1	1	1
CO 6	2	1	0	2	2	1	2	1	1	1	1	1	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**QUANTUM MECHANICS I**				
Type of Course	**Core in Major**				
Semester	**V**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Fundamental Mathematics Concepts: Vector, Matrix, 2nd Order ODE, Probability.				
Course Summary	This comprehensive course aims to provide students with a solid foundation in quantum mechanics, delving into theoretical concepts, honing problem-solving skills, and offering exciting possibilities through hands-on simulations.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate a deep understanding of the foundational principles of quantum mechanics	Understanding	Conceptual Knowledge	Written exams, quizzes
CO2	Solve complex quantum mechanical problems using mathematical formalism such as the Schrödinger equation	Applying	Procedural Knowledge	Problem sets, simulations
CO3	Analyze the quantum behavior of systems with discrete and continuous spectra	Analyzing	Conceptual Knowledge	Homework assignments, exams

CO4	Explain the physical significance of quantum mechanical operators and their properties	Understanding	Conceptual Knowledge	Class discussions, presentations
CO5	Predict the outcomes of quantum experiments and interpret their results within the framework of quantum theory	Evaluating	Conceptual Knowledge	Virtual lab experiments, projects
CO6	Apply quantum mechanics principles to understand topics such as box problem and quantum harmonic oscillator	Applying	Procedural Knowledge	Research papers, presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**THE WAVE FUNCTION**	**6**	**10**
	1	The Schrödinger Equation, The Statistical Interpretation.	1	
	2	Probability: Discrete Variables, Continuous Variables.	2	
	3	Normalization	1	
	4	Momentum	1	
	5	The Uncertainty Principle.	1	
	Sections 1.1 – 1.6 of chapter 1 of Book 1			
II		**TIME – INDEPENDENT SCHRÖDINGER EQUATION**	**13**	**20**
	6	Stationary States – Time-independent Schrodinger Equation, Time-independence of expectation values, A definite value of the total energy, General solution as a linear combination of separable solutions, Probability amplitudes.	3	
	7	The Infinite Square Well	3	
	8	The Free Particle – Wave packet, Phase and Group velocities	2	
	Sections 2.1, 2.2 and 2.4 of chapter 2 of Book 1			

	9	The Conservation of Probability: Probability Density, Probability Current Density, Interpretation of Equation of Continuity.	1	
	10	The Potential Step : Case $E > V_0$, Case $E < V_0$.	2	
	11	The Potential Barrier : Case $E > V_0$, Case $E < V_0$ – Tunneling.	2	
	Sections 3.6.4 of chapter 3, and sections 4.4, 4.5.1 and 4.5.2 of chapter 4 of Book 2			
III	**MATHEMATICAL TOOLS OF QUANTUM MECHANICS**		**20**	**25**
	12	The Hilbert Space and Wave Functions: The Linear Vector Space, The Hilbert Space, Dimension and Basis of a Vector Space, Square-Integrable Functions – Wave Functions	3	
	13	Dirac Notation: Kets, Bras, Bra-Kets and their Properties	2	
	14	Operators: General Definitions, Hermitian Adjoint and Its Properties, Hermitian Operators.	2	
	15	Commutator Algebra	1	
	16	Uncertainty Relation between Two Operators – General Relation and Heisenberg Uncertainty Relations	1	
	17	Functions of Operators	1	
	18	Eigenvalues and Eigenvectors of an Operator, Theorems 2.1 – 2.5.	2	
	19	Representation of Discrete Bases: Matrix Representation of Kets and Bras, Matrix Representation of Operators, Change of Bases and Unitary Transformations, Matrix Representation of the Eigenvalue Problem.	3	
	20	Representation of Continuous Basis: General Treatment, Position Representation, Momentum Representation, Connecting Position and Momentum Representations.	4	
	21	Matrix and Wave Mechanics: Matrix Mechanics, Wave Mechanics	1	
	Sections 2.2, 2.3, 2.4.1, 2.4.2, 2.4.4 – 2.4.6, 2.4.8, 2.5.1.1, 2.5.1.2,2.5.2, 2.5.3, 2.6.1 – 2.6.4.3 and 2.7 of chapter 2 of Book 2			
IV	**THE QUANTUM HARMONIC OSCILLATOR**		**9**	**15**
	22	The Harmonic Oscillator: Energy Eigenvalues, Energy Eigenstates, Energy Eigenstates in Position Space (up to the first excited state only), The Matrix Representation of Various Operators, Expectation Values of Various Operators.	6	
	23	3D Problems in Cartesian Coordinates – General Treatment:	1	

		Separation of Variables		
	24	The Box Potential – Rectangular and Cubic Box Potentials, Degeneracy	1	
	25	The 3D Harmonic Oscillator: Anisotropic and Isotropic Oscillators, Degeneracy	1	
	Sections 4.8 – 4.8.5 of chapter 4, and sections 6.2.1, 6.2.3 and 6.2.4 of chapter 6 of Book 2			
Solved and unsolved problems of the relevant sections from the prescribed texts shall be discussed or given as assignment.				
V	**OPEN – ENDED MODULE: COMPUTER SIMULATIONS OF QUANTUM SYSTEMS**		**12**	
	Computer Simulations of quantum systems such as potential well, harmonic oscillator etc. can be done using appropriate numerical techniques and eigenvalue solvers in Python. The objectives can be to determine the energies of these systems and plot the probabilities of the states.			

Books and References:

1. Introduction to Quantum Mechanics (Third Edition) by David J Griffiths (Book 1)
2. Quantum Mechanics: Concepts and Applications (Second Edition) by Nouredine Zettili (Book 2)
3. Principles of Quantum Mechanics by Ramamurti Shankar
4. Quantum Mechanics: Theory and Applications" by Ajoy Ghatak and S. Lokanathan
5. Lectures on Quantum Mechanics by B. K. Agarwal
6. Quantum Mechanics: Non-Relativistic Theory" by L. D. Landau and E. M. Lifshitz
7. NPTEL video lectures: https://nptel.ac.in/courses/122106034

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	0	0	0	2	0	3	1	0	0	1	1	1
CO 2	3	2	3	0	3	0	3	1	1	0	1	1	1
CO 3	3	0	3	0	3	0	3	1	0	0	1	1	1
CO 4	3	0	0	0	2	0	3	1	0	0	1	1	1
CO 5	3	0	3	0	3	0	3	1	0	0	1	1	1
CO 6	3	0	3	0	3	0	3	1	0	0	3	1	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**THERMODYNAMICS**				
Type of Course	**Core in Major**				
Semester	**VI**				
Academic Level	**300 – 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Proficiency in calculus, basic physics principles including mechanics and heat transfer, and a foundational understanding of chemistry are typically prerequisites for an undergraduate thermodynamics course.				
Course Summary	Thermodynamics course covers fundamental principles such as the conservation of energy, entropy, and thermodynamic properties of substances, providing students with the knowledge to analyse and predict the behaviour of systems in various contexts, from power generation to environmental processes				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate a solid understanding of the fundamental principles of	Understanding	Fundamental Principles	Conceptual quizzes,

	thermodynamics, including the laws of thermodynamics and their mathematical representations.			written examinations
CO2	Apply thermodynamic concepts to analyze and solve problems in classical physics.	Application	Application in Classical Physics	Problem-solving exercises, laboratory experiments
CO3	Utilize mathematical tools, including calculus and differential equations, to model thermodynamic systems and predict their behavior.	Application	Mathematical Modelling; Evaluation Tools	Mathematical problem sets, computational assignments
CO4	Interpret thermodynamic properties of materials and their phase transitions, connecting theoretical concepts with experimental observations.	Analysis	Knowledge Category: Properties of Matter	Data analysis projects, laboratory reports
CO5	Evaluate and compare the efficiency and performance of thermodynamic processes and cycles, including practical applications such as heat engines and refrigeration systems.	Evaluation	Efficiency and Performance	Performance assessments, design projects
CO6	Apply thermodynamics principles to interdisciplinary areas such as materials science, environmental science, and astrophysics, demonstrating the relevance and versatility of thermodynamic concepts.	Application	Interdisciplinary Applications	Research projects, case studies
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**ZEROTH LAW AND FIRST LAW OF THERMODYNAMICS**		**10**	**16**
	1	Thermodynamic Limit, Extensive and Intensive Variables, The Ideal Gas	1	
	2	A Definition of Heat, Heat Capacity, Specific Heat Capacity, Molar Heat Capacity, C_p and C_v	1	
	3	Thermal Equilibrium and Zeroth Law of Thermodynamics	1	

	4	A System in Thermal Equilibrium, Functions of State	1	
	5	The First Law of Thermodynamics	1	
	6	Heat Capacity	2	
	7	Reversibility	1	
	8	Isothermal and Adiabatic Expansion of Ideal Gas	2	
	Sections 1.2 – 1.3 of chapter 1, 2.1 – 2.2 of chapter 2, 4.1 of chapter 4, 11.1 – 11.3 of chapter 11, 12.1 – 12.3 of chapter 12 of Book 1			
II	**HEAT ENGINES AND THE SECOND LAW OF THERMODYNAMICS**		**9**	**16**
	9	The Second Law of Thermodynamics	1	
	10	The Carnot Engine	2	
	11	Carnot's Theorem	1	
	12	Equivalence of Clausius and Kelvin Statements	1	
	13	Examples of Heat Engines	1	
	14	Heat Engines Running Backwards: Refrigerator and Heat Pump	1	
	15	Clausius' Theorem	2	
	Sections 13.1 – 13.7 of chapter 13 of Book 1			
III	**ENTROPY**		**10**	**16**
	16	Definition of Entropy	1	
	13	Irreversible Change	2	
	14	The First Law Revisited	1	
	15	The Joule Expansion of Ideal Gas	1	
	16	The Statistical Basis for Entropy	1	
	17	Entropy of Mixing	1	
	18	Maxwell's Demon	1	
	19	Entropy and Probability	2	

	Sections 14.1 – 14.8 of chapter 14 of Book 1			
IV	**THERMODYNAMIC POTENTIALS, THIRD LAW OF THERMODYNAMICS AND PHASE TRANSITIONS**		**16**	**22**
	20	Thermodynamic potentials – Internal Energy (U), Enthalpy (H), Helmholtz Function (F) and Gibbs Function (G)	3	
	21	Availability and Constraints	1	
	22	Maxwell's Relations	2	
	23	Different Statements of the Third law and the Consequences of the Third Law	2	
	24	Latent Heat, Clausius – Clapeyron Equation and Phase Diagrams	3	
	25	Stability and Metastabilty	2	
	26	Gibbs Phase Rule	1	
	27	Classification of Phase Transitions	2	
	Sections 16.1 – 16.6 of chapter 16, 18.1 – 18.2 of chapter 18, 27.1 – 27.3 of chapter 27, 28.1 – 28.5, 28.7 of chapter 28 of Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Verification of Boyle's law and Charle's law** ● Boyle's law (PV= a constant) states that at a constant temperature, volume of a gas is inversely proportional to pressure. ● Determine the volume - pressure relation at constant temperature using the water column. ● Plot the pressure versus volume graph and verify Boyle's law. ● Verify the law at minimum two different temperatures. ● Charle's law (V/T = a constant) states that at constant pressure, volume is directly proportional to temperature. ● In this experiment determine the temperature - volume relation at constant pressure using the water column.		

		• Plot the temperature versus volume graph and verify the Charle's law. • Verify the law at minimum two different pressures.		
	2	**Verification of Gay-Lussac's law** • Gay-Lussac's law (P/T = a constant) states that at constant volume, pressure is directly proportional to temperature. • In this experiment determine the temperature - pressure relation at constant pressure using metallic bulb and water column or pressure gauge or using Jolly's bulb apparatus. • Plot the temperature versus volume graph and verify the Charle's law.		
	3	**Specific heat of metal** • Specific heat of an object is the amount of heat required to change the temperature by unit degree Celsius per unit mass. • The amount of heat transferred and the change in temperature can be obtained using suitable metal object and water bath. • The metal block of suitable mass is kept in constant temperature water bath at a higher temperature/boiling water, until thermal equilibrium is attained. Then immerse the metal block in a beaker filled with water at room/lower temperature until thermal equilibrium is attained. • By equating heat gain (of water and beaker) to heat loss (of metal rod) and the temperature change of metal block, specific heat of metal can be estimated. • Determine the specific heat of at least two different metals.		
	4	**Latent heat of fusion of ice** • Latent heat of ice is the heat energy absorbed to change its phase from solid to liquid without changing its temperature. • To measure the heat transferred, cubes of ice are mixed in water taken in a beaker. • By equating heat gain by (ice to melt and melt ice to rise its temperature up) to heat loss (by water and beaker), the latent heat of fusion of ice can be determined. • Experiment should be performed in thermally insulated / thermocol box.		
	5	**Thermal conductivity by Searle's method**		

		● Determine the thermal conductivity of copper or any other metal using Searle's method / apparatus.		
	6	**Thermal conductivity by Forbes method** ● Determine the thermal conductivity of steel or copper or any other metal using Searle's method / apparatus.		
	7	**Temperature coefficient of resistance of a metal** ● Resistance of metals increases with increase in temperature. ● Measure the resistance of the metal coil, using Carey Foster's bridge or Potentiometer or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature. ● Plot graph and find the temperature coefficient of resistance.		
	8	**Characteristics of NTC thermistor** ● Resistance of Negative Temperature Coefficient (NTC) thermistors decreases with increase in temperature. ● Measure the resistance of the thermistor, using Carey Foster's bridge or Potentiometer or ExpEYES or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature. ● Plot the graph and study the characteristics.		
	9	**Band gap of a semiconductor** ● Measure the reverse bias current/resistance of a semiconductor diode as a function of temperature, using Carey Foster's bridge or Potentiometer or ExpEYES or any other suitable method. ● Plot the logarithm of resistance/current against the inverse of temperature. ● From the slope, the band gap from the semiconductor can be obtained.		
	10	**Thermo emf of a Thermocouple** ● Study the variation of thermo emf of a thermocouple as a function of temperature of the hot junction while maintaining the cold junction at 0 degree Celsius.		

	11	**Newton's law of cooling** ● According to Newton's law of cooling, the rate of heat loss of a hot body is proportional to the difference in temperature between the body and the surroundings. ● The calorimeter is filled with hot water and the variation in temperature is noted as a function of time. ● Cooling rate graph is plotted and law is verified. ● Emissivity of the surface of the calorimeter can also be determined. ● ExpEYES and PT1000 sensor may be used to record the temperature. https://expeyes.in/experiments/thermal/cooling.html		
	12	**Thermal conductivity of a bad conductor by Lee's Disc method** ● Determine the thermal conductivity of a bad thermal conductor using Lee's disc apparatus.		
	13	**Determination of coefficient of linear thermal expansion of metal** ● Linear coefficient of thermal expansion is the change in length of a material per unit change in temperature per unit length. ● Measure the length of a long metal rod as function of temperature. ● Plot the length / change in length of the rod as function of temperature. ● From the slope coefficient of linear thermal expansion of metal can be obtained. ● Perform the experiment for minimum two different metals.		
	14	**Melting point of wax** ● Fill a test tube with wax until half and use a thermometer inside the wax / test tube to measure wax temperature. Avoid the thermometer touching the test tube. ● Immerse the test tube in a water bath with the help of a stand, in such a way that the wax is below the water level. ● Use a suitable flame / heating rate and measure the wax temperature as a function of time at a suitable time interval. ● Plot temperature versus time graph. ExpEYES and PT1000 sensor may be used to record the temperature. https://expeyes.in/experiments/thermal/cooling.html ● The temperature increases initially and remains constant until the wax melts completely. The flat temperature gives		

		the melting point of wax (The melting point depends on the type of wax used)		
	15	**Simulate the Thermodynamic process in PV diagram and estimate the work done by numerical integration** ● Plot isothermal, adiabatic and isobaric process in the PV diagram. ● Estimate the work done by numerical integration in each case. ● Refer section 4.2 of Book 2		
	16	**Simulate the Carnot Cycle in PV diagram and estimate the efficiency by numerical integration** ● Plot the Carnot cycle in the PV diagram. ● Estimate the work done in each process by numerical integration and estimate efficiency. ● Compare the estimated efficiency with theoretical efficiency. ● Refer section 4.6 of Book 2		

Books and References:

1. Concepts in Thermal Physics by Stephen J Blundell and Katherine M. Blundell (Book 1)
2. Thermal Physics Tutorials with Python Simulations (CRC Press, 2023) by Minjoon Kouh and Taejoon Kouh (Book 2)
3. Thermal Physics by Charles Kittel and Herbert Kroemer
4. An Introduction to Thermal Physics by Daniel V. Schroeder
5. Heat and Thermodynamics by Mark Zemansky, Richard Dittman
6. Thermal Physics by Garg, Bansal, and Ghosh
7. Thermodynamics and Statistical Physics by Satya Prakash
8. Heat Thermodynamics and Statistical Physics by Brij Lal , N Subrahmanyam and PS Hemne
9. NPTEL video lectures: https://nptel.ac.in/courses/115106090

Mapping of COs with PSOs and POs :

	PSO1	PSO 2	PSO3	PSO 4	PSO 5	PSO 6	PO1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7
CO 1	3	0	0	0	0	0	1	0	0	1	0	0	0
CO 2	2	0	3	0	2	0	1	0	0	1	0	0	0
CO 3	2	0	3	0	2	0	0	0	0	1	0	0	0

CO 4	2	0	2	0	2	0	0	0	0	1	0	0	0
CO 5	2	0	3	0	2	0	0	0	0	1	0	0	0
CO 6	2	0	3	0	3	0	0	0	0	1	0	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**ELECTRONICS II**				
Type of Course	**Core in Major**				
Semester	**VI**				
Academic Level	**300 – 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	PHY2CJ101- Electronics I				
Course Summary	Course provides students with a comprehensive understanding of transistor operation, FET characteristics, and Op-Amp applications, preparing them for designing and analyzing electronic circuits.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamental principles of analog and digital electronics.	Understand	Basic Concepts	Quizzes, Tests
CO2	Analyse different types of amplifiers and their applications.	Analyse	Applications	Homework Assignments

CO3	Design amplifier circuits based on given specifications.	Apply	Circuit Design	Laboratory Experiments
CO4	Analyse the operation of different types of FETs (JFETs, MOSFETs).	Analyse	Device Operation	Homework Assignments
CO5	Understand the operational principles of Operational Amplifiers (Op-amps).	Understand	Basic Concepts	Quizzes, Assignments
CO6	Analyse and design sequential logic circuits using state diagrams and flip-flops.	Analyse	Circuit Design	Laboratory Experiments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**TRANSISTOR AMPLIFIERS AND OSCILLATORS**	**12**	**20**
	1	Single Stage Transistor Amplifier	3	
	2	Multi stage amplifier	3	
	3	Feed Back	2	
	4	Advantages of negative feedback	1	
	5	Transistor Oscillators – Colpitt's, Hartley, Phase shift	3	
	Sections 10.1 – 10.6, 11.3 – 11.5, 13.1 – 13.6, 14.3 – 14.7, 14.10 – 14.13 of Book 1			
II		**FIELD EFFECT TRANSISTORS**	**10**	**15**
	6	Types of FET	1	
	7	Principle and working of JFET	2	

	8	Difference Between JFET and BJT	1	
	9	JFET amplifier	2	
	10	Output Characteristics of JFET	2	
	11	MOSFET	2	
	Sections 19.1 – 19.12, 19.27 – 19.28 of Book 1			
III	**OPERATIONAL AMPLIFIERS**		**12**	**20**
	12	Differential Amplifier	3	
	13	OP-Amp	2	
	14	OP-Amp with Negative Feedback	3	
	15	Summing Amplifiers	2	
	16	Integrator and Differentiator	2	
	Sections 25.1 – 25.5, 25.7, 25.8, 25.15 – 25.17, 25.22 – 25.27, 25.32 – 25.37 of Book1			
IV	**DIGITAL ELECTRONICS**		**11**	**15**
	17	Basic Logic Gates (26.11-26.14)	2	
	18	Combination of Logic Gates (26.15-26.17, 26.19)	1	
	19	Boolean Algebra and logic circuits(26.20-26.23)	2	
	20	Combinational logic circuits(26.24-26.30)	2	
	21	Electronic Adders (26.32)	1	
	22	Flip – Flops (26.33)	3	
	Sections 26.11 – 26.17, 26.19 – 26.30, 26.32, 26.33 of Book1			
V	**PRACTICALS**		**30**	

	Conduct any 6 experiments from the given list (4 experiments from 1-8 and 2 from 9-12) and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list.			
	1	**Study the frequency response of common emitter(CE) transistor amplifier.** ● Design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias. ● Analyse the frequency response, draw the curve and find the bandwidth, without feedback.		
	2	**Study the negative feedback in CE transistor amplifier.** ● Design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias. ● Determine the voltage gain with and without negative feedback. ● Repeat the analysis by changing the feedback fraction. ● Optional: Frequency response study may be repeated.		
	3	**Construction of LC oscillator (Hartley or Colpitt's)** ● Construct a LC oscillator (Hartley or Colpitt's) and measure the frequency using CRO/ExpEYES for different values of L and C. Compare with the theoretical values.		
	4	**Construction of phase shift oscillator** ● Construct a phase shift oscillator and measure the frequency using CRO/ExpEYES for different values of R and C. Compare with the theoretical values.		
	5	**Construction astable multivibrator using transistors.** ● Construct an astable multivibrator using transistors and and measure the frequency using CRO/ExpEYES for different values of R and C. Compare with the theoretical values.		
	6	**Construction astable multivibrator using IC 555.** ● Design an astable multivibrator of desired frequency (say 1000 Hz) and duty cycle (say 60%) using IC 555 and measure the frequency using CRO/ExpEYES. Compare with the theoretical values.		
	7	**Operational Amplifier –inverting, non inverting amplifier and voltage follower.** ● Design inverting and non inverting amplifiers of different voltage gain. ● Measure and verify the gain using CRO/ExpEYES. ● Construct a voltage follower and verify that the gain is unity.		

	8	**Operational Amplifier- adder, subtractor** ● Design arithmetic circuits(adder and subtractor) using OP AMP, with two input voltages and measure the result using multimeter/CRO/ExpEYES.		
	9	**Digital electronics** **Construction of basic gates using diodes (AND, OR) & transistor (NOT)** ● Realize the logic AND and OR gates using diodes and NOT gate using a transistor and verify the truth table. Logic output can be checked using a multimeter or LED.		
	10	**Construct Half adder using universal gates and study the operation.** ● Implement half adder using NAND/NOR gates and verify the truth table for each input/output combination.		
	11	**Verification of De-Morgan's Theorems using basic gates.** ● Realize the either side of the De-Morgan's Theorems using gates from appropriate ICs and verify the truth table for each input/output combination.		
	12	**To construct and study the operations of the RS and JK Flip-Flops using IC's** ● Realize RS Flip-Flop using NAND gates and verify the truth table ● Realize JK Flip-Flop using NAND gates from appropriate ICs and verify the truth table		

Books and References:

1. Principles of Electronics by V K Mehtha and Rohith Mehtha (Book 1)
2. Electronic Devices and Circuit Theory by Robert L. Boylestad and Louis Nashelsky
3. Electronic Principles by Albert Malvino and David J. Bates
4. Analog Electronics: Devices, Circuits, and Techniques by Chitralekha Mahanta
5. Basic Electrical and Electronics Engineering by R.K. Rajput
6. Semiconductor Devices: Physics and Technology by S. M. Sze

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	3	0	2	1	0	2	1	2	0	2	2	1
CO 2	1	2	3	3	2	2	0	1	0	2	1	2	0
CO 3	2	1	2	2	1	1	2	1	2	1	0	1	1
CO 4	2	2	0	1	2	0	3	2	1	2	1	0	0
CO 5	2	0	2	2	1	2	2	0	1	1	2	1	0
CO 6	1	2	1	0	2	1	1	2	0	2	1	2	1

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">NUCLEAR AND PARTICLE PHYSICS</td></tr>
<tr><td>Type of Course</td><td colspan="5">Core in Major</td></tr>
<tr><td>Semester</td><td colspan="5">VI</td></tr>
<tr><td>Academic Level</td><td colspan="5">300 - 399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>4</td><td>-</td><td>-</td><td>60</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Strong foundation in classical mechanics, electromagnetism, quantum mechanics, and mathematics along with a basic understanding of modern physics concepts.</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course in nuclear and particle physics provides an in-depth exploration of the fundamental constituents of matter, their interactions, and the underlying principles governing nuclear structure, particle behavior, and their implications in theoretical and experimental physics.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamental principles of nuclear and particle physics.	Understand	Conceptual Knowledge	Quizzes, Tests

CO2	Analyse nuclear structure and properties, including nuclear forces and decay processes.	Analyse	Procedural Knowledge	Homework Assignments
CO3	Apply theoretical models to predict nuclear reactions and particle behavior.	Apply	Conceptual Knowledge	Problem Sets, Projects
CO4	Analyse the processes and mechanisms of radioactive decay.	Analyse	Procedural Knowledge	Homework, Exams
CO5	Describe the operation and components of particle accelerators.	Understand	Basic Concepts	Virtual lab Demonstrations
CO6	Analyse the principles and techniques of particle Detectors.	Analyse	Conceptual Knowledge	Problem Sets, Exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	**NUCLEAR PROPERTIES AND NUCLEAR MODELS**		**15**	**20**
	1	Introduction	1	
	2	Quantitative Facts About Nucleus	2	
	3	Binding Energy	2	
	4	Nuclear Angular Momentum; Nuclear Moments; Parity	3	
	5	Nuclear Force	1	
	6	Liquid Drop model	3	
	7	Shell Model	3	
	Sections 1.1 – 1.10 of chapter 1; sections 2.1 – 2.3 of chapter 2 of Book 1			

II		**RADIOACTIVITY**	**15**	**20**
	8	Introduction	1	
	9	Laws of Disintegration; Radioactive Series	3	
	10	Alpha Emission	3	
	11	Beta Decay	4	
	12	Gamma Decay	2	
	13	Artificial or Induced Radioactivity; Applications of Radioactivity	2	
	Sections 3.1, 3.2, 3.5 – 3.8 of Book 1			
III		**NUCLEAR REACTIONS**	**9**	**15**
	14	Nuclear Reaction Cross-section	1	
	15	Conservation Laws in Nuclear Reactions; Kinematics of Nuclear Reactions; Compound Nucleus	3	
	16	Nuclear Fission	2	
	17	Nuclear Fusion	2	
	18	Interaction of Gamma Rays with Matter	1	
	Sections 4.1, 4.3 – 4.8, 5.5 of Book 1			
IV		**PARTICLE PHYSICS**	**9**	**15**
	19	Types of Interactions	1	
	20	Classification of Elementary Particles	1	
	21	Quantum Numbers	2	
	22	Conservation Laws; Weak Decays of Strange Particles	3	
	23	Quarks; Qualitative Description of Quark Model	2	
	Sections 8.3, 8.4, 8.6 – 8.8, 8.10, 8.11of chapter 8 of Book 1			
V		**OPEN-ENDED MODULE: PARTICLE ACCELERATORS AND RADIATION DETECTORS**	**12**	
Books and References:				

1. Introduction to Nuclear and Particle Physics - V K Mittal, R C Verma and S C Gupta (Book 1)
2. Introductory Nuclear Physics by Kenneth S. Krane
3. Concepts of Modern Physics by Arthur Beiser
4. Nuclear and Particle Physics: An Introduction by Brian R. Martin and Graham Shaw
5. Nuclear and Particle Physics: An Introduction by S. N. Ghoshal and T. K. Basak
6. Nuclear Physics: Theory and Experiment by Raj Kumar Gupta

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO 3	PO 4	PO 5	P O6	PO 7
CO 1	2	2	3	2	0	2	2	1	2	2	0	2	2
CO 2	3	2	2	3	2	0	3	0	0	2	2	0	0
CO 3	3	3	3	2	0	2	2	2	1	0	2	1	2
CO 4	2	2	2	2	0	0	3	0	2	2	0	0	0
CO 5	2	3	2	2	1	3	1	2	0	2	1	2	2
CO 6	0	2	2	2	0	2	0	0	2	0	0	2	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**MATHEMATICAL PHYSICS**				
Type of Course	**Core in Major**				
Semester	**VII**				
Academic Level	**400 - 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Fundamentals of vectors, calculus and kinematics.				
Course Summary	This course explores Newton's Laws of Motion and how they can be applied to solve different mechanical systems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate proficiency in manipulating matrices and tensors algebraically and geometrically	Applying	Procedural Knowledge	Written exams, problem sets
CO2	Apply various transforms such as Fourier, Laplace, and Z-transforms to analyze signals and systems	Applying	Procedural Knowledge	Homework assignments, exams

CO3	Understand the properties and applications of special functions such as Bessel, Legendre, and Hermite functions	Understanding	Conceptual Knowledge	Class discussions, presentations
CO4	Solve differential equations using series solutions methods, including power series and Frobenius methods	Applying	Procedural Knowledge	Laboratory experiments, simulations
CO5	Analyze the behavior of complex functions, including their mappings and singularities, in the complex plane	Analyzing	Conceptual Knowledge	Projects, research papers
CO6	Utilize complex analysis techniques to solve problems in physics, engineering, and other applied fields	Applying	Procedural Knowledge	Design projects, presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**MATRICES AND TENSORS**	**11**	**17**
	1	Linear Combinations, Linear Functions, Linear Operators; Linear Dependence and Independence	2	
	2	Special Matrices and Formulas	1	
	3	Eigenvalues and Eigenvectors; Diagonalizing Matrices	2	
	4	Tensors: Introduction, Cartesian Tensors, Tensor Notation and Operations; Kronecker Delta and Levi-Civita Symbol, Pseudovectors and Pseudotensors	3	
	5	Curvilinear Coordinates and Metric Tensor; Vector operators in Orthogonal Curvilinear Coordinates	2	
	6	Non-cartesian Tensors	1	

	Sections 3.7 – 3.9, 3.11 of chapter 3, and sections 10.1 – 10.3, 10.5, 10.6, 10.8 – 10.10 of chapter 10 of Book 1 Self-study: Sections 3.1 – 3.6, 3.10, 3.12, 10.4, 10.7 of Book 1			
II	**FOURIER TRANSFORMS AND SPECIAL FUNCTIONS**		**11**	**17**
	7	Fourier Coefficients; Dirichlet Conditions; Complex Form of Fourier Series; Other Intervals	3	
	8	Fourier Series of Even and Odd Functions; Parseval's Theorem	1	
	9	Fourier Transforms, Parseval's Theorem for Fourier Integrals	2	
	10	Dirac Delta Function	2	
	11	Factorial Function; Gamma Function; Recursion Relation	1	
	12	Gamma Function of Negative Numbers; Some Important Formulas Involving Gamma Functions; Stirling's Formula	2	
	Sections 7.5 – 7.9, 7.11, 7.12 of chapter 7, sections 11.2 – 11.5, 11.11 of chapter 11 of Book 1 Self-study: Sections 7.1 – 7.4, 7.10, 8.8 – 8.11, 11.6 – 11.9 of Book 1			
III	**SERIES SOLUTIONS OF DIFFERENTIAL EQUATIONS**		**13**	**20**
	13	Introduction; Legendre's Equation; Legendre Polynomials; Rodrigues' Formula	3	
	14	Generating Function for Legendre Polynomials; Recursion Relations	2	
	15	Orthogonality and Normalization of Legendre Polynomials; Legendre Series	2	
	16	Associated Legendre Functions	1	
	17	Generalized Power Series (Method of Frobenius)	1	
	18	Bessel's Equation and Its Second Solution; Graphs and Zeros of Bessel Functions; Recursion Relations	3	
	19	Orthogonality of Bessel Functions	1	
	Sections 12.1, 12.2, 12.4, 12.5, 12.7 – 12.15, 12.19 of chapter 12 Book 1			

	Self-study: Sections 12.3, 12.6, 12.16, 12.17, 12.22 of Book 1			
IV	**COMPLEX FUNCTIONS**		**10**	**16**
	20	Introduction; Analytic Functions	2	
	21	Contour Integrals	2	
	22	Laurent Series	1	
	23	Residue Theorem; Methods of Finding Residues	2	
	24	Evaluation of Definite Integrals by the Use of Residue Theorem; Residues at Infinity	3	
	Sections 14.1 – 14.8 of chapter 14 of Book 1 Self-study: section 14.9 and 14.10 of Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	Using matrix inversion, solve the system of homogeneous linear equations.		
	2	Simulate and verify that the trace is unchanged after diagonalization.		
	3	Simulate the square wave, triangular wave and sawtooth wave using Fourier series (See section 5.12 of Book 2).		
	4	Simulate and analyzing periodic signals using Fourier transform.		
	5	Simulate the Bessel and Spherical Bessel functions.		
	6	Simulate the Legendre and Associated Legendre functions and Spherical harmonics.		
	7	Simulate the Laguerre and Associated Laguerre Polynomials.		
	8	Simulate the Hermite Polynomials.		

	9	Simulate the Airy Functions.		
	10	Simulate and solve differential equations by power series method.		

Books and References:

1. Mathematical Methods in the Physical Sciences (3rd Edition, Indian Adaptation, Wiley) by Mary L Boas (Book 1)
2. Mathematical Methods for Physics and Engineering by K F Riley, M P Hobson and S J Bence, 3rd edition
3. Mathematical Methods for Physicists by G.B Arfken and H J Weber (Academic Press)
4. Advanced Engineering Mathematics by Erwin Kreyzig (Wiley)
5. NPTEL video lectures: https://nptel.ac.in/courses/115106086
6. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from https://scischool.in/python/index.html

Mapping of COs with PSOs and POs :

	PSO 1	PS O2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	0	1	0	2	1	1	0	1	1	1	1	0
CO 2	0	0	3	0	2	1	1	0	1	1	1	1	0
CO 3	1	0	2	0	3	1	1	0	1	1	1	1	0
CO 4	0	1	3	0	2	1	1	0	1	1	1	1	0
CO 5	0	0	2	0	3	2	1	0	1	1	2	1	0
CO 6	1	0	3	1	2	2	1	0	1	1	2	1	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">CLASSICAL MECHANICS</td></tr>
<tr><td>Type of Course</td><td colspan="5">Core in Major</td></tr>
<tr><td>Semester</td><td colspan="5">VII</td></tr>
<tr><td>Academic Level</td><td colspan="5">400 - 499</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Strong foundation in introductory physics covering Kinematics, Dynamics and basic calculus, alongside a familiarity with vectors, Newton's laws of motion, and mathematical techniques such as differential and integral calculus.</td></tr>
<tr><td>Course Summary</td><td colspan="5">Exploring topics such as Lagrangian and Hamiltonian Mechanics, Variational principles and coupled oscillations, often incorporating advanced mathematical techniques like differential geometry and calculus of variations.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the principles of calculus of variations and its applications in finding extremals of functionals	Understanding	Conceptual Knowledge	Written exams, quizzes

CO2	Apply variational calculus techniques to solve problems involving optimization and constraint satisfaction	Applying	Procedural Knowledge	Problem sets, simulations
CO3	Analyze the Lagrangian formulation of classical mechanics and its equivalence to Newtonian mechanics	Analyzing	Conceptual Knowledge	Homework assignments, exams
CO4	Derive and interpret the Euler-Lagrange equation and its solutions for various physical systems	Analyzing	Procedural Knowledge	Class discussions, presentations
CO5	Formulate and solve Hamilton's equations of motion for dynamical systems in phase space	Applying	Procedural Knowledge	Laboratory experiments, projects
CO6	Investigate the behavior of coupled oscillators and their dynamics using analytical and numerical methods	Analyzing	Conceptual Knowledge	Research papers, presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**CALCULUS OF VARIATIONS**	**7**	**12**
	1	Introduction; Statement of the Problem	1	
	2	Euler Equations	2	
	3	The ‘Second Form’ of the Euler Equation	1	
	4	Functions with Several Dependent Variables; Euler Equations when Auxiliary Conditions are Imposed	2	

	5	The Delta Notation	1	
	Sections 6.1 – 6.7 of chapter 6 of Book 1			
II	**LAGRANGIAN DYNAMICS**		**13**	**20**
	6	Introduction; Hamilton's Principle	2	
	7	Generalized Coordinates	1	
	8	Lagrange's Equations of Motion in Generalized Coordinates	3	
	9	Lagrange's Equations with Undetermined Multipliers	2	
	10	Equivalence of Lagrange's and Newton's Equations	1	
	11	Essence of Lagrangian Dynamics	1	
	12	Conservation Theorems	3	
	Sections 7.1 – 7.9 of chapter 7 of Book 1			
III	**HAMILTONIAN DYNAMICS**		**17**	**25**
	13	Canonical Equations of Motion in Hamiltonian Dynamics	3	
	14	Dynamical Variables and Variational Calculus	2	
	15	Phase space and Liouville's Theorem	2	
	16	Virial Theorem	2	
	17	Canonical Transformations	2	
	18	Discovering Three New Forms of the Generating Function	2	
	19	Poisson Brackets	1	
	20	Hamilton – Jacobi Equation	3	
	Sections 7.10 – 7.13 of chapter 7 of Book 1; sections 6.1 – 6.4 of chapter 6 of Book 2			

IV	**COUPLED OSCILLATIONS**		**8**	**13**
	21	Introduction; Two Coupled Harmonic Oscillators; Weak Coupling	3	
	22	General Problem of Coupled Oscillations	2	
	23	Normal Coordinates	2	
	24	Molecular Vibrations	1	
	Sections 12.1 – 12.4, 12.6, 12.7 of chapter 12 of Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7^{th} experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	Mode constants of a vibrating strip. To determine the first and second mode constants of a steel vibrating strip; Y to be measured by the Cantilever method and frequency of vibration by the Melde's string method.		
	2	Simulate the orbits for various total energy in central force motion.		
	3	Simulate and verify Rutherford's scattering formula.		
	4	Simulate the Van der Pol oscillator and obtain the limit cycle.		
	5	Simulate and plot the phase space trajectory of a projectile.		
	6	Simulate and plot the phase space trajectory of a simple pendulum in and around the separatrix.		
	7	Simulate the two dimensional harmonic oscillation motion for various phase angles. By tuning the conditions obtain various Lissajous curves. (See section 3.3 of Book 1)		
	8	Simulate the motion (time dependence of position, velocity, energy, rate of loss of energy, etc.) of the damped harmonic oscillator (See section 3.5 of Book 1)		
	9	Simulate the response of linear oscillators to impulsive forcing functions (See section 3.9 of Book 1)		

Books and References:

1. Classical Dynamics of Particles and Systems by Stephen T Thornton and Jerry B.Marion, Fifth edition (Book 1)
2. Analytical Mechanics by Louis N Hand and Janet D Finch (Book 2)
3. A Student's Guide to Lagrangians and Hamiltonians by Patrick Hamill
4. A Student's Guide to Analytical Mechanics by John L Bohn
5. Classical Mechanics by N C Rana and P S Joag
6. Classical Mechanics by Herbert Goldstein, Charles P. Poole Jr. and John L. Safko
7. Classical Mechanics by John R. Taylor
8. Introduction to Classical Mechanics: With Problems and Solutions by David Morin
9. Classical Mechanics: Point Particles and Relativity by Walter Greiner
10. NPTEL video lectures: https://nptel.ac.in/courses/122106027
11. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from https://scischool.in/python/index.html

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PS O6	PO 1	PO 2	PO 3	PO 4	PO5	PO6	PO7
CO 1	2	0	1	0	2	1	1	0	1	1	1	1	0
CO 2	2	1	3	1	2	1	1	0	1	1	1	1	0
CO 3	2	0	3	0	2	1	1	0	1	1	1	1	0
CO 4	2	0	3	0	2	1	1	0	1	1	1	1	0
CO 5	2	1	3	1	2	1	1	0	1	1	1	1	0
CO 6	2	2	3	1	2	2	1	0	1	1	2	1	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**QUANTUM MECHANICS II**				
Type of Course	**Core in Major**				
Semester	**VII**				
Academic Level	**400 - 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Fundamental Physical and Mathematics Concepts of Quantum Mechanics				
Course Summary	Delves deeper into the mathematical formalism and theoretical principles of quantum theory, exploring topics such as advanced wave function theory, scattering theory, perturbation theory,etc.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate Proficiency in Solving Schrödinger Equation Problems in Spherical Polar Coordinates.	U, Ap	C, P	Instructor-created exams / Quiz
CO2	Analyze Angular Momentum Concepts and Apply Them to Quantum Systems.	An, Ap	C, P	Practical Assignment / Observation of Practical Skills
CO3	Construct and Interpret Eigenvalues and Eigenfunctions of Angular Momentum Operators	C, U	C, P	Seminar Presentation / Group Tutorial Work

CO4	Evaluate Perturbation Theory Techniques for Solving Quantum Mechanical Problems.	E	C, P	Instructor-created exams / Home Assignments
CO5	Critically Analyze Scattering Phenomena and Predict Experimental Outcomes.	An, E	C	One Minute Reflection Writing assignments
CO6	Synthesize Advanced Quantum Mechanical Concepts to Solve Complex Problems.	C	C, M	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**THE CENTRAL POTENTIAL**	**12**	**14**
	1	Schrodinger Equation in Spherical Polar Coordinates : Separation of variables, The angular equation and spherical harmonics.	5	
	2	The Radial Equation,	1	
	3	Infinite Spherical Well,	2	
	4	The Hydrogen Atom : Radial Wave Function, Spectrum of Hydrogen	4	
	Sections: 4.1, 4.2 and Example 4.1 of Book 1			
II		**ANGULAR MOMENTUM**	**13**	**20**
	5	Angular Momentum : Orbital angular momentum, General formalism of angular momentum	3	

	6	Matrix representation of angular momentum, Geometrical representation of angular momentum.	1	
	7	Eigenfunctions of Angola Momentum - Lz only.	1	
	8	Spin : Experimental evidence of spin, General theory of spin, spin ½ and Pauli matrices.	3	
	9	Addition of Angular Momenta : Addition of Two Angular Momenta General Formalism, Calculation of the Clebsch–Gordan Coefficients.	5	
	Sections: 5.1 – 5.7.1 and 7.3.1 – 7.3.2 of Book 2			
III		**APPROXIMATION METHODS**	**14**	**24**
	10	Non-degenerate Perturbation Theory: First-order and Second-order theory	2	
	11	Degenerate Perturbation Theory : Two-fold degeneracy, Higher-order degeneracy.	1	
	12	Zeeman effect: Weak-field Zeeman effect, Strong-field Zeeman effect	1	
	13	Intermediate field Zeeman effect	2	
	14	Stark Effect	1	
	15	The Variational Method: Theory	1	
	16	Example: 1D Harmonic Oscillator	1	
	17	WKB Approximation: WKB wavefunction in classical and non-classical (tunneling) region, Connection Formula.	3	
	18	Examples: Potential well with one vertical wall, Potential well with no vertical walls	2	
	Sections: 6.1, 6.2, 6.4, 7.1, Example - 7.1, 8.1, 8.2, 8.3, Examples - 8.3 and 8.4 of Book1			

IV		**SCATTERING**	**9**	**12**
	19	Classical Scattering Theory	1	
	20	Quantum Scattering Theory	1	
	21	Partial Wave Analysis: Formalism, Strategy, Phase Shifts	3	
	22	Born Approximation: Integral Form of Schrödinger Equation, First Born Approximation, Born Series.	4	
	Sections: 11.1, 11.2, 11.3, 11.4 of Book 1			
*Solved and unsolved problems of the relevant sections from the prescribed texts shall be discussed or given as assignment.				
V		**PRACTICALS**	**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	Photoelectric effect: Determination of Plank's constant.		
	2	Frank Hertz experiment: To measure the ionization potential of Mercury by drawing current versus applied voltage.		
	3	Elementary experiments using Laser: (a) Study of Gaussian nature of laser beam (b) Evaluation of beam spot size (c) Measurement of divergence (d) Diameter of a thinwire.		
	4	Zeeman effect using Fabry-Perot etalon.		
	5	ESR spectrometer - Determination of g factor		
	6	Thomson's e/m measurement - To determine charge to mass ratio of the electron by Thomson's method.		
	7	Millikan's oil drop experiment - To measure the charge on the electron.		
	8	Simulate the Particle in a one dimensional box		

	9	Simulate the Particle in a quadratic potential.		
	10	Simulate the Quantum mechanical Tunnel barrier problem- Study the variation of transmission probability with L, E, V, and m.		
	11	Simulate the Hydrogen wave functions (s, p, d,f) using 3D plots.		
	12	Simulate the formation of wave packets as function of number of mixing waves		

Books and References:

1. Introduction to Quantum Mechanics, David J Griffiths, 3ed Edition. (Book 1)
2. Quantum Mechanics Concepts and Applications, Nouredine Zettili, 2nd Edition (Book 2)
3. Modern Quantum Mechanics by J. J. Sakurai and Jim Napolitano
4. Principles of Quantum Mechanics by R. Shankar
5. Quantum Mechanics: A Modern Development by Leslie E. Ballentine
6. Quantum Mechanics: Non-Relativistic Theory by L. D. Landau and E. M. Lifshitz.
7. NPTEL video lectures: https://nptel.ac.in/courses/122106034
8. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from https://scischool.in/python/index.html

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	0	2	0	3	1	2	0	1	1	3	1	0
CO 2	3	2	3	0	3	2	2	0	1	1	3	1	0
CO 3	3	1	3	0	3	2	2	0	1	1	3	1	0
CO 4	3	0	3	0	2	1	3	0	1	1	3	1	0
CO 5	3	1	3	0	2	1	3	1	1	1	3	1	0
CO 6	3	0	2	0	3	1	3	0	1	1	3	1	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">STATISTICAL MECHANICS</td></tr>
<tr><td>Type of Course</td><td colspan="5">Core in Major</td></tr>
<tr><td>Semester</td><td colspan="5">VII</td></tr>
<tr><td>Academic Level</td><td colspan="5">400 – 499</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">A solid foundation in classical mechanics, quantum mechanics, and thermodynamics. Additionally, proficiency in calculus, differential equations, and linear algebra is essential for understanding the mathematical formalism used in statistical mechanics. A familiarity with probability theory and basic concepts of probability distributions can also be beneficial, as statistical mechanics involves the statistical analysis of large ensembles of particles to understand their collective behavior and properties.</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course on statistical mechanics explores the principles governing the collective behaviour of large systems of particles, utilizing probabilistic methods to understand thermodynamic properties and the microscopic origins of macroscopic phenomena.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concept of multiplicity	Understand	Conceptual Knowledge	Written exams, quizzes
CO2	Apply the second law of thermodynamics	Apply	Procedural Knowledge	Problem sets, lab experiments
CO3	Analyze changes in entropy in various systems	Analyze	Conceptual & Procedural Knowledge	Case studies, simulations
CO4	Utilize Boltzmann statistics in statistical mechanics	Apply	Conceptual & Procedural Knowledge	Problem-solving exercises, projects
CO5	Employ quantum statistics in understanding systems	Apply	Conceptual & Procedural Knowledge	Research papers, presentations
CO6	Evaluate thermodynamic variables in complex systems	Evaluate	Conceptual & Procedural Knowledge	Research projects, oral exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**MULTIPLICITY, ENTROPY AND THE SECOND LAW**	**11**	**16**
	1	Two-State Systems, the Two-State Paramagnet	2	

	2	The Einstein Model of a Solid	1	
	3	Interacting Systems, Large Systems, Stirling's Approximation	2	
	4	Multiplicity Function of a Large Einstein Solid and Its Sharpness	2	
	5	Multiplicity Function of a Monatomic Ideal Gas and Interacting Ideal Gases	2	
	6	Multiplicity and Entropy, Entropy of an Ideal Gas, Entropy of Mixing, Reversible and Irreversible Processes	2	
	Sections 2.1 – 2.6 of chapter 2 of Book 1			
II	**INTERACTIONS, CHANGE IN ENTROPY AND THERMODYNAMIC VARIABLES**		**10**	**16**
	7	Thermal Equilibrium and Temperature	2	
	8	Change in Entropy and Heat Capacity, Measuring Entropy, Macroscopic View of Entropy	2	
	9	Paramagnetism: Analytic Solution only (The numerical solution of this problem is included as one of the experiments)	2	
	10	Mechanical Equilibrium and Pressure, Entropy and Heat Revisited	2	
	11	Diffusive Equilibrium and Chemical Potential	2	
	Sections 3.1 – 3.6 of chapter 3 of Book 1			
III	**BOLTZMANN STATISTICS**		**10**	**16**
	12	The Boltzmann Factor, the Partition Function and Average Values	2	
	13	Paramagnetism Revisited Using the Partition Function	1	
	14	Equipartition Theorem	1	
	15	The Maxwell Speed Distribution	2	
	16	Partition Functions and Free Energy	1	

	17	Partition Functions for Composite Systems	1	
	18	Ideal Gas Revisited Using the Partition Function, Predictions	2	
	Sections 6.1 – 6.7 of chapter 6 of Book 1; Problems in chapters 5, 19 and 20 of Book 2			
IV	**QUANTUM STATISTICS**		**14**	**22**
	19	The Gibbs Factor	1	
	20	Bosons and Fermions, The Distribution Functions	2	
	21	Degenerate Fermi Gases: Zero Temperature, Small Nonzero Temperatures, The Density of States, Sommerfeld Expansion	3	
	22	Blackbody Radiation: The Ultraviolet Catastrophe, The Planck Distribution, Photons, Summing over Modes, The Planck Spectrum, Total Energy, Entropy of a Photon Gas, Cosmic Background Radiation, Photons Escaping through a Hole, Radiation from Other Objects, The Sun and the Earth	4	
	23	Debye Theory of Solids	2	
	24	Bose-Einstein Condensation, Real-World Examples, Why Does It Happen?	2	
	Sections 7.1 – 7.6 of chapter 7 of Book 1; Problems in chapters 21, 23, 24, 29 and 30 of Book 2			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	Variation of surface tension with temperature - Jaeger's method. To determine the surface tension of water at different temperatures by Jaegar's method of observing the air bubble diameter at the instant of bursting inside water.		

	2	Stefan’s constant - To determine Stefan’sconstant.		
	3	Thermal conductivity of liquid and air by Lee’s disc method.		
	4	Viscosity of a liquid - Oscillating disc method. To determine the viscosity of the given liquid by measurements on the time period of oscillation of the disc in air and in the liquid.		
	5	Measurement of the thermal and electrical conductivity of Cu to determine the Lorents number.		
	6	Curie Weiss law - To determine the Curie temperature.		
	7	Measurement of the thermal relaxation time constant of a serial lightbulb.		
	8	Simulate the time dependent positions of collection of particles, having initial random velocity distribution, confined to a one dimensional box (See section 2.1 in Book 3).		
	9	Simulate the Statistical behaviour of two Einstein solids, (Solid A contains 200 oscillators and solid B contains 300 oscillators) sharing a total 100 units of energy, that can exchange energy. Find the equilibrium of the systems (See section 3.1 in Book 1).		
	10	Simulate the entropy, temperature and heat capacity of an Einstein solid containing 50 oscillators (initially) and from 0 to 100 units of energy (See problem 3.24 in Book 1).		
	11	Simulate the statistical behaviour of two-state paramagnet (spin half system) (see section 3.2 in Book 1).		
	12	Simulate the statistical nature of the Boltzmann distribution by distributing quanta of energy in a lattice of size 20*20 and plotting the histogram. Track the variation of the number of microstates (see example 4.2 in Book 2).		
	13	Simulate the statistics of occupation number (distribution function) of an ideal, quantum mechanical, non interacting i) Maxwell-Boltzmann ii) Bose-Einstein and iii) Fermi-Dirac systems.		
	14	Simulate the temperature dependent average energy per particle of an n-level system in thermal equilibrium at various temperatures for n = 2, 3, 4, 10 and 30 or higher. Use a normalized axis for comparison and draw the conclusions (see example 20.3 in Book 2).		
	15	Simulate the temperature dependent heat capacity per particle of an n-level system in thermal equilibrium at various temperatures for n = 2, 3, 4, 10 and 30 or higher values. Use a normalized axis for comparison and draw the conclusions (see example 20.3 in Book 2).		

	16	Simulate the temperature dependent average energy, entropy and heat capacity of the harmonic oscillator in thermal equilibrium at various temperatures. Use a normalized axis for comparison and draw the conclusions (see example 20.3 in Book 2).		
	17	Simulate the temperature dependence of fermi energy. Also simulate the dependence of number density and temperature on ground state pressure of an ideal fermi system.		
	18	Simulate the black body radiation spectra for three different temperatures and demonstrate the Wein's displacement law and Stefan's law (see section 23.6 in Book 2).		
	19	Simulate the temperature dependent heat capacity of an ideal Bose in the temperature range from 0 K to a high temperature four times the Bose-Einstein condensation temperature . Use a normalized axis for comparison and bring out the feature of Bose-Einstein condensation.		
	20	Simulate the temperature dependent pressure of an ideal Bose in the temperature range from 0 K to a high temperature four times the Bose-Einstein condensation temperature. Use a normalized axis for comparison and bring out the feature of Bose-Einstein condensation.		
	21	Simulate the behaviour of a quantum mechanical paramagnetic system as a function of B/T for systems with spins half to infinity (classical limit).		

Books and References:

1. Introduction to Thermal Physics (Oxford Edn., 2021) by Daniel V Schroeder (Book 1)
2. Concepts in Thermal Physics (Oxford Edn., 2006) by Stephen J Blundell and Katherine M. Blundell (Book 2)
3. Thermal Physics Tutorials with Python Simulations (CRC Press, 2023) by Minjoon Kouh and Taejoon Kouh
4. Fundamentals of Statistical and Thermal Physics by Frederick Reif
5. Statistical Mechanics by R.K. Pathria and Paul D. Beale
6. Equilibrium Statistical Physics by Michael Plischke and Birger Bergersen
7. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from https://scischool.in/python/index.html

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO 3	PSO 4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	1	1	0	3	1	2	1	1	1	3	1	0
CO 2	3	2	2	0	3	1	2	1	1	1	3	1	0
CO 3	3	2	3	0	3	1	2	1	1	1	3	1	0
CO 4	3	1	3	1	3	1	3	1	1	2	3	1	1
CO 5	3	1	3	1	3	1	3	1	1	2	3	1	1
CO 6	3	0	3	1	2	1	3	0	1	2	3	1	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**Electronics III**				
Type of Course	**Core in Major**				
Semester	**VII**				
Academic Level	**400 – 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	PHY2CJ101- Electronics I and PHY6CJ305- Electronics II				
Course Summary	Exploration of cutting-edge concepts and methodologies in digital and analog electronics, delving into advanced topics such as high-frequency circuit design, mixed-signal systems, and emerging semiconductor technologies.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamental principles of analog and digital electronics.	Understand	Basic Concepts	Quizzes, Tests

CO2	Analyse different types of amplifiers and their applications.	Analyse	Applications	Homework Assignments
CO3	Design amplifier circuits based on given specifications.	Apply	Circuit Design	Laboratory Experiments
CO4	Analyse the operation of different types of FETs (JFETs, MOSFETs).	Analyse	Device Operation	Homework Assignments
CO5	Understand the operational principles of Operational Amplifiers (Op-amps).	Understand	Basic Concepts	Quizzes, Assignments
CO6	Analyse and design sequential logic circuits using state diagrams and flip-flops.	Analyse	Circuit Design	Laboratory Experiments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**BJT AND FET FREQUENCY RESPONSE**	**12**	**18**
	1	Decibels and general frequency considerations	3	
	2	Low frequency analysis: BJT and FET amplifiers - Bode plots	4	
	3	High frequency response – Miller effect capacitance	3	
	4	Multistage frequency effects and square wave testing	2	
	Sections 11.3 – 11.11of Book1			

II		**APPLICATIONS OF OPERATIONAL AMPLIFIERS**	**10**	**16**
	6	Operational amplifier frequency responses - bode plot analysis	2	
	7	Filters - active low pass, high pass and band pass Butterworth filters, band pass filter with multiple feedback, notch filter.	3	
	8	Oscillators - Wien bridge oscillator, Astable and monostable multivibrators, Schmitt triggers	2	
	9	OPAMP as inverter, scale changer, summer, V to I converter	1	
	10	Integrator and Differentiator	2	
	Relevant Sections from Book 2			
III		**DIGITAL ELECTRONICS**	**18**	**23**
	12	Minimization of Boolean functions using Karnaugh map and representation using logic gates	4	
	13	Flip flops and registers: JK and MS JK and D flip-flops, shift registers using D and JK flip flops and their operations	5	
	14	Counters: shift registers as counters, ring counter, design of synchronous and asynchronous counters, state diagram, cascade counters	6	
	15	Memory: basic idea of static and dynamic RAM, basics of charge coupled devices	2	
	16	R-2R ladder D/A converter	1	
	Relevant Sections from Book 3			
IV		**MICROPROCESSORS AND MICROCONTROLLERS**	**5**	**13**
	17	Introduction to 8 bit microprocessor, internal architecture of Intel 8085 register organisation	2	

	18	Microcontrollers and embedded systems	1	
	19	AVR architecture: General purpose registers and data memory (no coding required)	2	
	Relevant Sections from Book 4			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	Design and construct OPAMP based summing and averaging amplifiers for three suitable inputs. Compare the designed and observed outputs.		
	2	Design and construct an astable multivibrator using OPAMP for suitable frequencies.		
	3	Design and construct a monostable multivibrator using OPAMP for suitable pulse widths.		
	4	Design and construct OPAMP based precision half and full wave rectifiers. Observe the o/p on CRO and study the circuit operation.		
	5	Design and construct a voltage controlled oscillator using timer IC 555. Study the performance.		
	6	Design and construct a narrow band-pass filter for a given centre frequency using a single OPAMP with multiple feedback. Study the frequency response.		
	7	Design and construct a two stage I.F amplifier circuit. Study the frequency response of single and coupled stages.		

	8	Design and construct a differential amplifier using transistors. Study frequency response and measure i/p, o/p impedances. Also measure CMRR of the circuit.		
	9	Design and construct a d.c voltage regulator using transistors and Zener diodes. Study the line and load regulation characteristics for suitable o/p voltage and maximum load current.		
	10	Design and construct a Wien bridge oscillator using OPAMP for different frequencies. Comparedesignedand observed frequencies.		
	11	Design and construct a triangular wave generator using OPAMPs for different frequencies.		
	12	Design and construct Schmidt triggers using OPAMPS - for symmetrical and non-symmetrical LTP/UTP. Trace hysteresis curve.		
	13	4 bit D/A converter using R-2R ladder network. Realization of 4 bit A/D converter using D/A converter.		
	14	Design and construct a 3 bit binary to decimal decoder using suitable logic gates. Verify the operation.		
	15	Study of 4 bit binary counter (IC 7493) and 4 bit decade counter (IC 7490) in various modes. Use the counters as frequency dividers.		
	16	Set up a four bit shift register IC 7495 and verify right shift and left shift operations for different data inputs.		
	17	Design and construct Second order Butterworth Low pass, High Pass and Band Pass filters using OPAMPs. Study the performance in each case.		
	18	a). Design and construct OPAMP based circuit for solving a second order differential equation. Study the performance. b). Design and construct OPAMP based circuit for solving a simultaneous equation. Study the performance.		

	19	Design and construct a Darlington pair amplifier using medium power transistors for a suitable output current. Study the frequency response of the circuit and measure the i/p and o/p impedances.		
	20	a) Study the V-I characteristics of a JFET. Determine pinch-off voltage, saturation drain current and cut-off voltage of the device. b) Design and construct a low frequency common source amplifier using JFET. Study the frequency response, measure the i/p and o/p impedances.		

Books and References:

1. Electronic devices and circuit theory by Robert Boylestad and Louis Nashelsky (Book 1)
2. OPAMPS and Linear Integrated Circuits by Ramakant A. Gaykwad (Book 2)
3. Fundamentals of Microprocessors and Microcomputers by B. Ram (Book 3)
4. The AVR microcontroller and embedded systems using assembly and C (Book 4)
5. Electronics Lab Manual Vol 1 and 2 by K. A. Navas

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO 4	PSO 5	PSO 6	PO 1	PO2	PO3	PO 4	PO 5	PO 6	PO 7
CO 1	3	1	0	0	3	1	2	1	1	0	3	1	0
CO 2	3	2	2	0	2	1	2	1	1	0	3	1	0
CO 3	3	2	3	1	2	1	2	1	2	0	3	1	0
CO 4	3	2	2	0	2	1	2	1	1	1	3	1	0
CO 5	3	1	1	0	3	1	2	1	1	0	3	1	0
CO 6	3	2	3	1	1	2	2	1	2	0	3	1	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**SOLID STATE PHYSICS**				
Type of Course	**Core in Major**				
Semester	**VIII**				
Academic Level	**400 - 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	The prerequisites for a course in solid state physics typically include a strong foundation in classical mechanics, electromagnetism, quantum mechanics, thermodynamics and statistical mechanics, and optionally solid state chemistry, along with recommended physics laboratory experience				
Course Summary	In a course on solid state physics, students delve into the fundamental principles governing the behavior of matter in its solid phase, exploring topics such as crystal structures, electronic properties, thermal properties, magnetic phenomena, and their applications, with an emphasis on understanding the microscopic origins of macroscopic properties and phenomena observed in solid materials.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the principles of crystal structures and their classification schemes	Understanding	Conceptual Knowledge	Written exams, quizzes
CO2	Analyze the electronic band structure of solids and its implications for electrical conductivity	Analyzing	Procedural Knowledge	Problem sets, simulations
CO3	Explain the principles of quantum mechanics as applied to solid state systems	Understanding	Conceptual Knowledge	Class discussions, presentations
CO4	Predict and interpret the thermal properties of solids using statistical mechanics	Applying	Conceptual Knowledge	Laboratory experiments, projects
CO5	Investigate the magnetic properties of materials based on their atomic and electronic structures	Analyzing	Procedural Knowledge	Research papers, presentations
CO6	Apply solid state physics principles to real-world applications such as semiconductor devices	Applying	Procedural Knowledge	Case studies, group projects
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**CRYSTAL STRUCTURE AND BINDING**	**13**	**20**
	1	Periodic array of atoms, fundamental types of lattices	2	
	2	Index systems for crystal planes, simple crystal structures	2	
	3	Diffraction of waves by crystals, scattered wave amplitude, Brillouin zones	4	

	4	**Crystal binding:** Crystals of inert gas, ionic crystals, covalent crystals, metals,	3	
	5	Hydrogen bonds	2	
	Pages 3 – 18, 27 – 40, 51 – 72 of Book 1			
II	**FREE ELECTRON THEORY AND BAND THEORY**		**13**	**20**
	6	Free electron Fermi gas: Energy levels in 1D, Effect of temperature on FD distribution	3	
	7	Free electron gas in 3D, heat capacity of electron gas	2	
	8	Electrical conductivity and Ohm's law, motion in magnetic field	2	
	9	Thermal conductivity of metals	2	
	10	Energy bands: nearly free electron model	2	
	11	Bloch equations, Kronig Penney model	2	
	Pages 135-159, 165-171 of Book 1			
III	**SEMICONDUCTOR AND SUPERCONDUCTIVITY**		**12**	**20**
	12	Band gap, equations of motion	2	
	13	Intrinsic carrier concentration	2	
	14	Impurity conductivity	2	
	15	Introduction to superconductivity, Sources of superconductivity, Response of magnetic field, Meissner effect	2	
	16	Origin of band gap, Isotope effect	1	
	17	Elements of BCS theory	1	
	18	Normal tunnelling and Josephson effect, High Tc superconductivity	2	

	Pages 189 – 216, Chapter 8 of Book 1 Sections 17.1 – 17.4, 17.6, 17.7, 17.11, 17.13, 17.14 of Book 2			
IV	**CRYSTAL VIBRATIONS AND THERMAL PROPERTIES**		**7**	**10**
	19	Vibrations of crystals with monatomic basis, First Brillouin zone	2	
	20	Group velocity, Long wavelength limit	1	
	21	Two atoms per primitive basis, quantisation of elastic waves	2	
	22	Phonon heat capacity (qualitative idea only) mention Debye and Einstein model	2	
	Respective Sections of chapter 4 and 5 of Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	Y and σ-Interference Method (a) elliptical (b) hyperbolic fringes. To determine Y and σ of the material of the given specimen by observing the elliptical and hyperbolic fringes formed in an interference setup.		
	2	Y & σ by Koenig's method.		
	3	Dielectric constant by Lecher wire - To determine the wavelength of the waves from the given RF oscillator and the dielectric constant of the given oil by measurement of a suitable capacitance by Lecher wire setup.		
	4	Constants of a thermocouple and temperature of inversion.		
	5	Susceptibility measurement by Quincke's and Guoy's methods - Paramagnetic susceptibility of salt and specimen.		
	6	Conductivity, Reflectivity, sheet resistance and refractive index of thin films.		
	7	Hall effect in semiconductors - To determine the carrier concentration in the given specimen of semiconducting material.		

	8	Absorption spectrum of KMnO4 and Iodine - To determine the wavelength of the absorption bands of KMnO4 and to determine the dissociation energy of iodine molecules from its absorption spectrum.		
	9	Ionic conductivity of KCl / NaCl crystals.		
	10	To study the Thermoluminescence of F-centres of Alkali Halides.		
	11	Variation of dielectric constant with temperature of a ferroelectric material (BariumTitanate) .		
	12	Dielectric constant of a non polar liquid.		
	13	Ultrasonic interferometer - To determine the velocity and compressibility of sound in liquids.		
	14	Band gap energy of Ge by four probe method - To study bulk resistance and to determine band gap energy.		
	15	Determination of Band gap energy of Ge and Si using diodes.		
	16	Thermionic work function - To determine the thermionic work function of the material of the cathode of the given vacuum diode/triode from the characteristic at different filament currents.		
	17	Simulate the temperature dependent heat capacity of different metals/solids with known Debye temperatures, such as Pb (\Theta_D = 88 K), Gd (\Theta_D = 169 K), Ag (\Theta_D = 215 K) and KCl (\Theta_D = 308 K), in thermal equilibrium at various temperatures using the Debye Model. Use a normalized axis for comparison and draw the conclusions (see example 24.2 in Book 3).		
	18	Simulate the density of states (degeneracy) of a one dimensional, two dimensional and three dimensional non interacting system (See section 6.2 in Book 4)		
	19	Simulate the equation of state (isotherms) for a van der Waals gas (see section 26.1 in Book 3).		
	20	Simulate the temperature dependent heat capacity of free electron gas for various electronic number density (See page 141, chapter 6 of Book 1).		
	21	Simulate the phonon dispersion relation in a solid		
	22	Simulate the response function, amplitude and average energy as function of driving frequency for a damped harmonic oscillator for various damping (see example 33.5 in Book 3).		

	23	Simulate the solution of the Kronig-Penney model for periodic potential in solid.		
	24	Simulate the electrical conductivity and hole concentration as a function of electron concentration for a semiconductor at a fixed temperature for np = constant (See page 214, chapter 8 of Book 1).		

Books and References:

1. Introduction to Solid State Physics by Charles Kittel; Wiley India Edition (Book 1)
2. Solid State Physics: Structure and properties of materials by M.A.Wahab (Third Edition)
3. Concepts in Thermal Physics (Oxford Edn., 2006) by Stephen J Blundell and Katherine M. Blundell.
4. Thermal Physics Tutorials with Python Simulations (CRC Press, 2023) by Minjoon Kouh and Taejoon Kouh.
5. Solid State Physics by Neil W. Ashcroft and N. David Mermin.
6. Solid State Physics: Essential Concepts by David W. Snoke.
7. The Oxford Solid State Basics by Steven H. Simon.
8. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely. downloadable from https://scischool.in/python/index.html

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	0	0	3	1	3	1	1	0	3	1	0
CO 2	3	2	2	0	3	1	3	1	1	1	3	1	0
CO 3	3	0	1	0	3	1	3	1	1	0	3	1	0
CO 4	3	2	2	1	3	1	3	1	1	1	3	1	0
CO 5	3	2	2	0	3	2	3	1	1	1	3	1	0
CO 6	3	1	3	2	3	2	3	2	2	1	3	1	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**SPECTROSCOPY**				
Type of Course	**Core in Major**				
Semester	**VIII**				
Academic Level	**400 – 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Strong foundation in atomic structure, chemical bonding and electromagnetic radiation and also require knowledge of quantum mechanics.				
Course Summary	The molecular spectroscopy course covers the principles, techniques, and applications of analysing molecular structures and dynamics using various spectroscopic methods.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the principles of molecular spectroscopy	Comprehension	Conceptual	Written exams, quizzes
CO2	Apply spectroscopic techniques to analyse molecules	Application	Procedural	Laboratory reports, projects

CO3	Interpret spectroscopic data accurately	Analysis	Procedural	Problem sets, case studies
CO4	Critically evaluate the limitations of spectroscopic methods	Evaluation	Conceptual	Research papers, presentations
CO5	Demonstrate proficiency in spectral interpretation	Synthesis	Procedural	Oral exams, practical exams
CO6	Relate spectroscopic theory to real-world applications	Application	Conceptual	Research projects, case studies
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**MICROWAVE AND INFRARED SPECTROSCOPY**	**13**	**18**
	1	The spectrum of non rigid rotator, e.g. of HF, spectrum of symmetric top molecule e.g. of CH_3Cl	3	
	2	Instrumentation for Microwave Spectroscopy Stark Modulator, Information derived from Rotational Spectrum	2	
	3	IR Spectroscopy: Born-Oppenheimer approximation	3	
	4	Effect of Breakdown of Born-Oppenheimer approximation	1	
	5	Normal modes and vibration of H_2O and CO_2	2	
	6	Instrumentation for I R Spectroscopy - Fourier transformation I R Spectroscopy	2	
	Sections 6.6, 6.7, 6.8, 6.9, 6.11, 6.13, 6.14, 7.1 – 7.71, 7.12, 7.15, 7.16, 7.17, 7.18 of Book 1			

II		**RAMAN SPECTROSCOPY**	**11**	**12**
	7	Rotational Raman Spectrum of Symmetric top molecules, e.g. of $CHCl_3$	3	
	8	Combined use of Raman & IR Spectroscopy in structure determination e.g. of CO_2 and NO_3	2	
	9	Instrumentation for Raman Spectroscopy	2	
	10	Non-linear Raman effects, Hyper Raman effect	2	
	11	Stimulated Raman effect and Inverse Raman Effect	2	
	Sections 8.32, 8.4, 8.5, 8.6, 8.7, 8.10, 15.1, 15.2, 15.3, 15.4 of Book1			
III		**ELECTRONIC SPECTROSCOPY OF MOLECULES**	**10**	**16**
	12	Vibrational Analysis of band systems	2	
	13	Deslander's table, Progressions & sequences	2	
	14	Information Derived from vibrational analysis	2	
	15	Franck Condon Principle, Rotational fine structure and P Q and R Branches	2	
	16	Fortrat Diagram, Dissociation Energy, Example of Iodine molecule	2	
	Sections 9.1 – 9.9 of Book 1			
IV		**SPIN RESONANCE SPECTROSCOPY**	**14**	**24**
	17	Interaction of nuclear spin and magnetic field, level population Larmour precession, Resonance Conditions	2	
	18	Bloch equations, Relaxation times, Spin-spin and spin lattice relaxation	3	
	19	The chemical shift, Instrumentation for NMR spectroscopy	2	

	20	Electron Spin Spectroscopy of the unpaired e, Total Hamiltonian, Fine structure, Electron Nucleus coupling and hyperfine spectrum.	3	
	21	Mossbauer Spectroscopy, Resonance fluorescence of γ-rays, Recoilless emission of γ-rays and Mossbauer effect	2	
	22	Chemical shift, effect of magnetic field. Eg. of Fe_{57}	2	
	Sections 10.1 – 10.9, 11.1 – 11.5.4, 13.1 – 13.5 of Book 1			
V	**OPEN ENDED MODULE: ATOMIC SPECTROSCOPY**			

Books and References:

1. Molecular structure and Spectroscopy by G. Aruldas (Book 1)
2. Principles of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash
3. Spectra of Atoms and Molecules by Peter F. Bernath
4. Molecular Spectroscopy by Jeanne L. McHale
5. Molecular Quantum Mechanics by Peter W. Atkins and Ronald S. Friedman
6. Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy by Daniel C. Harris and Michael D. Bertolucci

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	0	0	3	1	3	1	1	0	3	1	0
CO 2	3	2	1	0	3	1	3	1	1	1	3	1	0
CO 3	3	2	1	0	3	1	3	1	1	1	3	1	0
CO 4	3	2	2	0	3	1	3	2	1	1	3	1	0
CO 5	3	2	1	0	3	2	3	2	2	1	3	1	0
CO 6	3	1	2	1	3	2	3	2	1	1	3	1	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**ELECTRODYNAMICS III**				
Type of Course	**Core in Major**				
Semester	**VIII**				
Academic Level	**400-499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Electrodynamics I and II				
Course Summary	Students explore the intricate theoretical foundations and advanced applications of electromagnetism, delving into topics such as Maxwell's equations, electromagnetic waves, electromagnetic field theory, relativistic electrodynamics, and their applications in modern physics and engineering.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate mastery of Maxwell's equations and their applications in various contexts	Applying	Procedural Knowledge	Written exams, problem sets

CO2	Analyze electromagnetic wave propagation and interaction with matter using advanced mathematical techniques	Analyzing	Procedural Knowledge	Homework assignments, exams
CO3	Explain the physical significance of electromagnetic potentials and gauge transformations	Understanding	Conceptual Knowledge	Class discussions, presentations
CO4	Predict and interpret the behavior of electromagnetic fields in complex geometries and boundary conditions	Analyzing	Procedural Knowledge	Laboratory experiments, simulations
CO5	Apply relativistic electrodynamics principles to describe electromagnetic phenomena in the context of special relativity	Applying	Procedural Knowledge	Projects, research papers
CO6	Design and analyze advanced electromagnetic systems and devices, demonstrating creative problem-solving skills	Creating	Procedural Knowledge	Design projects, presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	**CONSERVATION LAWS AND ELECTROMAGNETIC WAVES**		**12**	**18**
	1	The Continuity Equation	1	

	2	Poynting's Theorem	1	
	3	Newton's Third Law in Electrodynamics	1	
	4	Conservation of Momentum, Angular Momentum	2	
	5	Magnetic Forces Do No Work	1	
	6	Electromagnetic Waves in Matter – Reflection and Transmission (Normal and Oblique Incidence)	3	
	7	Electromagnetic Waves in Conductors; Reflection at a Conducting Surface	1	
	8	The Frequency Dependence of Permittivity	2	
	Sections 8.1.1, 8.1.2, 8.2.1, 8.2.3, 8.2.4, 8.3, 9.3.2, 9.3.3, 9.4.1 – 9.4.3 of Book 1			
II	**POTENTIALS AND FIELDS**		**12**	**18**
	9	Scalar and Vector Potentials; Gauge Transformations	2	
	10	Coulomb and Lorenz Gauge; Lorentz Force Law in Potential Form	2	
	11	Retarded Potentials, Jefimenko's Equations	2	
	12	The Lienard – Wiechert Potentials; Fields of a Moving Point Charge	3	
	13	Multipole Expansion of the Scalar and Vector Potentials	3	
	Sections 10.1 – 10.3, 3.4.1 – 3.4.4, 5.4.3 of Book 1			
III	**RADIATION**		**8**	**12**
	14	What is Radiation; Electric Dipole Radiation	3	
	15	Magnetic Dipole Radiation; Radiation from an Arbitrary Source	3	
	16	Power Radiated by a Point Charge – Larmor and Lienard Formulae	2	

	Sections 11.1.1 – 11.2.2 of chapter 11 of Book 1			
IV	**ELECTRODYNAMICS AND RELATIVITY**		**16**	**22**
	17	Review of Special Theory of Relativity	2	
	18	The Structure of Space-Time; Relativistic Mechanics – Proper Time and Proper Velocity, Relativistic Energy and Momentum, Relativistic Dynamics	4	
	19	Magnetism as a Relativistic Phenomenon	2	
	20	How the Fields Transform	2	
	21	The Field Tensor	2	
	22	Electrodynamics in Tensor Notation	2	
	23	Relativistic Potentials	2	
	Review of sections 12.1.1 – 12.1.3; sections 12.1.4, 12.2.1, 12.2.2, 12.2.4 , 12.3.1 – 12.3.5 of chapter 12 of Book 1			
V	**Open-Ended Module: WAVEGUIDES AND TRANSMISSION LINES**		**12**	

Books and References:

1. Introduction to Electrodynamics, 5th Edn. by David J Griffiths; Prentice Hall India Learning Pvt. Ltd (Book 1)
2. Classical Electrodynamics by John David Jackson
3. Electrodynamics by Georgi V. Shilov
4. Principles of Electrodynamics by Melvin Schwartz
5. Electromagnetic Fields and Waves by Vladimir Rojansky
6. Electromagnetic Waves by David H. Staelin, Ann W. Morgenthaler, and Jin Au Kong

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	3	1	2	1	3	1	1	1	3	2	1

CO 2	3	3	3	1	2	1	3	1	1	1	3	2	1
CO 3	3	1	2	0	3	1	3	1	1	0	3	2	1
CO 4	3	3	3	2	2	2	3	1	1	1	3	2	1
CO 5	3	2	2	1	3	1	3	1	1	1	3	2	2
CO 6	2	2	3	3	1	3	3	1	2	1	3	2	2

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignmen t / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**PRINCIPLES OF RESEARCH METHODOLOGY**				
Type of Course	**Core in Major**				
Semester	**VIII**				
Academic Level	**400 - 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Major courses in first 6 semester				
Course Summary	This course equips students with the critical thinking skills and scientific methods to distinguish facts, design experiments, and analyze research.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Distinguish between scientific facts, generalizations, and pseudo-science, understanding the social nature of scientific	U	C	Instructor-created exams / Quiz

	activity and its role in democratic development.			
CO2	Critically evaluate the limitations of science, including its underlying assumptions and challenges in defining reality and rationality.	E	P	Instructor-created exams / Quiz
CO3	Explain the key concepts of description, causality, prediction, and explanation in science, along with the role of mathematics in scientific endeavors.	U	C	Instructor-created exams / Quiz/Viva
CO4	Differentiate between hypotheses, theories, and laws, critically evaluating the processes of verification, falsification, acceptance, and peer review in the scientific method.	An	P	Instructor-created exams / Home Assignments
CO5	Apply principles of measurement, including operationalization (variables and indicators), to scientific research. Students will be able to evaluate the validity, reliability, and reproducibility/replicability of measurements and identify potential sources of error.	Ap	P	Home Assignments
CO6	Design and analyze experiments, understanding the roles and limitations of experimentation, including natural, manipulative, and comparative approaches. Students will be able to assess the validity and reliability of experiments using appropriate epistemological strategies.	C	M	Seminar/Viva
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**METHODOLOGY OF SCIENCE**	**15**	**25**
	1	Science as facts, science as generalization, Some distinctions when describing science	3	
	2	Science as a social activity, scientific revolutions and paradigms	2	
	3	Science and pseudo-science	1	
	4	Science and democratic development		
	5	The limitations of science-presuppositions, fundamental questions on reality, Rationality	2	
	6	Description, Causality, Prediction and Explanation in science -	2	
	7	Mathematics and science	1	
	8	Hypothesis, Theories and laws	2	
	9	Verification, Falsification, Acceptance, Peer Review in Science - Scientific method	2	
		Sections 2.2.1 – 2.2.5, 2.3.1, 2.4.1, 2.5.1 – 2.5.4, 2.6.1 – 2.6.4, 2.8.1 – 2.8.4, 3.1 – 3.3, 4.1 – 4.4, 7.1 of Book 1		
II		**MEASUREMENT**	**9**	**15**

	10	Processes, Instruments and Operationalization, Operationalization (Variables and Indicators),	3	
	11	Criteria in Measurement, Validity, Reliability, Reproducibility/Replicability	3	
	12	Measurement Error, Potential Sources of Measurement Error, Random and Systematic Errors	3	
	Sections 5.2.1 – 5.2.2, 5.2.3 of Book 1			
III	**EXPERIMENTATION**		**12**	**15**
	13	The Roles and Limitations of Experimentation	2	
	14	Natural Experiments, Manipulative Experiments, Comparative Experiments	3	
	15	Experimentation and Research, Conducting Experiments	2	
	16	Validity and Reliability in Experimentation, Epistemological Strategies	3	
	15	Design of Experiments	2	
	Sections 6.1.1 – 6.1.2, 6.1.3, 6.2, 6.3, 6.4 of Book1			
IV	**SCIENTIFIC METHOD AND DESIGN OF RESEARCH**		**12**	**15**
	17	The Scientific Method, Research Design, Components,	2	
	18	Research Design and Proposal, Purpose of Proposal, Proposal Structure	3	
	19	Conceptual Framework (or Literature Review)	2	
	20	Research Questions/Hypotheses	1	
	21	Methods/Methodology	2	

	22	Validity, Concluding sections to proposal	2	
	Sections 7.1 – 7.2, 7.2.1, 7.2.2 of Book 1			
V	**OPEN ENDED MODULE: RESEARCH**		**12**	
		Basic, Applied and Evaluation Research, Multidisciplinary and Interdisciplinary Research, The Value of Having Research Skills, Formulating a Research Problem, Research in Relation to Teaching and Publishing. Ethics and Responsibility in Scientific Research, Ethics, Western and Eastern Perspectives on the Source of Ethics, Unethics, Guidelines for Ethical Practices in Research, Plagiarism, Integrity of data, Use and misuse of data, Ownership of and access to data, Obligation to report, Conflict of Interest, From Unethics to Ethics in Research, The Responsibility of Scientists and of Science as an Institution		

Books and References:

1. The Aims, Practices and Ethics of Science by Peter Pruzan; Springer International Publishing Limited (Book 1)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7
CO 1	0	0	0	0	1	0	2	2	0	0	0	2	1
CO 2	0	0	0	0	1	0	2	2	0	0	0	2	1
CO 3	1	0	1	0	1	1	2	2	0	0	1	2	1
CO 4	1	0	1	0	1	1	2	2	0	0	1	2	1
CO 5	0	1	0	0	0	0	2	2	1	1	1	2	1
CO 6	0	1	0	0	0	0	2	2	0	0	0	2	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

MAJOR ELECTIVE COURSES

Programme	**B.Sc. Physics Honours**				
Course Title	**PROPERTIES OF SOLIDS**				
Type of Course	**Major Elective (SPECIALIZATION I: MATERIALS SCIENCE)**				
Semester	**V**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	The prerequisites for the course on crystal structure, theory of solids, semiconductor properties, and dielectric and magnetic properties of solids include a solid foundation in physics, mathematics, quantum mechanics, chemistry, electricity, and magnetism.				
Course Summary	The course provides a comprehensive study of crystal structure, theory of solids, semiconductor properties, and dielectric and magnetic properties of solids, aiming to understand the fundamental principles governing the behavior of materials in these domains.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate an understanding of crystal structures and their impact on material properties	Apply	Conceptual Understanding	Examinations, Assignments
CO2	Analyze the theoretical models of solids and their applicability to real-world scenarios	Analyze	Application	Problem Sets, Case Studies

CO3	Evaluate semiconductor properties and their role in electronic device functionality	Evaluate	Application	Laboratory Experiments, Projects
CO4	Explain the principles underlying dielectric properties of solids and their technological applications	Understand	Conceptual Understanding	Presentations, Written Reports
CO5	Investigate magnetic properties of solids and their implications in magnetic storage and sensing technologies	Evaluate	Application	Research Papers, Presentations
CO6	Synthesize knowledge of crystal structure, theory of solids, semiconductor, dielectric, and magnetic properties to propose solutions to complex material-related problems	Create	Synthesis	Capstone Projects, Oral Defenses
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (48 + 12)**	**Marks (70)**
I		**CRYSTAL STRUCTURE**	**15**	**20**
	1	Crystal lattice and translation vectors, unit cell, basis	3	
	2	Symmetry operations, point groups and space groups	3	
	3	Types of lattices, lattice directions and planes, inter planar spacing	3	
	4	Simple crystal structures with examples	3	
	5	X-ray diffraction and reciprocal lattice. Brillouin zones	3	

	Sections 1.1 – 1.13, 2.1 – 2.2, 2.4, 2.7 of Book 1			
II		**THEORY OF SOLIDS**	**10**	**15**
	6	Drude – Lorentz's classical theory	1	
	7	Sommerfeld's quantum theory- Free electron gas in one dimension	2	
	8	Fermi energy, Total energy Density of states, Filling of energy levels	2	
	9	Application of free electron gas model	1	
	10	Band Theory of solids-Bloch theorem-Kronig Penney model-velocity and effective mass of electron	3	
	11	Distinction between metal, insulator and semiconductors	1	
	Sections 5.1 – 5.3, 6.1 – 6.5 of Book 1			
III		**SEMICONDUCTOR PROPERTIES**	**10**	**10**
	12	Semiconductors – Intrinsic and Extrinsic	2	
	13	Drift velocity	2	
	14	Mobility and conductivity of Intrinsic semiconductors	2	
	15	Carrier concentration, Fermi level	2	
	16	Conductivity for intrinsic and extrinsic semiconductors	2	
	Sections 7.1 – 7.6 of Book 1			
IV		**DIELECTRIC AND MAGNETIC PROPERTIES OF SOLIDS**	**13**	**25**
	17	Types of Magnetism – origin of permanent magnetic moment	1	
	18	Diamagnetism and Paramagnetism (classical theory), ferromagnetism (Weiss theory)	4	
	19	Antiferromagnetism and ferrimagnetism (Qualitative ideas only)	2	
	20	Polarisation, Susceptibility, Local field	2	

	21	Dielectric constant and polarizability and its sources	2	
	22	Ferro and Piezo electricity (Qualitative ideas only)	2	
	Sections 8.1 – 8.7, 9.1 – 9.7 of Book 1			
V	**OPEN ENDED MODULE:** CRYSTAL BONDING AND DEFECTS IN CRYSTALS		**12**	

Books and References:

1.Solid State Physics by R. K. Puri and V. K. Babbar (Book 1)

2.Solid State Physics by S O Pillai 6th Edition (Book 2)

3.Solid State Physics: Structure and Properties of Materials by M. A. Wahab (Book 3)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	2	2	0	0	0	0	0	0	0	0	0
CO 2	2	2	2	2	2	0	0	0	0	0	0	0	0
CO 3	2	3	2	2	2	0	0	0	0	0	0	0	0
CO 4	2	2	2	2	0	0	0	0	0	0	0	0	0
CO 5	2	3	2	2	2	0	0	0	0	0	0	0	0
CO 6	3	3	2	2	2	3	3	2	0	0	0	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**MATERIALS SCIENCE**				
Type of Course	**Major Elective (SPECIALIZATION I: MATERIALS SCIENCE)**				
Semester	**V**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	A strong foundation in physics and chemistry.				
Course Summary	This course aims to provide students with a comprehensive understanding of the fundamental principles underlying the behavior of materials, as well as the cutting-edge technologies driving innovation in this field.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the various types of materials, the bonding between the elements and molecules, and type of interacting forces among the molecular systems	U, An	F	Instructor-created exams / Quiz
CO2	Develop a fundamental understanding of the importance of the structure of the compounds and performance of materials.	U,R	F	Instructor-created exams / Quiz

CO3	Gain knowledge about the different types of materials that are used in different applications and the different properties of diversified materials.	U, Ap	F	Instructor-created exams / Quiz
CO4	Familiarize students with advanced characterization techniques used to analyze materials structurally, surface, optically, electrically and magnetically.	U, An	F	Instructor-created exams / Quiz
CO5	Explore the applications of advanced materials in various industries, energy technology, and electronic and other applications..	U, An	F	Instructor-created exams / Quiz
CO6	Make the students capable of developing various materials through project work.	U, Ap	F	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	MATERIALS, INTERATOMIC FORCES, AND BONDING IN SOLIDS		10	16
	1	What is material science and need of material science (Elementary ideas only)	1	
	2	Classification of materials – metals, ceramics, polymers, composites, Advanced materials, need of modern material	2	
	3	Bonding forces and energies, Primary Interatomic Bonds	2	
	4	Ionic Bonding, Covalent Bonding, Metallic Bonding, van der Waals Bonding	3	
	5	Examples of anomalous volume expansion of water	2	
	Sections 1.2 – 1.6, 2.5 – 2.8 of Book 1			

II		**Crystal Structure and Imperfections in Solids**	**10**	**16**
	6	Single Crystals, Polycrystalline materials, Anisotropy, Nanocrystalline solids	3	
	7	Imperfections, Vacancies and Self Interstitials	2	
	8	Impurities in Solids, Specification of composition, Dislocations- Linear defects, Interfacial defects, Volume defects	3	
	9	Atomic Vibrations, Microstructure, Grain size determination.	2	
	Sections 3.13 to 3.17, 4.1 to 4.11 of Book 1			
III		**TYPES OF MATERIALS**	**17**	**22**
	10	Conductors, insulators, and dielectrics: Thermal conductivity and electrical resistivity	3	
	11	Drilling down: the origins and manipulation of electrical properties,	3	
	12	Magnetic Materials: the physics and manipulation of magnetic properties	2	
	13	Materials selection for magnetic design	2	
	14	Materials for optical devices: The interaction of materials and radiation, the physics and manipulation of optical properties	4	
	15	The durability of Materials: oxidation, corrosion, and degradation	3	
	Sections 14.1 – 14.4, 15.1 – 15.4, 16.1 – 16.4, 17.1 – 17.2 of Book 2			
IV		**CHARACTERIZATION STUDIES AND TECHNIQUES**	**11**	**16**
	16	Electrical and electronic measurements	2	
	17	Hall Effect in Semiconductors Introduction,	2	
	18	Magnetism and Magnetic Measurement	1	
	19	Introduction, Electrochemical Techniques	2	
	20	Introduction, Cyclic Voltammetry	1	
	21	Optical Microscopy, Photoluminescence Spectroscopy	2	
	22	Raman Spectroscopy of Solids.	1	
	Relevant sections from Book 3			
V		**OPEN ENDED MODULE**	**12**	

		Synthesis of Gold / Silver Nanoparticle and Introductory Soft Lithography Using PDMS		
		Thin film deposition by spin coating or Dip coating or spray pyrolysis techniques (Metal Oxides: any compound)		
		Solid State Reaction of Powder Ceramics		
	Any two Sections from the Chapter 8/9/10 of book 4, Book 5 or reference 6			

Books and References:

1. Materials Science and Engineering An Introduction, 7th Edition by William D. Callister, Jr, John Wiley & Sons, Inc (Book 1)
2. Materials Engineering, Science, Processing and Design: Michael Ashby, Hugh Shercliff and David Cebon, Published by Elsevier Ltd (Book 2)
3. Characterization of Materials: Elton N. Kaufmann, Volumes 1 and 2, John Wiley and Sons Publications,2023(Book 3)
4. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, Springer, 3rd Edition (Book 4)
5. Simple Chemical Methods for Thin Film Deposition: Synthesis and Applications, Springer, ISBN 978-981-99-0960-5(Book 5)
6. Journal of Materials Science and Technology, 2013, 29 (5), 419 - 422

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	2	1	3	3	2	2	3	2	2	3	2
CO 2	3	1	3	2	3	3	3	2	3	2	3	3	3
CO 3	3	2	3	1	3	3	3	2	3	2	2	3	2
CO 4	3	1	2	2	3	3	2	2	3	2	3	2	0
CO 5	3	2	3	2	3	3	3	2	3	2	3	3	2
CO 6	3	0	1	1	3	3	1	2	3	2	3	3	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**NANOSCIENCE AND TECHNOLOGY**				
Type of Course	**Major Elective (SPECIALIZATION I: MATERIALS SCIENCE)**				
Semester	**VI**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY5EJ302(1)- Materials Science				
Course Summary	This Nanoscience and Technology aims to provide students with a solid foundation in the principles, techniques, and applications of nanotechnology, preparing them for careers in research and industry.				

Course Outcomes (CO):

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Understanding of Nanoscale Phenomena, the unique properties and behaviors of materials at the nanoscale.	U	F	Instructor-created exams / Quiz
CO2	Understand the science of nanomaterials: including quantum effects, surface phenomena, and size-dependent properties.	U, Up	F	Instructor-created exams / Quiz

CO3	Understand the knowledge about the type of nanomaterials and how the size effect affects the transport properties in nanomaterials	U, An	F	Instructor-created exams / Quiz
CO4	Knowledge of Nanofabrication Techniques: Students should learn about various techniques used to fabricate nanostructures and nanomaterials, such as top-down and bottom-up approaches.	U	F	Instructor-created exams / Quiz
CO5	To familiar with a range of characterization techniques used to analyze nanomaterials and nanostructures using conventional and advanced techniques.	U, An	F	Instructor-created exams / Quiz
CO6	Research Skills: Depending on the level of the course, students may develop research skills through laboratory work, independent projects, or literature reviews.	U, Ap	F	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		INTRODUCTION OF NANOSCALE SCIENCE	15	22
	1	Introduction to the nanoscale, Size effects in small systems, Quantum behaviors of the nanometric world[1]	2	
	2	Applications of Schrodinger equation - infinite potential well, potential step, potential box; trapped particle in 3D (nanodot), electron trapped in 2D plane (nanosheet), electrons moving in lD (nanowire, nanorod, nanobelt) [1]	5	
	3	Quantum confinement effect in nanomaterials. Electron confinement[1]	2	

	4	Density of states: Density of States for a Zero Dimensional (0D) Solid	3	
	5	Special nanomaterials: Density of States in a Two-Dimensional (2D) Potential Box	2	
	6	Thin Film, Density of States for a Particle in a Three-Dimensional Box	1	
	Chapter V of Book 1 and Sections 1.5, 1.5.2 of Book 2			
II	**NANOSTRUCTURES**		**10**	**15**
	7	Nanostructures: Zero, One Two, and Three-dimensional nanostructures,	3	
	8	some special nanostructures: Carbon nanomaterials, Fullerenes, Carbon Nanotubes (CNTs), Types of carbon nanotubes, Graphene	4	
	9	Metal-Organic Frameworks (MOF), Core-Shell Particles, Metamaterials, Bioinspired Materials.	3	
	Sections 11.2, 11.2.1, 11.2.2, 11.2.3, 11.2.6, 11.7, 11.8, 11.9 of Book 2			
III	**SYNTHESIS OF NANOMATERIALS**		**10**	**15**
	10	Mechanical Methods: High Energy Ball Milling	1	
	11	Physical Vapour Deposition with Consolidation, Laser Vaporization (Ablation)	1	
	12	Chemical Vapour Deposition (CVD), Ion Beam Techniques (Ion Implantation, Molecular Beam Epitaxy (MBE).	2	
	13	Synthesis of Nanomaterials—II (Chemical Methods): Sol-Gel Method, Hydrothermal Synthesis,	2	
	14	Sonochemical Synthesis, Microwave Synthesis	2	
	15	Self-Assembly: Basic Mechanism and Self Assembly of Nanoparticles Using Organic Molecules.	2	
	Sections 3.1, 3.2.1, 3.3, 3.3.1, 3.3.3, 3.4, 3.4.1, 3.4.2, 3.5, 3.7, 3.8, 4.8, 4.9, 4.10, 4.11, 6.1, 6.3.1 of Book 2			
IV	**ANALYSIS TECHNIQUES**		**13**	**18**
	16	Analysis Techniques: Optical Microscope: Confocal Microscope	2	
	17	Electron Microscopes: Scanning Electron Microscope	2	
	18	Transmission Electron Microscope (TEM)	2	

	19	Scanning Probe Microscopes (SPM), Atomic Force Microscope, Scanning Probe Microscopes (SPM)	2	
	20	XRD and diffraction from different types of samples	1	
	21	Diffraction from Nanoparticles.	2	
	22	X-Ray Ultra Violet Photoelectron Spectroscopies	2	
	Sections 7.2 7.2.2, 7.3, 7.4, 7.4.1, 7.4.2, 7.5.1, 7.5.4, 7.5.6, 7.6.8 of Book 2			
V	**OPEN ENDED MODULE**		**12**	
		Applications of Nanomaterials: Organic Photovoltaic cells, Fuel Cell, Hydrogen Generation and Storage, Photo Electrochemical Cells (PEC), Hybrid Energy Cells, Automobiles, Textiles, Sports and Toys, Cosmetics, Medical field, Space, Defense and Engineering.		
		Synthesis of nanoparticles and analysis using XRD, SEM, TEM, Optical Methods, etc		
	Sections 12.2, 12.2.2, 12.2.3-12.2.6, 12.3-12.7, 12.10, 14.4 of Book 2			

Books and References:

1. Introduction to Nanoscience and Nanotechnology, Chattopadhyaya and A. N. Banerjee, Publisher: PHI Learning and Private Limited (Book 1)
2. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, Springer, 3rd Edition (Book 2)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	3	2	3	3	3	2	3	2	3	3	3
CO 2	3	2	3	2	3	3	3	2	3	2	3	3	3
CO 3	3	2	3	2	3	3	3	2	3	2	3	3	3
CO 4	3	2	3	2	3	3	3	2	3	2	3	3	3
CO 5	3	2	3	2	3	3	3	2	3	2	3	3	3
CO 6	3	2	3	2	3	3	3	2	3	2	3	3	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**OPTOELECTRONICS AND SEMICONDUCTOR DEVICES**				
Type of Course	**Major Elective (SPECIALIZATION I: MATERIALS SCIENCE/SPECIALIZATION II: PHOTONICS)**				
Semester	**VI**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY5EJ302(1)- Materials Science				
Course Summary	The Optoelectronics and Semiconductor Devices course focuses on equipping students with an understanding of the principles, operation, design, and applications of optoelectronic devices and semiconductor devices.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding the operation and characteristics of various optoelectronic devices, such as light-emitting diodes (LEDs), laser diodes, etc	U	F	Instructor-created exams / Quiz
CO2	Understanding of semiconductor physics, including band theory, carrier transport, and semiconductor device operation principles.	U, R	F	Instructor-created exams / Quiz

CO3	Understand the knowledge about the radiative transition processes and other optoelectronic phenomenon.	U, Up	F	Instructor-created exams / Quiz
CO4	Understand the applications of optoelectronic and semiconductor devices in various fields such as telecommunications, imaging, sensing, displays, and energy conversion.	U, An	F	Instructor-created exams / Quiz
CO5	To be familiar with equipment and devices that work on the principle of semiconducting phenomena and theories of optoelectronics	U, Ap	F	Instructor-created exams / Quiz
CO6	Students will gain hands-on experience through laboratory experiments involving the characterization and testing of optoelectronic and semiconductor devices	An, Ap	F	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	**AN INTRODUCTION TO OPTOELECTRONICS**		**12**	**18**
	1	Emission and absorption processes, Photon statistics	2	
	2	The behaviour of electrons, Optical properties of some common materials	3	
	3	Electrons in a periodic lattice, Metals, insulators and semiconductors	3	
	4	Refraction, Absorption and emission, Fluorescence, Scattering	2	
	5	The absorption and emission of light by semiconductors	2	
	References: Section A1:1.6- 1.8, 2.2,2.6-2.10 of Book 1			

II	**SEMICONDUCTOR SCIENCE AND LIGHT-EMITTING DIODES**		**16**	**22**
	6	Semiconductor Science and Light-Emitting Diodes, energy Band diagrams.	3	
	7	The density of States, fermi–dirac function and metals, Extrinsic Semiconductors: n-type and p-type Semiconductors	3	
	8	compensation doping, nondegenerate and degenerate Semiconductors, Energy Band Diagrams in the Applied field (Basic ideas only: derivations not required)	4	
	9	Direct Band and Indirect band semiconductors: E-K Diagrams, PN-Junction principles (Basic ideas only: derivations not required)	3	
	10	Open circuits, PN Junction forward and reverse circuits (Basic ideas only: derivations not required)	3	
	References: Section 3.1 to 3.6 of Book 2			
III	**OPTOELECTRONIC SEMICONDUCTOR DEVICES I**		**10**	**15**
	11	Visible light-emitting diodes : Physics of LEDs, Optical properties of LEDs.	4	
	12	Radiative and non-radiative recombination, Electrical properties,	3	
	13	Current-voltage characteristics, Efficiencies, High efficiency LEDs and novel technologies	3	
	Reference : B1.1 Visible light-emitting diode of Book 1			
IV	**OPTOELECTRONIC SEMICONDUCTOR DEVICES II**		**10**	**15**
	19	Stimulated emission devices: Stimulated emission and Population inversion.	2	
	20	Photon amplification and laser Principles, Stimulated emission and einstein coefficients	2	
	21	Principle of the laser diode, hetero structure laser diodes	3	
	22	Photovoltaic devices: Solar cell: Basic Principles, operating current and Voltage and fill factor.	3	
	References: Section 4.1.A-B, 4.2.A,4.9,4.10.5.14. A-B of Book 2			
V	**OPEN ENDED MODULE**		**12**	
		Interferometers, Thin Film Optics: Multiple Reflections in Thin Films, LED Electronics, Equivalent Circuit of a Solar Cell, Solar Cell Structures and Efficiencies, Solar cell driving a load, Open circuit voltage and short circuit current		

	Sections 1.13-1.15, 3.18, 5.14.D of Book 2		

Books and References:

1. Handbook of Optoelectronics Volume II, John P Dakin & Robert G W Brown, 2006 by Taylor & Francis Group (Book 1)
2. Optoelectronics and Photonics: Principles and Practices S.O. Kasap, Pearson (Book 2)
3. Physics of Optoelectronics, Michael A. Parker, 2005 by Taylor & Francis Group, LLC (Book 3)
4. Optics and Photonics: An Introduction, SECOND EDITION ,F. Graham Smith et al, John Wiley and Sons (Book 4)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	2	2	3	2	3	2	3	2	3	3	2
CO 2	3	2	2	2	3	2	3	2	3	2	3	3	1
CO 3	3	2	2	2	3	2	3	2	3	2	3	3	1
CO 4	3	2	2	2	3	2	3	2	3	2	3	3	2
CO 5	3	2	2	2	3	2	3	2	3	2	3	3	3
CO 6	3	3	3	3	3	3	3	2	3	2	3	3	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Programme	**B.Sc. Physics Honours**				
Course Title	**PHOTONICS**				
Type of Course	**Major Elective (SPECIALIZATION II: PHOTONICS)**				
Semester	**V**				
Academic Level	**300 – 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Fundamental knowledge in Optics				
Course Summary	Photonics is the science and technology of generating, controlling, and detecting photons, which are particles of light. This course covers topics such as the fundamentals of light-matter interaction, optical components and systems, laser technology and fiber optics. It's a multidisciplinary field that combines elements of physics, optics and materials science to harness light for a wide range of practical purposes.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category #	Evaluation Tools used
CO1	Understand the concept and principles of energy levels, spontaneous emission and stimulated emission, optical gain, and threshold condition for lasing.	U	C	Written exams and quizzes
CO2	Understand the principles and working of various laser systems.	An	p	Presentations, written exam
CO3	Giving a rigorous theoretical background and framework for a	U	C	Written exams, Assignments

	nonlinear optical effect, followed by details of how such an effect is implemented in real applications.			
CO4	Understand the physical principles of optical fiber and the loss mechanisms in optical fiber. Demonstrate the understanding of fiber optic sensors.	U & Ap	C	Written exams and quizzes,experiments
CO5	Apply Photonics principles to real-world applications such as lasers and Optical fiber	U & Ap	C	Simple projects
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge (F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (48+12)**	**Marks (70)**
I		**LASERS: AN INTRODUCTION**	**15**	**25**
	1	Introduction, spontaneous and stimulated emission, main components of the laser	2	
	2	Understanding optical amplification: The EDFA	1	
	3	The resonator, The lasing action. Optical resonators	3	
	4	Einstein's equation and Conditions for light amplification, Metastable state, Population Inversion	3	
	5	Cavity life time, The threshold condition	2	
	6	Line shape function, Monochromaticity of laser beam	2	
	7	Laser Pumping – Two level system, Three level system	2	
		Sections 26.1, 26.1.1, 26.1.2, 26.1.3, 26.1.4 , 26.1.5, 26.5, 26.6, 26.6.1, 26.6.2 , 26.6.3, 26.7, 26.9 of Book 1		
II		**LASER SYSTEMS AND APPLICATIONS**	**8**	**10**
	8	Solid state lasers- Ruby Laser, Nd: YAG Laser	2	
	9	Liquid Lasers – Dye lasers	1	
	10	Gas Lasers – Helium-Neon laser, CO2 laser	1	
	11	Semiconductor Laser-Double heterojunction laser	2	
	12	Chemical Laser – HCl laser, HF laser, Free Electron laser	2	

		Sections 7.1, 7.5, 10.1, 10.2, 8.1, 8.5.1, 9.1, 10.3, 10.3.1, 10.3.2 of Book-2		
III		**NONLINEAR OPTICS**	**11**	
	13	Harmonic generation, Second Harmonic generation, Phase Matching	3	**15**
	14	Third Harmonic generation, Optical Mixing, Parametric generation of light	3	
	15	Frequency Upconversion, Self-focusing of light	2	
	16	Multiphoton processes- Two photon and three photon processes	3	
		Sections 13.1, 13.2, 13.3, 13.4, 13.5, 13.6, 13.7, 14.12, 14.2, 14.3, 14.7 of Book-2		
IV		**OPTICAL FIBER BASICS**	**14**	**20**
	17	Introduction ,Some Historical Remarks	1	
	18	Total Internal Reflection, The Numerical Aperture	2	
	19	Attenuation in Optical Fibers	2	
	20	Multimode Fibers, Pulse Dispersion in Multimode Optical Fibers, Dispersion and Maximum Bit Rates	4	
	21	Fiber Optic Sensors	2	
	22	TE Modes of a Symmetric Step Index Planar Waveguide (qualitative idea only Physical Understanding of Modes, TM Modes of a Symmetric Step Index Planar Waveguide (qualitative idea only)	3	
		Sections 27.1, 27.2, 27.3, 27.4, 27.7, 27.8, 27.10, 27.11, 27.14, 28.2, 28.3, 28.4 of Book-1		
V		**OPEN-ENDED MODULE: PROJECT /PRACTICAL**	**12**	
		Study the refraction of a laser beam in a glass slab and measure its refractive index using total internal reflection.		
		Determine the numerical aperture and acceptance angle of an optical fibre.		
		Measure the divergence of an edge emitting diode laser beam by measuring the dimensions of the beam projected onto a screen at different distances. Hence to calculate the beam divergence and spot size of the given laser beam		
	References:			

	1. Optics by Ajoy Ghatak 5th Edition (Book 1) 2. Laser and Nonlinear Optics by B B Laud (Book 2)		

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	0	0	0	0	0	3	2	0	0	0	0	1
CO 2	3	2	0	0	0	0	3	2	0	0	0	0	1
CO 3	3	0	0	0	0	0	3	2	0	0	0	0	2
CO 4	3	0	0	3	0	0	3	2	0	2	0	0	3
CO 5	3	0	0	3	0	0	3	2	0	2	0	0	2
CO 6	3	0	0	0	0	0	3	2	0	0	0	0	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**INTRODUCTORY MOLECULAR SPECTROSCOPY**				
Type of Course	**Major Elective (SPECIALIZATION II: PHOTONICS)**				
Semester	**V**				
Academic Level	**300 – 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY4CJ205- Modern Physics				
Course Summary	Introductory Molecular Spectroscopy provides a comprehensive overview of the principles governing the interaction between light and molecules. Students delve into spectroscopic techniques such as infrared, ultraviolet-visible, and nuclear magnetic resonance spectroscopy, gaining insights into molecular structure, dynamics, and interactions.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Gain basic knowledge on electromagnetic spectrum, spectral lines and diverse branches in spectroscopy	U	C	Viva Voce/ Seminar / Quiz
CO2	Gain theoretical know-how on rotational spectrum of diatomic and polyatomic molecules	An	P	Practical Assignment / Group Discussion
CO3	Gain theoretical know-how on vibrational spectrum of diatomic and polyatomic molecules	Ap	P	Seminar Presentation /

				Group Tutorial Work
CO4	Gain theoretical know-how on vibrating rotators and Born-Oppenheimer approximation	An	P	Instructor-created exams / Home Assignments
CO5	Gain theoretical know-how on Raman spectrum	Ap	M	Viva Voce
CO6	Gain practical knowledge on emission and absorption spectra	C	M	Group Discussion/ Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	**Introduction to Spectroscopy**		**5**	**8**
	1	Quantization of energy, Regions of spectrum	2	
	2	representation of spectra, Basic elements to practical spectroscopy	1	
	3	signal-to-noise ratio	1	
	4	width and intensity of spectral lines	1	
	Sections 1.1-1.7 of Book 1			
II	**Bioelectric Potentials and Major Physiological Systems of Human Body**		**11**	**16**
	5	Rotation of molecules, Rotational spectra	2	
	6	Rigid diatomic molecules, Intensities of spectral lines	2	
	7	Effect of isotopic substitution, Non-rigid rotator	2	
	8	The spectrum of non-rigid rotator	2	
	9	Polyatomic molecules – linear, symmetric and asymmetric top molecules, Stark effect	3	
	Sections 2.1-2.4 of Book 2			
III	**Infra-red Spectroscopy**		**16**	**23**

	10	Vibrating diatomic molecule - Energy of a diatomic molecule	2	
	11	Simple harmonic oscillator, Anharmonic oscillator	3	
	12	Diatomic vibrating rotator,	2	
	13	Vibration-Rotation spectrum of CO, Born – Oppenheimer approximation	3	
	14	Effect of Breakdown of Born Oppenheimer approximation	2	
	15	Vibration of polyatomic molecules	2	
	16	Influence of rotation on the spectra of polyatomic molecules, Analysis by infra-red techniques	2	
	Sections 3.1-3.7 of Book 1			
IV	**Raman Spectroscopy**		**16**	**23**
	17	Quantum and Classical approach towards Raman effect	3	
	18	Pure rotational Raman spectra of linear, Symmetric top and spherical top molecules	3	
	19	Vibrational Raman spectra, Rule of mutual exclusion	3	
	20	Overtone and Combination vibrations, Rotational fine structure	2	
	21	Polarization of light and Raman effect	2	
	22	Raman & IR Spectroscopy in structure determination, Instrumentation	3	
	Sections 4.1-4.6 of Book 1			
V	**Open Ended Module**			
	Electronic Spectroscopy of molecules Electronic spectra of diatomic molecules, Vibrational coarse structure: Progressions, Intensity of vibrational-electronic spectra: Franck Condon Principle, Dissociation Energy and Dissociation Products, Rotational fine structure of Electronic-Vibration transitions, Fortrat Diagram, Pre-dissociation			

Books and References:

1.Fundamentals of Molecular Spectroscopy by C N Banwell, McGraw Hill (Book 1)

2. Molecular Structure & Spectroscopy by G Aruldhas (Book 2)

3.Spectroscopy (volumes) by B P Straughan and S Walker

4.Introduction to Molecular Spectroscopy by G M Barrow, McGraw Hill

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	0	0	0	0	0	2	2	2	0	0	0	0
CO 2	2	0	2	0	0	0	2	2	2	0	0	0	0
CO 3	2	0	2	0	0	0	2	2	2	0	0	0	0
CO 4	2	0	2	0	0	0	2	2	2	0	0	0	0
CO 5	2	0	0	0	2	0	2	2	2	0	0	0	0
CO 6	0	0	0	0	0	3	2	2	2	0	0	0	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**BIOPHOTONICS**				
Type of Course	**Major Elective (SPECIALIZATION II: PHOTONICS)**				
Semester	**V**				
Academic Level	**300 – 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Fundamental knowledge in optics, photonics and biology				
Course Summary	Biophotonics is an interdisciplinary field that combines principles of physics, biology, and optics to study biological systems using light-based techniques. This course covers topics such as optical properties of biological tissues, imaging and biosensing techniques, instrumentation, and emerging trends. Students gain both theoretical knowledge and practical skills through lectures, and projects/lab, preparing them for careers in research, healthcare, and technology development.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding photobiology contributes to advancements in medical treatments, such as photodynamic therapy using exogenous photosensitizers.	U	C	Written exams, quizzes

CO2	Imaging in the field of biophotonics provides a comprehensive understanding of visualization techniques at various scales within the biological system.	An	p	Quizes, presentations
CO3	Studying the principles of optical biosensing, equips individuals with the knowledge to design, develop, and apply advanced sensing technologies.	U&Ap	C	Written exams, experiments
CO4	Understanding the techniques of a flow cytometer, tweezers, optical responses, and the principles of photodynamic therapy fosters the development of advanced diagnostic and therapeutic techniques. Additionally, exploring This knowledge contributes to advancements in both clinical diagnostics and biological research..	U & Ap	C	Written exams, quizzes
CO5	Apply Photonics principles to real-world applications such as imaging and sensors	Ap	C	Mini Projects
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge (F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks (70)
I		**Photobiology**	**14**	**20**
	1	Photobiology—At the Core of Biophotonics , Interaction of Light with Cells - Light Absorption in Cells, Light-Induced Cellular Processes,	3	
	2	Photochemistry Induced by Exogenous Photosensitizers ,Interaction of Light with Tissues - Photoprocesses in Biopolymers	3	
	3	Human Eye and Vision , Photosynthesis	2	

	4	In Vivo Photoexcitation - Free-Space Propagation	1	
	5	Optical Fiber Delivery System , Articulated Arm Delivery, Hollow Tube Waveguides,,	2	
	6	In Vivo Spectroscopy	1	
	7	Optical Biopsy ,Single-Molecule Detection,	2	
		Chapter 6 of Book 1		
II		**Bioimaging: Principles and Techniques**	**11**	**15**
	8	An Overview of Optical Imaging	1	
	9	Transmission Microscopy - Simple Microscope, Compound Microscope, Kohler Illumination	3	
	10	Fluorescence Microscopy, Confocal microscoy,	2	
	11	Fluorescence Resonance Energy Transfer (FRET)Imaging ,Fluorophores as Bioimaging Probes	2	
	12	Imaging of Organelles, Imaging of Microbes, Cellular Imaging, Tissue, *In Vivo* Imaging	3	
		Chapter 7 of Book 1		
III		**Optical Biosensors**	**9**	**10**
	13	Principles of Optical Biosensing	2	
	14	Fiber Optic Biosensors, Evanescent Wave Biosensors,	2	
	15	Surface Plasmon Resonance Biosensors	2	
	16	Some Recent Novel Sensing Methods, Commercially Available Biosensors.	3	
		Chapter 9 of Book 1		
IV		**Photonic tools for medical applications**	**14**	**25**
	17	Flow Cytometry A Clinical, Biodetection, and Research Tool,	2	
	18	Basics of Flow Cytometry- Basic Steps, The Components of a Flow Cytometer, Optical Response	3	
	19	Photodynamic Therapy: Basic Principles,	1	

	20	Laser Tweezers and Laser Scissors- New Biological Tools for Micromanipulation by Light Principle of Laser Tweezer Action	3	
	21	Design of a Laser Tweezer 490 Optical Trapping Using Non-Gaussian Beams	3	
	22	Laser Scissors -Laser Pressure Catapulting (LPC), Laser Capture Microdissection (LCM),	2	
		Sections 11.1,11.2, 12.1,14.1, 14.2, 14.3, 14.4, 14.6 of Book 1		
V	**Open Ended Module: Mini project**		**12**	
		1. Synthesis of Semiconductor Quantum Dots for Bioimaging		
		2. Fabrication of biosensors using optical fibers		

Text Book for study

1. Introduction to Biophotonics, Paras N Prasad, Wiley Interscience, A John Wiley & Sons, INC Publication (Book 1)

References:

1. Biomedical Photonics –A handbook-T.Vo Dinh (CRC Press 2002)

2. Nanophotonics, Paras N Prasad (Wiley Interscience, 2003)

3. Optic Fiber Communications, Gerd Keiser (McGraw –Hill International Editions)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PS O4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	0	0	0	0	0	3	2	0	0	0	0	3
CO 2	3	2	0	0	0	0	3	2	0	0	0	0	3
CO 3	3	0	0	0	0	0	3	2	0	0	0	0	3
CO 4	3	0	0	3	0	0	3	2	0	2	0	0	3
CO 5	3	0	0	0	0	0	3	2	0	0	0	0	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**PHYSICS OF THE HUMAN BODY**				
Type of Course	**Major Elective (SPECIALIZATION III: PHYSICS IN BIOLOGY)**				
Semester	**V**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Newtonian mechanics.				
Course Summary	This course analyses the human body from the viewpoint of mechanics and its static and dynamic equilibrium. The effects of collisions on human body, leading to fractures are explored. The significance of muscles of the human body is also analysed.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand & apply the laws of mechanics to the human body w.r.to its static equilibrium.	U, Ap	F	Instructor-created exams / Quiz
CO2	Understand dynamic equilibrium of human body.	U	F	Instructor-created exams / Quiz
CO3	Understand and analyse the effects of collision of human body from a mechanical force viewpoint.	U, An	F	Instructor-created exams / Quiz
CO4	Gain basic knowledge about various supporting structures of bones, a.k.a	U	F	Instructor-created exams / Quiz

	Ligaments, Tendons, Cartilage and how energy is stored in them.			
CO5	Basic understanding of fractures from mechanical force viewpoint.	U, An	F	Instructor-created exams / Quiz
CO6	Gain ideas about muscle and muscle activity from a mechanical viewpoint.	U, Ap	F	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**Static Equilibrium of the Body**	**12**	15
	1	Review of Forces, Torques, and Equilibrium. (Section 2.1)	1	
	2	Statics: Motion in One Plane and Levers. (Section 2.2)	2	
	3	Statics in the Body. The lower arm and hip as examples. (Sections 2.3, 2.3.1 (Case 1, Case 2 only), 2.3.2 (variation of problem with cane to provide support on the left side not required).	2	
	4	Total body equilibrium. (Section 2.3.2)	2	
	5	Equilibrium of the individual body components. (Section 2.3.2)	2	
	6	Standing: Stability: overall stability, local stability. (Section 3.2)	2	
	7	Forces on the feet. (Section 3.2)	1	
Sections from References: Chapter 2 and 3 of Book 1				
II		**Physical Aspects of Walking**	**8**	15
	8	Kinematics of walking, Friction (Electromyographic activity of the muscles not required). (Section 3.3, 3.3.1, 3.3.3)	3	
	9	Energetics. Collisions of the human body: Kinematics of a collision, partially elastic collisions. (Section 3.3.4, 3.10, 3.10.1)	3	
	10	Consequences of collisions (upto & including calculation of GSI, p.178. Modification of GSI not required). (Section 3.10.2)	2	
Sections from References: Chapter 3 of Book 1				

III		**Material Components of the Body**	**18**	**25**
	11	Introduction to Bone. (Section 4.1, 4.1.1)	3	
	12	Ligaments and Tendons, Cartilage. (Section 4.1.2, 4.1.3)	1	
	13	Elastic Properties: Basic Stress–Strain Relationships. (Section 4.2.1)	3	
	14	Other Stress–Strain Relations, Bone Shortening. (Section 4.2.2, 4.2.3)	3	
	15	Energy Storage in Elastic Media. (Section 4.2.4)	3	
	16	Energy Storage in Tendons and Long Bones. (Section 4.2.4)	3	
	17	Bone Fractures: Modes of Sudden Breaking of Bones (Section 4.7, 4.7.1 up to and excluding Breaking of Bones by Bending).	2	
Sections from References: Chapter 4 of Book 1				
IV		**Physical Aspects of Muscles**	**10**	**15**
		Muscles, Skeletal Muscles in the Body. (Section 5, 5.1)	2	
	19	Types of Muscle Activity - The Structure of Muscles (upto electron micrograph figure showing banded myofilament structure (p.339)). (Section 5.1.1, 5.2)	2	
	20	Activating Muscles: Macroscopic View. (Section 5.3 only. Section 5.3.1 not required).	2	
	21	Muscle Strength and Evolution: Increasing Strength with Training.	2	
	22	Muscle Evolution with Age, Muscle Fatigue. (Section 5.11).	2	
Sections from References: Chapter 5 of Book 1				
V		**Open Ended Module**	**12**	
		Advanced features of walking, running, jumping, Avoiding Fractures and Other Injuries: Materials for Helmets		
		Sections Chapters 3 & 4: 3.3, 3.4, 3.5, 4.9 of Book 1		

Books and References:

1. *Physics of the Human Body*, 2nd Edition, Irving P. Herman, Springer International Publishing, 2016 (Book 1)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	1	0	1	0	0	2	2	0	0	1	0	1
CO 2	2	0	0	0	0	0	2	2	0	0	0	0	0
CO 3	2	0	0	0	0	0	2	2	0	0	0	0	1
CO 4	2	0	0	0	0	0	2	2	0	0	0	0	1
CO 5	2	0	0	0	0	0	2	2	0	0	0	0	0
CO 6	2	1	0	0	0	0	2	2	0	0	0	0	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**INTRODUCTORY MEDICAL PHYSICS**				
Type of Course	**Major Elective (SPECIALIZATION III: PHYSICS IN BIOLOGY)**				
Semester	**V**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	A strong foundation in physics, mathematics, and basic biology concepts.				
Course Summary	The medical physics course provides an interdisciplinary exploration of the application of physics principles to medical imaging, radiation therapy, and radiation protection, emphasizing the theoretical and practical aspects essential for understanding and contributing to advancements in medical diagnostics and treatment.				

Course Outcomes (CO):

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Understand the concept of biometrics and its	Understanding	Conceptual Knowledge	Written exams, quizzes
CO2	Analyze bioelectric potentials and their	Analyzing	Conceptual Knowledge	Laboratory reports, projects
CO3	Identify and explain the major physiological	Understanding	Conceptual Knowledge	Presentations, written exams
CO4	Describe the principles underlying medical	Understanding	Conceptual Knowledge	Practical assessments, exams

CO5	Apply the principles of medical imaging to	Applying	Procedural Knowledge	Case studies, laboratory work
CO6	Evaluate the cognitive and technical aspects	Evaluating	Metacognitive Knowledge	Oral exams, practical exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**Biometrics – Man as a Physical Instrument**	**9**	**13**
	1	Features of biomedical instrumentation system: Range, sensitivity, linearity, hysteresis, frequency response, Accuracy, Signal to noise ratio, stability, simplicity.	2	
	2	Aspects of Man-instrument system: Information gathering, diagnosis, Evaluative, Monitoring, Control.	2	
	3	Components of the Man-Instrument system: The subject, stimulus, the transducer, signal conditioning equipment, display equipment, Recorder.	2	
	4	Physiological systems of the body - Biochemical system, cardio-vascular, respiratory, nervous systems. (Sufficient exercises)	3	
	Sections 1.2-1.6 of Book 1			
II		**Bioelectric Potentials and Major Physiological Systems of Human Body**	**22**	**32**
	5	Sources of Bioelectric potentials: Resting and action potentials, propagation of action potentials	2	
	6	Bio-electric potentials, ECG, EEG, EMG.	2	
	7	The heart and cardiovascular system: The heart, blood pressure, characteristics of blood flow	3	
	8	Electrocardiography-electrodes and leads, principles of recording, Measurement of blood pressure, direct and indirect methods (two methods, qualitative ideas only).	3	
	9	Measurements in respiratory system: The physiology of respiratory system	3	

	10	Mechanics of breathing-working of Spirometer.	1	
	11	Nervous system-The anatomy of nervous system, neuronal communication	3	
	12	Measurements from the nervous system, neuronal firing measurements	2	
	13	Principles of EEG and EMG.	3	
	Sections 3.1-3.3, 5.1-5.4, 6.1, 6.2, 8.1, 8.2, 10.1, 10.2,10,7 of Book 2			
III	**Principles of Medical Imaging -1**		**8**	**12**
	14	Ultrasonic Imaging: properties of ultrasound	2	
	15	modes of ultrasound transmission-pulsed, continuous, pulsed Doppler, ultrasound imaging, ultrasonic diagnosis, ultrasonic transducers	2	
	16	Generation of Ionizing Radiation	2	
	17	Instrumentation for Diagnostic X Rays	2	
	18	Special Techniques	2	
	Sections 9.2, 9.3, 14.1-14.3 of Book 1			
IV	**Principles of Medical Imaging-2**		**9**	**13**
	19	Radio-isotopes in Medical Diagnosis, Physics of Radioactivity	2	
	20	The Gamma Camera, Emission Computed Tomography (ECT), Positron Emission Tomography (PET Scanner)	2	
	21	Principles of NMR Imaging Systems, Image Reconstruction Techniques, Basic NMR Components.	3	
	22	Biological Effects of NMR Imaging, Advantages of NMR Imaging System	2	
	Sections 21.1, 21.2, 21.7, 21.9, 21.11, 22.1-22.5 of Book 2			
V	**Open Ended Module – Suggestive topics**		**12**	
	Biological effects of radiation, In vitro and in vivo testing, gamma rays for imaging, radio pharmaceuticals, the gamma camera, single photo emission computed tomography (SPECT), typical nuclear medicine images and normal and abnormal manifestations (*Techniques for radiation dosimetry by K Mahesh and D R Vij, Wiley Eastern Limited*) Lasers in Medicine - effects of laser radiation on tissue, surgical uses of Lasers, ophthalmic uses, photodynamic therapy, laser hazards-biological effects, photo thermal effects, photochemical effects, laser hazards to the			

	eye, to skin, safe exposure. (*Lasers in Medicine - An Introductory Guide, Gregory Absten, Springer Science Publications*)		

Books and References:

1. Biomedical Instrumentation and measurement", Leslie Cromwell, Prentice Hall of India, New Delhi (Book 1)
2. Biomedical Instrumentation by R S Khandpur, Tata Mc Graw Hill Publication, New Delhi (Book 2)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	0	1	0	0	0	0	2	2	2	0	0	0	0
CO 2	0	3	1	0	0	0	2	2	2	0	0	0	0
CO 3	0	0	2	0	0	0	2	2	2	0	0	0	0
CO 4	0	0	0	2	0	0	2	2	2	0	0	0	0
CO 5	0	0	0	0	2	0	2	2	2	0	0	0	0
CO 6	0	0	0	0	0	3	2	2	2	0	0	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**INTRODUCTORY BIOPHYSICS**				
Type of Course	**Major Elective (SPECIALIZATION III: PHYSICS IN BIOLOGY)**				
Semester	**VI**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Higher Secondary level Physics 2. Fundamental Mathematics Concepts: Concept of calculus- Solution of very simplest differential equation 3. High school level Chemistry and Biology				
Course Summary	In this course the student learn a bridge between Physics and Biology. Look at some of the biological phenomena and analyze them with math and physics to gain important insights. This course tries to show that there is a quantitative, Physical sciences approach to Biological problems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain why is nano world so different from macro world and predict what's going on there by incorporating physical ideas like Random walk, Diffusion, probabilistic facts, etc.	U	C	Instructor-created exams, Assignments
CO2	Explain the biological systems and models by dealing with statistical mechanics and transport phenomena	U	C	Instructor-created exams

CO3	Answer many real life questions like why don't bacteria swim like fish by applying equation of motion appropriate to the nano world	Ap, U, R	P	Instructor-created exams, Assignments
CO4	Explain the thermodynamic basis of various biochemical reactions in cells and tissues.	R, U	F	Instructor-created exams
CO5	Analyse the role of action potential in nerve impulses, and the physics of signal communication via neural systems.	Ap, U	P	Instructor-created exams
CO6	Explain everyday phenomena and various processes in living systems by applying physical principles	An	C	Assignments/ Seminar presentations
CO7	Make quantitative predictions by making a simplified model by applying many tools given in the course	An, C, U	M	Assignment/ Group Projects/Presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (12+48)	Marks (70)
I	**Open Ended Module**		12	
	Lectures/Reading: (4 hrs) **Introduction** - Nature and Subject of Biophysics Chapter 1 from Book 2 **Mysteries, Metaphors, Models-** What the ancients knew? What's inside cells Heat-Heat is a form of energy, How life generates order, How to do better on exams (and discover new physical laws), Dimensional analysis can help you catch errors and recall definitions, Dimensional analysis can also help you formulate hypotheses **What's inside cells** Cell physiology Sections 1.1.1, 1.2.1, 1.4.1, 1.4.2, 1.4.3, 2.1 of Book 1			

	Simulation (Along with the following modules or after completion of modules) (4 hrs) Example: Generation of random numbers, say between 0 and 1, and draw the probability distribution and fit curve with Gaussian distribution. (Note 1: Use any programming language or software Note 2: Use any software to plot, like gnu plot.)			
	Open-Ended Exploration and Assessment: (4 hrs) Recent development in Biophysics: Read an article from a scientific journal and discuss in groups and present as seminar			
	Group Assignment: Design a biological system which reflects the application of theories from any of the modules II-V or Find out an open problem in Biological system where physics theories make role.			
II	**The Molecular Dance**		**18**	**26**
	1	Probabilistic facts of life- *Discrete distribution, Continuous distribution, Expectation and variance, addition and multiplication rules*	2	
	2	Decoding the ideal gas law- *Temperature reflects the average kinetic energy of thermal motion, The complete distribution of molecular velocities is experimentally measurable, Boltzmann distribution, Activation barriers and control reaction rates, Relaxation to equilibrium*	3	
	3	Statistics of genetics & heredity: historical example	2	
	4	Brownian motion- *Just a little more history, Random walks lead to diffusive behaviour*	2	
	5	D*iffusion law is model independent, Friction is quantitatively leads to diffusion- Einstein's relation*	2	
	6	Other random walks- *The Confirmation of polymers*	1	
	7	Diffusion rules the sub cellular world, Diffusion follows a differential equation- *Fick's law, Diffusion equation*	2	
	8	Precise statistical prediction of random processes, Functions, Derivatives, and snakes under the rug	2	
	9	Biological Applications of Diffusion- *The permeability of artificial membranes is diffusive, Diffusion sets a fundamental limits on bacterial metabolism*	2	
Sections 3.1, 3.2, 3.3, 4.1, 4.3.1, 4.4, 4.5, 4.6.1, 4.6.2 of Book 1				
III	**Life in the slow lane: The low Reynolds number world-** Why don't bacteria swim like fish?		**10**	**14**

	10	Friction in Fluids- *Sufficiently small particles can remain in suspension indefinitely, The rate of sedimentation depends on solvent viscosity, Its hard to mix a viscous liquid*	3	
	11	Low Reynolds number- *Viscous force in Newtonian fluid, Relative importance of friction and inertia, time-reversal properties of dynamical law and dissipative character*	3	
	12	Biological Applications- *Swimming and Pumping, To Stir or Not to Stir?, Foraging, Attack, and Escape*	2	
	13	*Vascular networks, Viscous drag at DNA replication fork*	2	
Sections 5.1, 5.2, 5.3, of Book 1				
IV	**Entropy, Temperature, and Free energy**		**11**	**16**
	14	How to measure disorder; Entropy- *The Statistical Postulate, Entropy is a constant times the maximal value of disorder*	2	
	15	Temperature- *Heat flows to maximise disorder, Temperature is a statistical property of a system in equilibrium*	2	
	16	The Second Law- *Entropy increases spontaneously when a constraint is removed, Three remarks*	2	
	17	Open Systems- Free energy of a subsystem reflects the competition between entropy and energy, Entropic forces as derivates of free energy	3	
	18	Microscopic systems- The Boltzmann distribution follows from the statistical postulate, The minimum free energy principle also applies to microscopic systems	2	
Sections 6.1, 6.2, 6.3, 6.4, 6.5.1, 6.5.2, 6.6.1, 6.6.3 of Book 1				
V	**Nerve Impulses**		**9**	**14**
	19	The problem of nerve impulses- *Phenomenology of action potential*	2	
	20	Cell membrane as an electrical network	3	
	21	Simplified mechanism of action potential- *The puzzle, mechanical analogy*	2	
	22	Nerve, Muscle, synapse	2	
Sections 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.4 of Book 1				
Book for Study: 1. Biological Physics: Energy, Information, Life (*Student Edn.*) by Philip Nelson (Book 1) 2. Biophysics- An Introduction (*2nd Edn.*), Roland Glaser 3. Biophysics: An Introduction, 2nd Edn by Rodney Cotterill 4. Physical Biology of the Cell, R. Phillips, J. Kondev and J. Theriot				

5. Random Walks in Biology, Howard Berg
6. Zoological Physics: Quantitative Models of Body Design, Actions, and Physical Limitations of Animals by Boye K. Ahlborn

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	0	1	0	0	3	2	0	0	2	0	1
CO 2	3	1	0	0	0	0	3	2	0	0	0	0	2
CO 3	3	0	3	0	0	0	3	2	0	0	0	0	1
CO 4	3	1	0	0	0	0	3	2	0	0	0	0	1
CO 5	3	0	1	0	0	0	3	2	0	0	0	0	1
CO 6	3	0	0	0	1	1	3	2	0	0	0	0	1
CO 7	3	0	0	0	0	1	3	2	0	0	0	0	2

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓
CO7		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**APPLIED NUCLEAR PHYSICS**				
Type of Course	**Major Elective (SPECIALIZATION IV: DATA SCIENCE AND ARTIFICIAL INTELLIGENCE)**				
Semester	**VI**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Fundamental ideas in mechanics, electromagnetism, and mathematical physics along with the basic understanding of concepts in modern physics like atomic and nuclear structure.				
Course Summary	The course in Applied Nuclear Physics provides an in-depth account of the fundamental constituents of matter, their interactions, and the underlying principles governing nuclear structure, particle behaviour, and their implications in different walks of modern technology.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand Radioactive Processes: Explain the mechanisms and types of radioactive decay. Understand internal conversion and their roles in radioactive decay chains and environmental radioactivity.	Understand	Conceptual Knowledge	Quizzes, Tests

CO2	Analyze Nuclear Collisions and Reactions: Describe nuclear collision processes, understand nomenclature and probes, calculate cross sections and reaction rates, and discuss examples of isotope production and nuclear reactions, including elastic scattering and resonance.	Analyse	Procedural Knowledge	Homework Assignments
CO3	Apply Radiation Interaction Principles: Utilize the Bethe-Bloch formula to predict energy loss of heavy charged particles in matter, interpret Bragg curves, and analyze the dependence on projectile and medium. Understand gamma-ray attenuation and neutron interaction processes including attenuation and moderation.	Apply	Conceptual Knowledge	Problem Sets, Projects
CO4	Explore Neutron Physics: Discuss the properties of neutrons, classify different types of neutrons, and understand the various sources of neutrons. Use neutron detectors like the BF3 counter.	Analyse	Procedural Knowledge	Homework, Exams
CO5	Assess Biological Effects of Radiation: Evaluate the biological impacts of radiation exposure, differentiate between direct and indirect physical and chemical damage, calculate dose and dose rate, and understand dose distribution and its relative biological effectiveness. Assess human exposure from natural and artificial sources.	Understand	Basic Concepts	Virtual lab Demonstrations
CO6	Utilize Radiation in Industrial and Analytical Applications: Demonstrate the use of radiation in industrial applications. Apply analytical techniques for materials analysis.	Apply	Conceptual Knowledge	Problem Sets, Projects
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	**RADIOACTIVITY AND NUCLEAR COLLISIONS**		**12**	**20**
	1	Radioactivity and Radioactive Decay – Alpha emission, beta emission and electron capture, gamma emission and internal conversion	2	
	2	Rate of radioactive decay, Radioactive decay chains	2	
	3	Radio activity in the environment, Radioactive dating	1	
	4	Nuclear collisions, Nomenclature, Probes	1	
	5	Cross sections, differential cross- section and reaction rates	2	
	6	Isotope production, examples of nuclear reactions	2	
	7	Elastic scattering, Resonance. (Sufficient exercises)	2	
	Sections 1.5 and 1.6 of Book 1			
II	**RADIATION INTERACTION AND NEUTRON PHYSICS**		**12**	**20**
	8	Interaction of Radiation with Matter – Heavy charged particles	2	
	9	Bethe-Bloch Formula, Energy Dependence	2	
	10	Bragg curve, Projectile dependence, Medium dependence	2	
	11	Gamma ray attenuation, Neutrons, attenuation, neutron moderation	2	
	12	Neutron Physics - Discovery of neutron, Properties of neutrons, Magnetic moment measurement, Classification of neutrons	2	
	13	Sources of neutrons, radioactive sources, photo neutrons, Neutron detector-(BF3 counter) (Sufficient exercises)	2	
	Sections from 5.1 and 5.5 (Book for study 1) and 13.1 to 13.11 (Book 2)			
III	**BIOLOGICAL EFFECTS OF RADIATIONS**		**12**	**15**

	14	Biological effects of radiations - direct and indirect physical damage, indirect chemical damage	2	
	15	Dose, Dose rate and Dose distribution	3	
	16	Dose distribution and relative biological effectiveness, equivalent and effective dose	2	
	17	Damage to critical tissues	2	
	18	Human exposure to radiation, Natural sources, Artificial sources of exposure. (Sufficient exercises)	3	
	Section 7.1 and 7.5.2of Book 1			
IV	**INDUSTRIAL AND ANALYTICAL APPLICATIONS**		**12**	**15**
	19	Industrial and Analytical Applications – Industrial uses, Tracing, Gauging	2	
	20	Material modification, sterilization, Neutron Activation Analysis	3	
	21	Rutherford Back scattering	2	
	22	Particle Induced x-ray emission techniques for materials analysis	3	
	23	Accelerator mass spectrometry. (Sufficient exercises).	2	
	Sections from 8.1 to 8.6of Book 1			
V	**OPEN-ENDED MODULE** **NUCLEAR MEDICINE** - X-radiography and gamma camera, Positron Emission Tomography, Radiation therapy- using photons and electrons, radio nuclides, Neutron therapy, therapy with heavy charged particles, (Book 1) **Or** **REACTOR PHYSICS** – Neutron moderation mechanism, slowing down of neutrons, moderation ratio, diffusion of neutrons, reactor equation, critical size. (Book 2) **COMMERCIAL NUCLEAR REACTORS** – Gas cooled reactors, Pressurized water reactor, Heavy water reactors, Breeder reactors. **THERMONUCLEAR FUSION** – Basic principles, fusion containers –magnetic confinement, inertial confinement **Or** **USE OF PYTHON AS AN ANALYTIC TOOL -** Radiation attenuation in different material media can be modelled, computed and plotted with Python		**12**	

	Problems on material analysis in NAA, RBS and PIXE etc. can be done with Python programming. Analysis of Neutron diffusion and moderation mechanisms with appropriate computational tools.		

Books and References:

1. Nuclear Physics - Principles and Applications, John Lilley, Manchester Physics series, John Wiley and Sons (Book 1)
2. Nuclear Physics – SN Ghoshal, S-Chand & Company(Book 2)

Supplementary Readings -

3. Atomic and Nuclear Physics, N. Subrahmanyam , Brij Lal , Jivan Seshan, , S-Chand and company
4. Nuclear Physics, Anwar Kamal, Springer Publishers,
5. Nuclear Physics, D. C. Tayal, Himalaya Publishing House
6. The Basics of Nuclear Physics, Christopher Cooper, Roshan Publishing group, NY.
7. Nuclear Methods in Science and Technology, Yuri M. Tsipenyuk, IOP Publications

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	3	2	0	2	2	1	2	2	0	2	2
CO 2	3	2	2	3	2	0	3	0	0	2	2	0	0
CO 3	3	3	3	2	0	2	2	2	1	0	2	1	2
CO 4	2	2	2	2	0	0	3	0	2	2	0	0	0
CO 5	2	3	2	2	1	3	1	2	0	2	1	2	2
CO 6	0	2	2	2	0	2	0	0	2	0	0	2	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B. Sc. Physics Honours**				
Course Title	**FOUNDATIONS OF DATA SCIENCE**				
Type of Course	**Major Elective (SPECIALIZATION IV: DATA SCIENCE AND ARTIFICIAL INTELLIGENCE)**				
Semester	**V**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Fundamental Programming Concepts in Python 2. Basic idea of linear algebra				
Course Summary	The course will introduce the fundamental concepts of linear algebra, probability and statistics required for a program in data science				

Course Outcomes (CO):

CO	**CO Statement**	**'ognitive .evel***	**Knowledge Category#**	**Evaluation Tools used**
CO1	tudents will evaluate eigenvalues and igenvectors to decompose matrices, nabling them to analyze and interpret ata transformations effectively	An	P	nstructor-reated exams / ssignment
CO2	roficiency in solving linear quations using linear algebra and nderstanding the geometric nterpretation of solutions.	Ap	P	nstructor-reated exams / ssignment
CO3	tudents will apply fundamental robability concepts to solve real-vorld problems	Ap	P	ssignment /)uiz

CO4	tudents will utilize statistical chniques for data interpretation nd decision-making.	Ap	P	nstructor-reated exams / ssignment
CO5	tudents will apply sampling chniques and hypothesis tests to nake inferences about populations om sample data, using one-tailed, vo-tailed tests, and ANOVA for nalysis.	Ap	C	ssignment / ase Studies
CO6	evelop critical thinking and roblem-solving skills	E	M	Assignment / ase Studies
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create(C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Mark
I		**Linear Algebra**	**10**	**12**
	1	Matrices: Properties of matrix, Various kind of Matrices	1	
	2	Elementary Transformations of Matrices and Rank of Matrices	2	
	3	Determinants, Minors, Cofactors, Inverse of a matrix	2	
	4	Linear Independence: Characteristic equations, Eigen values and Eigen Vector	2	
	5	Solving system of linear equations: Gauss Elimination Method, Gauss Jordan method	3	
	Relevant sections of Book 1			
I I		**Basic Statistics and Descriptive Measures**	**10**	**15**
	6	Measures of Central Tendency	2	
	7	Measures of Dispersion	2	
	8	Measures of Skewness	2	
	9	Measures of Kurtosis	2	
	10	Correlation and Regression	2	
	Relevant sections of Book 2			
III		**Theory of Probability**	**13**	**21**
	11	Classical and Empirical Probability	2	

	12	Events, Algebra of events	2	
	13	Classical approach to probability, Axiomatic definitions of probability, Simple problems	2	
	14	Theorems of probability - Addition Theorem, Multiplication Theorem	2	
	15	Conditional probability	2	
	16	Bayes' Theorem and Geometrical Probability – Examples and Problems	3	
	Relevant sections of Book 2			
IV	**Advanced Probability Distributions**		**15**	**22**
	17	Discrete and continuous random variables and probability distribution	2	
	18	Binomial distribution: Definition, Expectation, Variance, Moment Generating Function and Problems	3	
	19	Poisson distribution: Definition, Expectation, Variance, Moment Generating Function and Problems	3	
	20	Normal distribution: Definition, Expectation, Variance, Moment Generating Function, Standard normal curve and Problems	3	
	21	Testing of Hypothesis: General principles of testing, Two types of errors	2	
	22	Type of Testing: T-Test, ANOVA-Test, Chi-square test (Basics only)	2	
	Relevant sections of Book 2			
V	**Open Ended Module**		**12**	

Books and References:

1. Gilbert Strang, "Introduction to Linear Algebra", Wellesley-Cambridge Press (Book 1)
2. Fundamentals of Mathematical Statistics. S.C. Gupta , V.K. Kapoor, Sultan Chand & Sons, 2020 (Book 2)
3. Introduction to Mathematical Statistics, Hogg R V Craig A T, Macmillan
4. Probability and Statistics for Engineers, Miller I Freund J E, Prentice Hall of India
5. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley
6. Higher Engineering Mathematics, B S Grewal, Khanna Publishers

Mapping of COs with PSOs and POs :

	PSO 1	PSO-2	PSO 3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	1	2	2	3	1	3	1	2	2	3	2	1
CO 2	3	1	2	2	3	1	3	1	2	2	3	2	1
CO 3	2	2	3	2	2	2	3	1	3	2	3	2	2
CO 4	2	2	3	2	2	2	3	1	3	2	3	2	2
CO 5	2	2	3	2	2	2	3	1	3	2	3	2	2
CO 6	1	1	2	2	1	2	3	3	2	2	3	3	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	**Assignment /Viva**	**Practical Skill Evaluation**	**End Semester Examinations**
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**EXPLORATORY DATA ANALYSIS USING PYTHON**				
Type of Course	**Major Elective (SPECIALIZATION IV: DATA SCIENCE AND ARTIFICIAL INTELLIGENCE)**				
Semester	**V**				
Academic Level	**300 -399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Fundamental Programming Concepts in Python 2. Basic idea of Statistics				
Course Summary	This course provides insight into the basic concepts of data analysis and different visualization tools and techniques and teaches the application of these techniques using Python packages.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the types of data and the applications of data science	U	C	Instructor-created exams / Quiz
CO2	Analyse the irregularities present in the data and perform data cleaning	An	C	Problem-solving assessments
CO3	Become familiar with data format & programs used in data analysis	U	F	Practical Assignment / Observation of Practical Skills

CO4	Understand & apply Pandas module for data analysis	U, Ap	P	Instructor-created exams, Practical Assignment / Observation of Practical Skills
CO5	Understand & apply Seaborn module for data visualization	U, Ap	P	Instructor-created exams, Practical Assignment / Observation of Practical Skills
CO6	Learners will develop skills in advanced features of spreadsheets such as macros, protecting data sheets and workbooks, utilizing split, freeze, and hide options effectively	Ap	P	Assignments/ Case Studies
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create(C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Mark 70
I		**Introduction to Data Science**	**8**	**10**
	1	Introduction to Data Science-Definition	2	
	2	Evolution of Data Science	2	
	3	Data Science Roles	2	
	4	Application of data sciences.	2	
	References 1. O'Neil, Cathy, and Rachel Schutt. Doing data science: Straight talk from the frontline. " O'Reilly Media, Inc.", 2013. 2. Machine Learning in Data Science using Python, Dr. R. Nageswara Rao, Dream tech press, 2022 3. Shah, Chirag. A Hands-On Introduction to Data Science. United Kingdom, Cambridge University Press, 2020			

II		**Data Collection and Data Pre-Processing**	**12**	**18**
	5	Data and Data Attributes , Types of Data & Data Attributes	2	
	6	Data Collection Strategies	2	
	7	Data Pre-Processing , Data Cleaning	2	
	8	Data Integration and Transformation	3	
	9	Data Reduction and Discretization	3	
	References Chapter 2, 3 of Book 2			
III		**Data Analysis and Manipulation using Pandas**	**12**	**18**
	10	Introducing different data file formats: csv, xls, tab, dat formats.	2	
	11	Series - constructing from an array, using explicitly defined indices, using a dictionary	2	
	12	Data Frame - constructing from arrays, dictionaries, structured arrays, and series, Indexing of data frames	2	
	13	Arithmetic and Binary operations on Data frame	2	
	14	Broadcasting operations	2	
	15	Universal functions, melt() and pivot()	2	
	References Chapter 5 of Book 1			
IV		**Data Visualization using Seaborn**	**16**	**24**
	16	Review of Data Visualization using matplotlib	2	
	17	Loading datasets in Seaborn, Distribution plot	2	
	18	Count plot, box plot, scatter plot, joint plot.	3	
	19	Line Plot, displaying scatter plot with regression line	2	
	20	Creating subplots	3	
	21	Heat map - cat plot	2	
	22	Violin plot - pair plot.	2	
	References Chapter 6 of Book 1			

V	**Open ended Module** **Hands-on Data Visualization:** Working with Pandas data frames Basic plots using Matplotlib Distribution Plots: Histogram, Density Plot, Box Plot, Violin Plot etc **Plotting Geospatial Data** Introduction to Geoplotlib, The Design Principles of Geoplotlib Geospatial Visualizations - Choropleth Plot, GeoJSON File Introduction to Folium Visualizing Data: Building a Google map from geocoded data Making Things Interactive with Bokeh : Introduction to Bokeh, Concepts of Bokeh, Interfaces in Bokeh Bokeh Server, Presentation, Integrating, Adding Widgets	**12**	

Books and References

1. Data Science and Machine Learning using Python by Reema Thereja Mc Graw Hill(Book1)
2. Data Mining Concepts and Techniques by Jiawei Han , Elsiever(Book 2)
3. O'Neil, Cathy, and Rachel Schutt. Doing data science: Straight talk from the frontline. " O'Reilly Media, Inc.", 2013.
4. Machine Learning in Data Science using Python, Dr. R. Nageswara Rao, Dream tech press, 2022

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	0	1	0	2	0	2	0	1	2	2	0	0
CO 2	1	2	2	1	1	2	2	0	2	2	2	0	0
CO 3	2	1	2	1	1	1	2	0	1	2	2	0	0
CO 4	2	1	2	2	2	2	2	0	2	3	3	0	1

CO 5	2	1	2	2	2	2	2	0	2	3	3	0	1
CO 6	1	2	2	1	1	2	2	0	2	2	2	0	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B. Sc. Physics Honours**				
Course Title	**FOUNDATIONS OF ARTIFICIAL INTELLIGENCE**				
Type of Course	**Major Elective (SPECIALIZATION IV: DATA SCIENCE AND ARTIFICIAL INTELLIGENCE)**				
Semester	**VI**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practica L per week	Total Hours
	4	4	-	-	60
Pre-requisites	Awareness of algorithmic approaches				
Course Summary	The course introduces the concept of artificial intelligence. The various knowledge representation and Knowledge Inference methods are introduced. The course introduces the application of AI in various fields.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Able to gain insight into the evolution of key ideas and technologies by exploring the Artificial Intelligence history and its foundational concepts.	U	C	Instructor-created exams /Quiz/Assignment/ Seminar
CO2	Able to acquire knowledge and skills to understand, design, implement intelligent agents to perceive, reason and act within their environments.	U	C	Instructor-created exams/ Quiz/Assignment/ Seminar

CO3	Proficiency in various uninformed and informed search strategies along with constraint satisfaction problem solving methods.	U	C	Instructor-created exams/ Quiz/Assignment/ Seminar
CO4	Ability to design and implement logical agents and construct ontologies that capture the semantics of a domain, facilitating knowledge representation.	U	C	Instructor-created exams/ Quiz/Assignment/ Seminar
CO5	Understand the ethical considerations of AI and their societal impacts and gain insights into the future trajectory of AI by analysing the emerging trends.	U	C	Instructor-created exams/ Quiz/Assignment/Seminar
CO6	Represent various AI problems using algorithmic approaches and enhance problem-solving skills by visualizing solutions through the utilization of software tools.	U, Ap	C, P	Practical Assignment / Observation of Practical Skills
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Mark
I		**Introduction to AI**	**8**	**12**
	1	Artificial Intelligence: Definition, Advantages and Disadvantages	1	
	2	History of Artificial Intelligence	2	
	3	Types of Artificial Intelligence	2	
	4	Applications of AI	2	
	5	The Future of AI	1	
	References Chapter 1 of Book 1, Chapter 1 of Book 2			
II		**Artificial Intelligence Technologies**	**16**	**22**
	6	Techniques in AI	2	
	7	Intelligence and Components of Intelligence	3	

	8	Agent and Environment	3	
	9	Informed Search Algorithms and Uninformed Search Algorithms	3	
	10	Hill Climbing Algorithm in Artificial Intelligence	3	
	11	Local Search Algorithms	2	
	References Chapter 3 of Book 1, Chapter 2 of Book 2			
III	**Knowledge Representation & Reasoning**		**14**	**21**
	12	Knowledge Representation , Knowledge based agents, The Wumpus world	3	
	13	Types of Knowledge ,Techniques of Knowledge Representation in AI, Logical Connectives in Propositional Logic	3	
	14	Inference Rules, Forward Chaining and Backward Chaining in AI	3	
	15	Reasoning: Probabilistic Reasoning in Artificial Intelligence	2	
	16	Bayes' Theorem : Bayesian Belief Network in Artificial Intelligence	3	
	References Chapter 4,5 of Book 1, Chapter 12,13,14 of Book 2			
IV	**Current Trends in Artificial Intelligence**		**10**	**15**
	17	AI and Ethical Concerns	1	
	18	AI as a Service (AIaaS)	1	
	19	Robotics	2	
	20	Recent Trends in AI	2	
	21	Expert System: Characteristics, Components and Applications	2	
	22	Internet of Things(IoT) and Artificial Intelligence of Things (AIoT)	2	
	References Chapter 8 of Book 1, Chapter 26,27 of Book 2			
V	**Open Ended Module:** .		**12**	

Books and References

1. Artificial Intelligence Beyond Classical AI by Reema Thareja , Pearson Education(Book 1)
2. Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig, Pearson Education (Book 2)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	0	0	0	1	0	3	0	1	1	2	1	0
CO 2	2	2	1	1	1	1	3	2	2	2	2	1	1
CO 3	2	2	3	1	1	1	3	1	2	2	3	1	1
CO 4	2	2	2	1	1	2	3	2	2	2	3	2	1
CO 5	1	0	1	0	1	0	3	1	1	2	3	3	1
CO 6	2	2	3	1	1	2	3	1	2	3	3	1	2

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B. Sc. Physics Honours**				
Course Title	**MACHINE LEARNING USING PYTHON**				
Type of Course	**Major Elective (SPECIALIZATION IV: DATA SCIENCE AND ARTIFICIAL INTELLIGENCE)**				
Semester	**VI**				
Academic Level	**300 -399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Awareness of algorithmic approaches 2. Data Analysis Using Python				
Course Summary	This course deals with various algorithms to enable computers to learn data without being explicitly programmed. An insight into various types of machine learning algorithms, strategies for model generation and evaluation are given in this course.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts and importance of Machine Learning, its types	U	C	Instructor-created exams / Quiz
CO2	Understand & apply Scikit-learn module for Machine Learning	U,Ap	P	Instructor-createEd exams, Observation of Practical Skills

CO3	Understand the supervised learning algorithms and its application	U,Ap	P	Instructor-created exams/ Quiz/Assignment/ Seminar
CO4	Understand the unsupervised learning algorithms and its application	U,Ap	P	Instructor- created exams/ Quiz/Assignment/ Seminar
CO5	Understand the semi supervised learning algorithms and its application	Ap	P	Practical assignments and practical tests
CO6	Develop critical thinking skills to analyze and solve complex problems using machine learning approaches	Ap	P	Practical assignments and practical tests
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create(C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Mark
I		**Introduction to Machine Learning**	**10**	**15**
	1	Introduction to Machine Learning - Learning Types of Machine Learning	2	
	2	Computational Tools for ML	2	
	3	Introduction to Scikit-learn, Getting Datasets, Generating Your Own Dataset	2	
	4	Getting Started with Scikit-learn- Fitting the Model, Making Predictions,	2	
	5	Data Cleansing- Cleaning Rows with NaNs, Removing Duplicate Rows	2	
		References Chapter 9 of Book 1, Chapter 5 of Book 3		
II		**Supervised Learning Algorithms**	**15**	**25**
	6	Supervised Learning – Introduction and Types	1	

	7	Regression - Simple Linear Regression , Multiple Linear Regression	3	
	8	Classification	2	
	9	Naive Bayes classifier algorithm	3	
	10	Decision Tree	2	
	11	K nearest neighbor (KNN)	2	
	12	Logistic Regression	2	
	References Chapter 10,11 of Book 1, Chapter 2 of Book 2			
III	**Unsupervised Learning Algorithms**		**15**	**18**
	13	Unsupervised Learning	2	
	14	Clustering	2	
	15	K-means Clustering	3	
	16	Hierarchical clustering - Two approaches	3	
	17	Association rule learning	2	
	18	Apriori Algorithm	3	
	References Chapter 10,11 of Book 1, Chapter 3 of Book 2			
IV	**Reinforcement Learning**		**8**	**12**
	19	Semi-supervised learning	2	
	20	Markov Decision Process (MDP)	2	
	21	Markov Chain and Markov Process	2	
	22	Applications of Markov Decision Process	2	

	References Chapter 5 of Book 2		
V	**Open Ended Module:** .	**12**	

Books and References :

1. Data Science and Machine Learning using Python by Reema Thereja Mc Graw Hill (Book 1)
2. Machine Learning by Dr Ruchi Doshi, Dr Kamal Kant Hiran, Ritesh Kumar Jain Dr Kamlesh Lakhwani BPB Publications (Book 2)
3. Python Machine Learning by Wei-Meng Lee , John Wiley & Sons (Book 3)
4. Machine Learning in Data Science using Python, Dr. R. Nageswara Rao, Dream tech press, 2022(Book 4)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	0	2	0	3	1	3	1	1	2	3	1	1
CO 2	2	2	3	1	3	3	2	2	2	3	2	2	2
CO 3	2	2	3	1	3	3	2	2	2	3	3	2	2
CO 4	2	2	3	1	3	3	2	2	2	3	3	2	2
CO 5	2	2	3	1	3	3	2	2	2	3	3	2	2
CO 6	1	2	3	2	2	3	3	3	3	3	3	3	3

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ASTROPHYSICS**				
Type of Course	**Major Elective**				
Semester	**V**				
Academic Level	**300 – 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY4CJ205 Modern Physics				
Course Summary	This course gives a pedagogical introduction to astronomy and astrophysics by introducing the students the techniques to measure astronomical parameters, the properties of the Sun, stellar evolution and properties of galaxies and an overview of the Universe.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate a deep understanding of theoretical frameworks in astronomy,	U	C	Instructor-created exams / Quiz

	including celestial mechanics, stellar structure, and cosmology.			
CO2	Apply basic physical principles from a broad range of topics in physics to address complex astronomical phenomena.	Ap	P	Viva Voce / Home Assignments/ Seminar Presentations
CO3	Get knowledge of positional astronomy, astronomical parameters and tools.	U	C	Instructor-created exams / Quiz
CO4	Able to explain the physics of Sun and the evolution of stars.	U	C	Instructor-created exams / Quiz
CO5	Describe the morphology and classification of galaxies and galaxy clusters.	U	C	Instructor-created exams / Quiz
CO6	Expose scientific knowledge about the origin and evolution of the universe.	U	C	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	**ASTRONOMICAL PARAMETERS AND TOOLS**		**12**	**18**
	1	The celestial sphere, The constellations, The celestial coordinate system	2	

	2	Stellar luminosity, Stellar distances, The parsec, The Cepheid variable distance scale	3	
	3	Stellar magnitudes, Apparent magnitudes, Magnitude calculations, The absolute magnitude scale, The standard formula to derive absolute magnitudes	3	
	4	Colour and surface temperature, Stellar photometry, Stellar spectra, Spectral types, Spectroscopic parallax.	2	
	5	Basics of refracting telescopes- Resolution, Magnification, Newtonian telescope	1	
	6	Active and adaptive optics, Active optics, Adaptive optics	1	
	Sections 1.3, 1.3.1, 1.3.2. 1.3.3, 1.3.4, 1.4, 5.3, 5.4, 5.5, 5.7, 5.10, 5.10.1, 5.10.2, 6.1, 6.2, 6.2.1, 6.4, 6.4.1, 6.5, 6.6, 6.7, 6.7.2, 6.8, 8.3.3 of Book 1			
II	**THE SUN AND HR DIAGRAM**		**12**	**18**
	7	The Sun, Overall properties of the Sun, The Sun's total energy output, The Fraunhofer lines in the solar spectrum	2	
	8	Nuclear fusion, The proton–proton cycle	2	
	9	The solar neutrino problem, The solar atmosphere, chromosphere and corona	2	
	10	The solar wind, The sun's magnetic field and the sunspot cycle, Prominences, flares and the interaction of the solar wind with the earth's atmosphere	3	
	11	The Hertzsprung–Russell diagram, The main sequence, The giant region, The white dwarf region, The stellar mass–luminosity relationship, Stellar lifetimes	3	
	Sections 2.2-2.8, 6.9, 6.12, 6.13 of Book 1			
III	**STELLAR EVOLUTION**		**12**	**18**

	12	Stellar Evolution, Low mass stars, Mid mass stars. Moving up the main sequence	2	
	13	The triple alpha process, The helium flash, Variable stars	3	
	14	Planetary nebula, White dwarfs, The discovery of white dwarfs, The future of white dwarfs, Black dwarfs, The evolution of a sun-like star, Evolution in close binary systems – the Algol paradox	3	
	15	High mass stars in the range >8 solar masses, Type II supernova, The Crab Nebula, Neutron stars and black holes,	2	
	16	The discovery of pulsars, What can pulsars tell us about the universe? Black holes, The detection of stellar mass black holes	2	
	Chapter 7 of Book 1			
IV	**GALAXIES AND THE UNIVERSE**		**12**	**16**
	17	The Milky Way, Open star clusters, Globular clusters, The interstellar medium and emission nebulae	2	
	18	Size, shape and structure of the Milky Way, A super-massive black hole at the heart of our galaxy	2	
	19	Other galaxies, Elliptical galaxies, Spiral galaxies, Evidence for an unseen component in spiral galaxies – dark matter, Irregular galaxies, The Hubble classification of galaxies	3	
	20	Active galaxies, Groups and clusters of galaxies, Superclusters, The structure of the universe	2	
	21	Big Bang models of the universe, The expansion of the universe, The cosmological redshift, The steady state model of the universe, Big Bang or Steady State?	2	
	22	The cosmic microwave background, The discovery of the cosmic microwave background, Inflation, Formation of the primeval elements	1	

	Sections 8.1-8.3, 9.2-9.9 of Book 1		
V	**OPEN ENDED MODULE: MASTERING HASHING FOR EFFICIENT DATA HANDLING**	**12**	
	• VO Tools. Reference 6 • Session 8.4, Question 1 of Book 1 • Planets, comets, asteroids etc. • Vizier, CDS, NED, SDSS etc. • Observing in other wavebands • Binary stars and Extra-solar Planets	12	
	References: Book 2-5		

Books and References:

1. Introduction to Astronomy and Cosmology by Ian Morison, John Wiley & Sons, 2008 (Book 1)
2. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books. (Book 2)
3. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.(Book 3)
4. Baidyanath Basu, 'An introduction to Astrophysics', Second printing, Prentice -Hall of India Private Limited, New Delhi, 2001.(Book 4)
5. Astronomy: A Physical Perspective by Marc L. Kutner, Cambridge University Press(Book 5)
6. https://va-iitk.vlabs.ac.in/?page=listexp

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	2	3	1	1	2	3	2	3	1	2	3	3
CO 2	3	2	2	1	2	2	3	2	3	1	2	3	3
CO 3	2	2	2	2	2	2	3	2	3	1	2	3	3
CO 4	2	2	2	2	2	2	3	2	3	1	2	3	3
CO 5	3	2	2	1	2	2	3	2	3	1	2	3	3
CO 6	3	2	3	2	2	2	3	2	3	1	2	3	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**SPACE PHYSICS**				
Type of Course	**Elective in Major**				
Semester	**VI**				
Academic Level	**300 - 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY4CJ205- Modern Physics				
Course Summary	This course introduces the student to Space Physics. The various subdisciplines of the topic such as structure and properties of the solar system with emphasis on Earth and the Sun and their magnetic fields, the elements of planetary science, the rudiments of space weather as well as basics of space flight dynamics are dealt with in detail.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic structure and parameters of the Earth and the Sun including their atmospheres and their magnetic fields	U	C	Instructor-created exams / Quiz
CO2	Understand the basic elements of planetary science including the structure of the solar system and the classification of its constituents	U	C	Viva Voce / Home Assignments/ Seminar Presentations

CO3	Understand the basics of space weather and its various phenomena such as solar wind, interplanetary space and solar activities like coronal mass ejections	U	C	Instructor-created exams / Quiz
CO4	Understand the theory behind the orbital dynamics and the technology of rocket and spacecraft propulsion	U & Ap	C	Instructor-created exams / Quiz
CO5	Interpret the complex structures and dynamics of Earth's magnetosphere, including the polar cusp, plasma sheet, ring current, radiation belts, and associated wave phenomena.	Ap	C	Instructor-created exams / Quiz
CO6	Equip with the knowledge and skills necessary to apply principles of space science in analyzing and understanding various phenomena within our solar system and beyond.	U	C	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (48 +12)**	**Marks (70)**
I		**The Earth and the Sun**	**14**	**20**
	1	The Earth - Gross properties, Internal structure of the Earth	2	
	2	The terrestrial atmosphere, The Earth's magnetic field	2	
	3	Motions of the Earth, Solar – Terrestrial relations, The Earth in Space	2	
	4	The Sun - Introduction, Vital statistics of the Sun, The Solar Photosphere,	3	
	5	Structure of Solar atmosphere, The solar interior, Sunspots and solar cycle	3	
	6	Other features of Solar activity, Radio Studies of the Quiet Sun, Radio radiation of the disturbed Sun	2	

	Sections 5.1 to 5.6,5.8, 4.1 -to 4.3, 4.5-4.10 of Book 1			
II	**Planetary Science**		**14**	**20**
	7	Planetary science – Introduction, the solar system in the last four millennia	2	
	8	Origin of the solar system, Evolution of atmospheres	3	
	9	Terrestrial planets, Outer planets, structure and classification	3	
	10	Comets, Asteroids, their origin and properties	2	
	11	Magnetospheres of planets, their structure and prominent properties	2	
	12	Planetary missions, Other solar systems	2	
	Sections 3.1 to 3.11 of Book 2			
III	**Space Weather**		**10**	**15**
	13	What is a space plasma, What is a plasma, The realm of plasma physics	2	
	14	The solar wind and interplanetary magnetic field, Magnetic reconnection	2	
	15	Space weather – introduction, Solar activity, The Solar wind	2	
	16	Aurora, Auroral substorms, Solar flares, The ionosphere	2	
	17	Coronal mass ejections and geomagnetic storms, Magnetic storms and substorms	2	
	Sections 5.1 to 5.5, 5.7, 5.8, 5.11, 5.14 of Book 2			
IV	**Orbital Dynamics**		**10**	**15**
	18	Celestial Mechanics - Foundations, Attraction of a spherical body	1	
	19	The two – body approximation, The two – body orbit, Kepler's equation, Determination of orbit	2	
	20	Space Dynamics - The energy requirements, Rocket propulsion	2	
	21	Sub – orbit flights, Artificial satellites, Lunar and Planetary probes	3	
	22	Multistage rockets- introduction, Reusable launch vehicles	2	
	Sections 2.1 to 2.9, 3.1 to 3.6 of Book 1 Sections 7.1, 7.4,7.7 of Book 3			

V	Open Ended Module: The Terrestrial Magnetosphere		12	
		he structure of the Magnetosphere The polar cusp, The near - Earth plasma sheet, The ring current The plasmasphere, The radiation belts; the South Atlantic anomaly Waves in the magnetosphere. Classification of waves		
	References: Books 2-5			

Books and References:

1. Astrophysics of the Solar System – K D Abhyankar, Universities Press, 1999 (Book 1)
2. Space Science – Louise K. Harra & Keith O. Mason, Imperial College Press, London, 2004 (Book 2)
3. Space Flight Dynamics – William E Wiesel, McGraw Hill, 3rd Ed., 2010 (Book 3)
4. Space Physics: An Introduction – C T Russell, Luhmann & Strangeway, Cambridge University Press, 2016
5. Astrophysics, Stars and Galaxies - K D Abhyankar, Universities Press, 2001
6. A Question and Answer Guide to Astronomy by Bely, Christian and Roy, Cambridge University Press
7. Introduction to Space Physics – M.G. Kivelson & C.T.Russell, Cambridge University Press, 1995

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	0	0	0	0	0	3	2	0	0	0	0	3
CO 2	3	2	0	0	0	0	3	2	0	0	0	0	3
CO 3	3	2	0	0	0	0	3	2	0	0	0	0	3
CO 4	3	0	0	2	0	0	3	2	0	2	0	0	3
CO 5	3	0	0	0	0	0	3	2	0	0	0	0	3
CO 6	3	0	0	0	0	0	3	2	0	0	0	0	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignme nt /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ATMOSPHERIC PHYSICS**				
Type of Course	**Major Elective**				
Semester	**VI**				
Academic Level	**300 – 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Basic thermodynamics. 2. Basic electrostatics.				
Course Summary	This course explores the structure and dynamics of the Earth's atmosphere. The vertical structure of the atmosphere, atmospheric thermodynamics, Earth's heat and radiation budget as well as atmospheric electricity are discussed. Basics of climate change and atmospheric photochemistry are also introduced.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic structure of the atmosphere and its constituents stratified to several layers. Understand rainfall, its distribution as well as the role played by winds.	U, R	F	Instructor-created exams / Quiz
CO2	Obtain basic idea of global warming. Apply the concepts of pressure, temperature, humidity to atmosphere and their role in climate change.	U, Ap	F, P	Instructor-created exams / Quiz
CO3	Apply thermodynamical concepts and latent energy to analyse stability of air parcel	Ap, An	F, C	Instructor-created exams / Quiz
CO4	Understand the atmospheric energy budget and the role played by radiation in it.	U, Ap	F	Instructor-created exams / Quiz
CO5	Understand basic atmospheric photochemistry and the role of trace gases.	U	F	Instructor-created exams / Quiz
CO6	Understand cloud physics and thunderstorm electricity. Apply the concept of electric field to atmosphere in the form of lightning and learn about lightning protection measures.	U, Ap	F, P	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Modul e	Uni t	Content	Hrs (48 +12)	Mar ks (70)
I		**INTRODUCTION TO ATMOSPHERIC PHYSICS**	**13**	18
	1	The atmosphere — Origin and Composition of the atmosphere.	2	
	2	Different layers of the atmosphere. Vertical thermal structure of the atmosphere – distribution of pressure and temperature.	3	
	3	Global distribution of precipitation.	2	
	4	Measurement techniques: air temperature, relative humidity, pressure, rain fall.	2	
	5	Introduction to atmospheric boundary layer.	2	
	6	Greenhouse effect, global warming.	2	
Atmospheric Physics, Chapter 1, Chapter 2: 2.1-2.4, Chapter 3: 7. *Basics of Atmospheric Science*, Chapter 1:1.3, 1.5.1, Chapter 8: 8.1, 8.2, 8.9. 8.10				
II		**ATMOSPHERIC THERMODYNAMICS**	**9**	12
	7	Adiabatic processes –concept of an air parcel, lapse rate, thermodynamic parameters and diagrams.	3	
	8	Atmospheric stability- unsaturated air, saturated air, conditional and convective instability.	3	
	9	CAPE, CINE, CIFK and CISK.	3	
Chapter 3: 3.4, 3.6. of Atmospheric Science, John M. Wallace. Peter V. Hobbs, Chapter 5: 5.5.3. of *Atmospheric Science,*				
III		**ATMOSPHERIC RADIATION AND PHOTOCHEMISTRY**	**15**	25
	10	Radiation: The spectrum of radiation – Black body radiation.	1	
	11	Planck function, radiative properties of non-black bodies.	3	

<table>
<tr><td rowspan="5"></td><td>12</td><td>Scattering and absorption by air molecules and particles.</td><td>2</td><td rowspan="5"></td></tr>
<tr><td>13</td><td>Atmospheric windows, solar constant.</td><td>2</td></tr>
<tr><td>14</td><td>Surface radiation budget and net radiation, radiative forcing.</td><td>3</td></tr>
<tr><td>15</td><td>Atmospheric photochemistry of NO, NO2, O3, CH4, CO.</td><td>3</td></tr>
<tr><td>16</td><td>Absorption of radiation by trace gases.</td><td>1</td></tr>
<tr><td colspan="4">Atmospheric Physics, Chapter 3: 2, 3, 8, 10. Basics of Atmospheric Science, Chapter 4: 4.1, 4.2, 4.3, 4.4, 4.5, Chapter 12: 12.1.2, 12.13, 12.1.4. Atmospheric Chemistry and Physics, Chapter 4: 4.5, 4.6, 4.7, 4.9, 4.10.</td><td></td></tr>
<tr><td rowspan="7">IV</td><td colspan="2">ATMOSPHERIC ELECTRICITY</td><td>11</td><td rowspan="7">15</td></tr>
<tr><td>17</td><td>Cloud morphology, structure and dynamics of thunder clouds.</td><td>2</td></tr>
<tr><td>18</td><td>Fair weather electric field in the atmosphere and potential gradient.</td><td>2</td></tr>
<tr><td>19</td><td>Ionisation in the atmosphere, conduction currents, point discharge current, air Earth currents.</td><td>2</td></tr>
<tr><td>20</td><td>Electric field in thunderstorm, theories of thundercloud electrification.</td><td>2</td></tr>
<tr><td>21</td><td>Lightning discharge, global electric circuit, Cloud electrification mechanisms.</td><td>2</td></tr>
<tr><td>22</td><td>Physics of lightning-lightning protection.</td><td>1</td></tr>
<tr><td colspan="4">Atmospheric Physics, Chapter 6: 2-7. Atmospheric Science, Chapter 5: 5.5.2, 5.5.3. Chapter 6: 6.7, Chapter 8: 8.3.2.</td><td></td></tr>
<tr><td rowspan="2">V</td><td colspan="2">OPEN ENDED MODULE</td><td>12</td><td></td></tr>
<tr><td></td><td>Optical features of the atmosphere: Refraction, scattering, Diffraction phenomena, aurorae, Indian monsoon.</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Relevant sections from chapters 2-7, Rainbows, Halos and Glories.</td><td></td><td></td></tr>
</table>

Books and References:

1. Atmospheric Physics, J. V. Iribarne, H.R. Cho, Springer, 1980 (Book 1)
2. Atmospheric Science, John M. Wallace. Peter V. Hobbs, Elsevier, 2006 (Book 2)
3. Atmospheric Chemistry and Physics, John H. Seinfeld, Spyros N. Pandis, John Wiley & Sons, 2006.
4. Basics of Atmospheric Science 2nd Edition, A. Chandrasekar, PHI, 2010
5. Rainbows, Halos and Glories, Robert Greenler, Cambridge University Press, 1980.
6. Atmosphere, Weather and Climate 9th edition, Roger G. Barry, Richard J Chorley, Routledge, 2017.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO3	PS O4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7
CO 1	3	2	2	2	3	3	3	2	3	1	2	3	3
CO 2	2	2	2	2	3	2	3	2	3	1	2	3	3
CO 3	2	3	2	3	3	3	3	2	3	1	2	3	3
CO 4	2	2	3	2	2	2	3	2	3	1	2	3	3
CO 5	2	2	2	2	3	2	3	2	3	1	2	3	3
CO 6	2	3	3	2	2	3	3	2	3	1	2	3	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**QUANTUM COMPUTATION AND QUANTUM INFORMATION**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 – 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Linear Algebra 2. Basic Quantum Mechanics				
Course Summary	The Quantum Computation and Quantum Information course provides students with a comprehensive understanding of quantum computing and quantum information theory. Fundamental principles including superposition, entanglement, and quantum gates are explored, laying the groundwork for quantum computation. Students delve into advanced quantum algorithms such as Shor's and Grover's algorithms, which promise exponential speedup over classical counterparts for specific tasks. Additionally, the course examines practical applications like quantum teleportation, super dense coding, quantum error correction, and quantum key distribution, showcasing the real-world implications of quantum information processing. By the end of the course, students emerge equipped with both theoretical knowledge and practical insights, positioning them at the forefront of this rapidly evolving field.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Comprehensive Understanding of Mathematical Formulations of Quantum Mechanics.	U	C	Viva Voce/ Seminar / Quiz
CO2	Proficiency in Analyzing and Utilizing Entanglement.	An	P	Practical Assignment / Group Discussion
CO3	Mastery of Quantum Gates and Circuits.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Application of Entanglement and Management of Quantum Noise.	An	P	Instructor-created exams / Home Assignments
CO5	Proficient Use of Tools in Quantum Information Theory.	Ap	M	Viva Voce
CO6	Integration and Application of Quantum Concepts in Practical Scenarios.	C	M	Group Discussion/ Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (12+48)	Marks (70)
I	OPEN ENDED MODULE: MATHEMATICAL FORMULATIONS OF QUANTUM MECHANICS		12	

II		**INTRODUCTION TO INFORMATION THEORY**	**14**	**20**
	1	Classical information, Information content in a signal, Entropy and Shannon's information theory, Probability basics (Chapter 1)	2	
	2	Representing composite states in Quantum mechanics, Tensor products of column vectors, Operators and tensor products, Tensor products of matrices (Chapter 4)	3	
	3	The Density Operator for a Pure State, Time Evolution of the Density Operator, The Density Operator for a Mixed State, Key Properties of a Density Operator (Chapter 5)	2	
	4	Probability of Obtaining a Given Measurement Result, Characterizing Mixed States, Probability of Finding an Element of the Ensemble in a Given State (Chapter 5)	2	
	5	The Partial Trace and the Reduced Density Operator, The Density Operator and the Bloch Vector (Chapter 5)	2	
	6	Distinguishing Quantum States and Measurement, Projective Measurements (Chapter 6)	1	
	7	Measurements on Composite Systems, Generalized Measurements, Positive Operator-Valued Measures (Chapter 6)	2	
	Sections from References: Chapters – 1, 4, 5, 6 of Book 1.			
III		**ENTANGLEMENT, QUANTUM GATE AND CIRCUITS**	**18**	**25**
	8	Bell's Theorem, Bipartite system and the Bell basis, When is a state entangled (Chapter 7)	2	
	9	The Pauli Representation, Entanglement Fidelity, Using Bell States for Density Operator Representation (Chapter 7)	2	
	10	Schmidt Decomposition, Purification (Chapter 7)	2	
	11	Classical logical gates, Single qubit gates, More single qubit gates (Chapter 8)	2	

	12	Basic quantum circuit diagram, Controlled gates, Gate decomposition (Chapter 8)	2	
	13	Hadamard gates, The phase gate. (Chapter 9)	1	
	14	Quantum Interference, Quantum Parallelism, Deutsch Jozsa Algorithm (Chapter 9)	3	
	15	Quantum Fourier transform, Shor's Algorithm, Quantum Searching and Grover's Algorithm (Chapter 9)	4	
	Sections from References: Chapters – 7, 8, 9 of Book 1.			
IV	**APPLICATION OF ENTANGLEMENT AND QUANTUM NOISE**		**11**	**18**
	16	Teleportation, Entanglement swapping, Superdense coding (Chapter 10)	3	
	17	A brief overview of RSA encryption, Basic quantum cryptography (Chapter 10)	2	
	18	The B92 protocol, The B91 protocol (Chapter 11)	2	
	19	Single qubit errors, Quantum Operation and Krauss operators (Chapter 12)	2	
	20	The depolarization channel, The bit flip and phase flip channels, Amplitude damping, Phase damping, Quantum error correction. (Chapter 12)	2	
	Sections from References: Chapters – 10, 11, 12 of Book 1.			
V	**TOOLS OF QUANTUM INFORMATION THEORY**		**5**	**7**
	21	The no-cloning theorem, Trace distance, Fidelity (Chapter 13)	2	
	22	Entanglement of formation and concurrence, Information content and entropy. (Chapter 13)	3	
	Sections from References: Chapter – 13 of Book 1.			

Books and References:

1. Quantum Computing Explained – David McMahon (Book 1)
2. Quantum Computation and Quantum Information – Michael A Nielsen and Isaac L Chuang (Book 2)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PS O6	PO 1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	0	0	2	0	0	3	2	0	2	0	0	2
CO 2	0	2	0	2	0	0	3	2	0	2	0	0	2
CO 3	0	0	2	2	0	0	3	2	0	2	0	0	1
CO 4	0	0	0	2	0	2	3	2	0	2	0	0	1
CO 5	0	0	0	2	2	0	3	2	0	2	0	0	2
CO 6	0	0	2	0	0	3	3	2	0	2	0	0	1

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN PHYSICS**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 – 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Fundamental Programming Concepts in Python 2. Basic idea of statistics and linear algebra				
Course Summary	This course explores the fundamentals of Artificial Intelligence and Introduces the basic concepts of Machine Learning Techniques. Also explores various clustering, classification and regression techniques.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Grasp the concepts and importance of Artificial Intelligence, historical context and how the brain processes information.	U	C	Instructor-created exams / Quiz
CO2	Acquire a solid understanding of machine learning principles, algorithms, and evaluation techniques and apply them effectively to real-world problems.	U	C	Instructor-created exams / Home Assignments
CO3	Understand neural networks, perceptron, linear regression, and multilayer perceptron (MLP) and practical implementation for real-world problems using MLP.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Acquire a comprehensive understanding of deep learning models, their comparison with traditional machine learning, various types of deep neural networks and their architecture.	U	C	Instructor-created exams / Home Assignments
CO5	Design and develop machine learning models using Keras and MLP for various problems in the real world.	Ap	P	Practical Assignment / Observation of Practical Skills
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE**	**10**	**15**
	1	What is Artificial Intelligence - Turing Test - Cognitive modeling approach	2	
	2	Foundations of AI - How do brain process information - How can we build an efficient computer	3	
	3	History of AI - The birth - Early Enthusiasm - Knowledge-based systems - AI adopts the scientific method - Intelligent agents - Availability of large data sets	4	
	4	The State of art	1	
		Section 1.1 - 1.4 of Book 1		
II		**FOUNDATIONS OF ML**	**12**	**18**
	5	Introduction to Machine Learning - Learning - Types of Machine Learning	1	
	8	Supervised Learning - Regression - Classification	2	
	9	Learning process - Terminology - Weight Space	3	
	10	Testing machine learning algorithms - Training - Testing - Validation - Matrices to evaluate the model	3	
	11	Turning data into probabilities - Basic statistics - Bias Variance tradeoff	3	
		Chapter 1 & 2 of Book 2		
III		**ARTIFICIAL NEURAL NETWORKS**	**17**	**25**

	12	The brain and neutron - McCulloch and Pitts Neurons - Neural Networks	2	
	13	Perceptron - Bias - Learning rate - Perceptron learning algorithm - implementation	3	
	14	Linear Separability - Perceptron Convergence Theorem	3	
	15	Linear Regression - An example problem	2	
	16	Multi-layer Perceptron -Forward Network - Backpropagation of Errors - Algorithmic details	4	
	17	How to implement MLP - Data - Training - Overfitting	2	
	18	Overview of different problems using MLP - Steps involved in MLP	1	
	Chapter 3 & 4 of Book 3			
IV	**DEEP LEARNING FUNDAMENTALS**		**9**	**12**
	19	Deep Learning - Working of DL Model - Comparison between DL and ML	1	
	20	Applications of Deep Learning - Libraries for implementing DL - TensorFlow and Keras	2	
	21	Types of Neural Networks - ANN - MLP - CNN - RNN	4	
	22	Architecture of Keras - Model - Layer - Loss - Optimizer - Metrics	2	
	Section 12.1 - 12.4 of Book 3			
V	**MINI PROJECT: OPEN ENDED**		**30**	
	1	Implement the following: **1. Design a MLModel:** With ionosphere data to identify any structure is present in a radar data using Keras **2. Design ML Classifier:** To classify RR Lyrae stars using KNN.		

		3. Design a MLP Classifier for classification problems: Data can be anything including the topics in Physics, Astrophysics, Climate Studies etc.		
	Sections from References: 1. Section 12.4 of Book 3 2. https://sigmoidal.ai/en/k-nearest-neighbors-k-nn-for-classifying-rr-lyrae-stars/			

Books and References:

1. Artificial Intelligence – A Modern Approach Third Edition by Stuart Russel and Peter Norvig. Section 1.1 - 1.4 (Book 1)
2. Machine Learning: An Algorithmic Perspective by Stephen Marsland (Book 2)
3. Data Science and Machine Learning using Python by Reema Thereja (Book 3)
4. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Third Edition by Aurélien Géron.
5. Machine Learning in Data Science using Python by R Nageswara Rao

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	0	1	0	2	1	3	1	1	1	2	1	1
CO 2	2	1	2	0	2	1	3	2	1	2	3	1	1
CO 3	1	2	3	1	2	2	3	1	1	2	3	2	1
CO 4	2	0	2	0	2	1	3	1	1	2	3	1	1
CO 5	1	1	2	2	3	2	3	2	2	3	3	2	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**DIGITAL SIGNAL PROCESSING**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 - 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Fundamental Mathematics Concepts: sequences and Series, Integration, Matrices. Fourier Theorem 2. Basic idea of transducers.				
Course Summary	This course outlines the fundamentals of signal processing by digital means.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the characteristics of discrete-time signals and systems.	U	C	Quizzes, homework assignments, exams

CO2	Apply the Z-transform to analyse discrete-time signals and systems.	Ap	P	Problem-solving exercises, projects
CO3	Analyse the frequency content of discrete-time signals using the Z-transform.	An	C	Homework assignments, exams
CO4	Design discrete-time filters for specific signal processing tasks.	C	M	Laboratory assignments, projects
CO5	Implement signal processing algorithms using digital signal processing tools.	Ap	P	Projects, simulations
CO6	Interpret and evaluate the performance of signal processing systems.	E	C	Case studies, presentations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**INTRODUCTION**	**8**	**15**
	1	Signals, Systems. and Signal Processing	1	
	2	Classification of Signals	1	
	3	The Concept of Frequency in Continuous-Time and Discrete-Time Signals	2	
	4	Analog-to-Digital and Digital-to-Analog Conversion	3	

	5	Digital-to-Analog Conversion	1	
	Sections 1.1, 1.2, 1.3 (1.3.1 and 1.3.2 only), 1.4 (1.4.1 to 1.4.6) of Book 1			
II	**DISCRETE-TIME SIGNALS AND SYSTEMS**		**14**	**20**
	6	Discrete-Time Signals	2	
	7	Discrete-Time Systems	2	
	8	Analysis of Discrete-Time Linear Time-Invariant Systems	4	
	9	Discrete-Time Systems Described by Difference Equations	3	
	10	Correlation of Discrete-Time Signals	3	
	Sections 2.1, 2.2, 2.3, 2.4, 2.6 (2.6.1 and 2.6.2 only) of Book 1.			
III	**THE Z-TRANSFORM**		**13**	**15**
	11	The z Transform	3	
	12	Properties of the z-Transform	3	
	13	Rational z-Transforms	3	
	14	Inversion of the z-Transform	4	
	Sections 3.1, 3.2, 3.3, 3.4 of Book1			
IV	**FREQUENCY ANALYSIS OF DISCRETE-TIME SIGNALS**		**13**	**20**
	15	The Fourier Series for Discrete-Time Periodic Signals	2	
	16	Power Density Spectrum of Periodic Signals.	1	
	17	The Fourier Transform of Discrete-Time Aperiodic Signals.	1	
	18	Relationship of the Fourier Transform to the z-Transform	1	
	19	The Cepstrum	1	
	20	Properties of the Fourier Transform for Discrete-Time	2	

		Signals		
	21	Frequency Domain Sampling: The Discrete Fourier Transform	3	
	22	Properties of the DFT	2	
	Sections 4.2(4.2.1, 4.2.2,4.2.3,4.2.6,4.2.7), 4.4, 7.1(7.1.1, 7.1.2, 7.1.3), 7.2(7.2.1, 7.2.2) of Book 1			
V	**OPEN ENDED MODULE: FILTERS**		12	
	1	Various filters like lowpass filter, highpass filter, bandpass filter, Bandpass filter, Notch filter, comp filter etc Digital resonators Digital sinusoidal oscillators	12	
	Sections from References: 5.4 from Book 1			

Books and References:

1. Digital Signal Processing: Principles, Algorithms, and Applications. John G. Proakis, Dimitris G. Manolakis Fourth edition. (Book 1)
2. Digital Signal Processing Oppenheim, Alan V (Book 2)
3. Digital Signal Processing Ramesh Babu, P (Book 3)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	2	1	3	3	3	2	3	1	2	3	3
CO 2	3	2	2	2	3	3	3	2	3	1	2	3	3
CO 3	3	3	3	2	3	2	3	2	3	1	2	3	3
CO 4	3	2	2	3	3	3	3	2	3	1	2	3	3
CO 5	3	2	2	3	3	3	3	2	3	1	2	3	3
CO 6	3	2	3	2	3	3	3	2	3	1	2	3	3

Correlation Levels:

Level	Correlation
0	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**DIGITAL ELECTRONICS**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 – 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY2CJ101- ELECTRONICS I & PHY6CJ305- ELECTRONICS II				
Course Summary	The course covers the design and analysis of combinational logic circuits, sequential circuits using flip-flops, counters, and registers, as well as techniques for interfacing digital systems with the analog world, providing a comprehensive understanding of digital logic design principles and applications.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Design and analyze combinational logic circuits	Apply	Procedural Knowledge	Homework assignments, exams

CO2	Implement sequential circuits using flip-flops	Apply	Procedural Knowledge	Laboratory experiments, projects
CO3	Design and construct various types of counters	Create	Procedural Knowledge	Design projects, simulations
CO4	Analyze the operation of registers in digital systems	Understand	Conceptual Knowledge	Quizzes, concept tests
CO5	Interface digital systems with analog components	Apply	Procedural Knowledge	Case studies, practical exams
CO6	Evaluate and troubleshoot digital-analog interfaces	Analyze	Procedural Knowledge	Laboratory reports, demonstrations
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**COMBINATIONAL LOGIC CIRCUITS**	**10**	**16**
	1	Sum-of-Products Form, Simplifying Logic Circuits, Algebraic Simplification	2	
	2	Designing Combinational Logic Circuits, Karnaugh Map Method, Exclusive-OR and Exclusive-NOR Circuits	4	
	3	Parity Generator and Checker	2	
	4	Enable/Disable Circuits	2	
	Sections 4.1-4.8 of Book 1			

II		**FLIP-FLOPS AND RELATED DEVICES**	**12**	**18**
	5	Clocked S-R Flip-Flop, Clocked J-K Flip-Flop, Clocked D Flip-Flop, D Latch (Transparent Latch)	3	
	6	Asynchronous Inputs, Flip-Flop Timing Considerations, Potential Timing Problem in FF Circuits	2	
	7	Flip-Flop Applications, Flip-Flop Synchronization, Detecting an Input, Sequence, Detecting a Transition or"Event"	2	
	8	Data Storage and Transfer, Serial Data Transfer: Shift Registers, Frequency Division and Counting, Application of Flip-Flops with Timing Constraints	3	
	9	Microcomputer Application, Schmitt-Trigger Devices, One-Shot (Monostable Multivibrator)	2	
	Sections 5.6-5.23 of Book 1			
III		**COUNTERS AND REGISTERS**	**12**	**18**
	10	Asynchronous (Ripple) Counters, Propagation Delay in Ripple Counters, Synchronous (Parallel) Counters,	3	
	11	Counters with MOD Numbers < 2N,Synchronous Down and Up/ Down Counters	3	
	12	Presettable Counters, IC Synchronous Counters	2	
	13	Register Data Transfer, IC Registers	2	
	14	Shift-Register Counters	2	
	Sections 7.1-7.7,7.15-7.17 of Book 1			
IV		**INTERFACING WITH THE ANALOG WORLD**	**14**	**18**
	15	Review of Digital Versus Analog, Digital-to-Analog Conversion	1	
	16	DAC Circuitry, DAC Specifications	2	

	17	An Integrated-Circuit DAC, DAC Applications	2	
	18	Analog-to-Digital Conversion	2	
	19	Digital-Ramp ADC, Data Acquisition	1	
	20	Successive-Approximation ADC, Flash ADCs	2	
	21	Sample-and-Hold Circuits, Multiplexing	2	
	22	Digital Signal Processing (DSP), Applications of Analog Interfacing	2	
	Sections 11.1-11.6,11.8-11.12,11.15-11.18 of Book 1			
V		**OPEN ENDED MODULE- MEMORY DEVICES**	**12**	
	Books and References: 1. Digital systems principles and applications by Moss, Gregory L._ Tocci, Ronald J._ Widmer, Neal S -Pearson, 12 Edition (Book 1) 2. Digital Design" by M. Morris Mano and Michael D. Ciletti 3. Digital Electronics: Principles and Applications" by Roger L. Tokheim 4. Digital Fundamentals" by Thomas L. Floyd and David M. Buchla 5. Digital Logic and Computer Design" by M. Morris Mano			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PS O4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	0	2	3	3	2	2	2	0	0	2	2	1
CO 2	2	2	2	3	3	2	2	2	0	0	2	2	1
CO 3	2	2	3	3	3	2	2	2	0	0	2	2	1
CO 4	1	2	2	3	3	2	2	2	0	0	2	2	1
CO 5	2	2	2	2	3	2	2	2	0	0	2	2	1
CO 6	2	2	3	3	3	2	2	2	0	0	2	2	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**COMMUNICATION ELECTRONICS**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 - 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY2CJ101- ELECTRONICS I & PHY6CJ305- ELECTRONICS II				
Course Summary	Communication Electronics delves into the theory and practical implementation of electronic circuits and systems used in telecommunications, covering topics such as modulation techniques, signal processing, and transmission line theory, to facilitate efficient and reliable communication networks.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate an understanding of amplitude and frequency modulation techniques and their applications	Understand	Conceptual Understanding	Examinations, Assignments
CO2	Apply pulse and digital modulation techniques to design and analyze communication systems	Apply	Application	Problem Sets, Lab Reports
CO3	Analyze the components and operation of radio transmitters, receivers, and antennas in communication systems	Analyze	Application	Research Papers, Projects
CO4	Evaluate the principles and techniques of digital signal processing as applied to communication systems	Evaluate	Application	Presentations, Discussions
CO5	Explain the functionality and characteristics of radio transmitters, receivers, and antennas	Understand	Conceptual Understanding	Written Reports, Essays
CO6	Synthesize knowledge of modulation techniques, radio systems, and digital signal processing for designing and implementing communication systems	Create	Synthesis	Capstone Projects, Oral Defenses

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**AMPLITUDE AND FREQUENCY MODULATION TECHNIQUES**	**12**	**15**
	1	Theory of Amplitude modulation	2	
	2	Double side band suppressed carrier Technique (DSBSC) and Single side band technique (SSB)	3	

	3	Generation of AM, DSBSC and SSB signals.	1	
	4	Theory of Angle modulation, Frequency modulation, Phase modulation and comparison of Frequency and Phase modulation	2	
	5	Frequency spectrum of FM wave, Narrow band and wide band FM, Noise and Frequency modulation	2	
	6	Pre-emphasis and De-emphasis, Comparison of AM and FM	2	
	Relevant sections from Book 1			
II	**PULSE AND DIGITAL MODULATION TECHNIQUES**		**10**	**15**
	7	Pulse Amplitude Modulation, Pulse width Modulation, Pulse Position Modulatio	4	
	8	Demodulation of Pulse modulated signals	3	
	9	Amplitude Shift keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK)	3	
	Relevant sections from Book 1			
III	**RADIO TRANSMITTERS, RECEIVERS AND ANTENNAS**		**14**	**25**
	10	AM, FM and SSB transmitters	1	
	11	Tuned Radio frequency receiver (TRF), Superheterodyne receiver, AM receiver	1	
	12	RF section and characteristics, frequency changing and tracking, ,	1	
	13	Intermediate frequencies and IF amplifiers, Automatic Gain control	1	
	14	FM Receiver and Ratio detector	1	
	15	Antennas, Potential functions and the EM field	2	
	16	Radiation from an oscillating dipole, far field and near field approximations	2	

	17	Power radiated by a current element, Radiation resistance of a short dipole, Radiation from a quarter wave monopole (qualitative ideas only)	2	
	18	Directivity – Gain and effective aperture of an antenna	1	
	19	Antenna arrays – Two element, linear and binomial, Frequency independent antennae, Log periodic antennae, Yagi antennae.	2	
	Relevant sections from Boos 1, 2 and 3			
IV	**ELEMENTS OF DIGITAL SIGNAL PROCESSING TECHNIQUES**		**12**	**15**
	20	Classifications of signals, concept of frequency in continuous-time and discrete–time signals	2	
	21	Theory of A/D and D/A conversion, Sampling of Analog signals, sampling Theorem	3	
	22	Quantization of continuous amplitude signal, Coding of quantized samples, Discrete time, linear time invariant systems	2	
	23	Techniques of analysis of linear systems, Resolution of a discrete time signal into impulses, Response of LTI systems to arbitrary inputs	2	
	24	Convolution sum - properties of convolution and the interconnection of LTI systems, Casual LTI systems, Stability of LTI systems.	3	
	Relevant sections from Books 4			
V	**OPEN ENDED MODULE**		**12**	

	1	Elements of communication system: Need for modulation, Basics of signal representation and analysis, sine wave and Fourier series review, Frequency spectra of Non-sinusoidal Waves, Noises in signals, Signal-to-noise ratio, Broadband communication systems:– Multiplexing, frequency and time division multiplexing, Short and Medium Haul systems, Coaxial cables, fiber-optic links, Microwave links Propagation of radio waves - Ground waves, Sky wave propagation, Space waves, Tropospheric scatter propagation, Extra terrestrial communication. Ionosphere – Reflection and refraction of waves by the ionosphere – Attenuation,	12	
	Relevant sections from Books 1 and 5			

Books and References:

1. Electronic Communication Systems, 5th Edition, George Kennedy, B. Davis, S. R. M Prasanna, McGraw Hill, 2015 (Book 1)
2. Fundamentals of Applied Electromagnetics, Fawwaz T Ulaby, Pearson Education (Book 2)
3. Electromagnetic waves and Radiating Systems, Jordan E. C. and Balmain, K. G. , Prentice Hall India Ltd. (Book 3)
4. Digital Signal Processing, Proakis and Manolakis, Prentice Hall of India (1997) (Book 4)
5. Electronic Communications, Dennis Roddy and John Coolen, J., Pearson Education, Dorling Kindersley (India) Pvt. Ltd. (Book 5)
6. Foundations of Antenna Theory and Techniques, Vincent F. Fusco, Pearson Education Limited
7. Fundamentals of Communication Systems, John G Proakis, Masoud Salehi, Pearson Education
8. Antenna and Wave Propogation, John D Kraus
9. Digital Signal Processing, C. Ramesh Babu Durai, Laxmi Publications, New Delhi
10. An Integrated Course in Electronics & Communication Engineering, J B Gupta, S.K. Kataria & Sons Educational Publisher
11. Signals and Systems, Alan V. Oppenheim and Alan S. Willsky, Prentice Hall series

Mapping of COs with PSOs and POs :

	PSO 1	PS O2	PS O3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	0	0	0	0	2	2	2	0	2	0	0
CO 2	3	3	0	0	0	0	2	2	2	0	2	0	0
CO 3	3	3	3	0	0	0	2	2	2	0	2	0	0
CO 4	3	3	3	2	0	0	2	2	2	0	2	0	0
CO 5	3	2	0	0	0	0	2	2	2	0	2	0	0
CO 6	3	2	2	2	0	0	2	2	2	0	2	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**PLASMA PHYSICS**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 – 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	A strong foundation in classical mechanics, electromagnetism, quantum mechanics, and fluid dynamics is essential as prerequisites for the course in plasma physics.				
Course Summary	The course in plasma physics provides an in-depth exploration of the behavior, properties, and applications of ionized gases, encompassing fundamental theories, experimental techniques, and practical implications across various fields such as astrophysics, fusion research, and industrial plasma technologies.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate an understanding of the basic principles of plasma physics, including plasma formation and properties	Understand	Conceptual Understanding	Examinations, Assignments
CO2	Apply fluid dynamics concepts to analyze the behavior of plasmas and the propagation of waves within them	Apply	Application	Problem Sets, Lab Reports
CO3	Analyze the equilibrium and stability of plasma systems using relevant theoretical models and mathematical techniques	Analyze	Application	Research Papers, Projects
CO4	Evaluate plasma behavior and interactions based on kinetic theory, considering particle distribution functions and collisional processes	Evaluate	Application	Presentations, Discussions
CO5	Explain the physical mechanisms underlying wave propagation and instabilities in plasmas, considering both linear and nonlinear effects	Understand	Conceptual Understanding	Written Reports, Essays
CO6	Synthesize knowledge of plasma physics theories and principles to propose solutions to complex plasma-related problems in various applications	Create	Synthesis	Capstone Projects, Oral Defenses
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	**INTRODUCTION TO PLASMA PHYSICS**		**13**	**18**
	1	Existence of plasma, Definition of Plasma	2	
	2	Debye shielding 1D and 3D, Criteria for plasma	3	

	3	Applications of Plasma Physics (in brief)	1	
	4	Single Particle motions -Uniform E & B fields	3	
	5	Nonuniform B field, Non uniform E field	2	
	6	Time varying E field, Adiabatic invariants and applications	2	
	Sections 1.1 to 1.7.7, 2.1 to 2.8.3 of Book 1			
II	**PLASMA AS FLUIDS AND WAVES IN PLASMAS**		**17**	**28**
	7	Introduction –The set of fluid equations, Maxwell's equations	1	
	8	Fluid drifts perpendicular to B, Fluid drifts parallel to B	2	
	9	The plasma approximations, Waves in Plasma - Waves, Group velocity, Phase velocity	2	
	10	Plasma oscillations, Electron Plasma Waves, Sound waves, Ion waves	2	
	11	Validity of Plasma approximations	2	
	12	Comparison of ion and electron waves	2	
	13	Electrostatic electron oscillations parallel to B, Electrostatic ion waves perpendicular to B	2	
	14	The lower hybrid frequency, Electromagnetic waves with B0, Cutoffs and Resonances, Electromagnetic waves parallel to B0	2	
	15	Hydromagnetic waves, Magnetosonic wave	2	
	Sections 3.1 to 3.6, 4.1 to 4.20 of Book 1			
III	**EQUILIBRIUM AND STABILITY**		**10**	**14**
	16	Hydro magnetic equilibrium, The concept of b	2	
	17	Diffusion of magnetic field into plasma	3	
	18	Classification of instability, Two stream instability, the gravitational instability	3	

	19	Resistive drift waves, the Weibel instability	2	
	Sections 6.1 to 6.8 of Book 1			
IV	**KINETIC THEORY**		**8**	**10**
	20	The meaning of f(v), Equations of kinetic theory	2	
	21	Derivation of the fluid equations	2	
	22	Plasma oscillations and Landau damping	2	
	23	the meaning of Landau damping, Physical derivation of Landau damping, Ion Landau damping	2	
	Sections 7.1 to 7.6.1 of Book 1			
V	**OPEN ENDED MODULE**			
	INTRODUCTION TO CONTROLLED FUSION		12	

Books and References:

1. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion (Book 1)
2. K.L. Goswami, Introduction to Plasma Physics – Central Book House, Calcutta (Book 2)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	0	0	0	0	0	2	2	0	0	0	0	1
CO 2	2	2	1	0	0	0	2	2	0	0	0	0	1
CO 3	3	3	3	1	0	0	2	2	0	0	0	0	1
CO 4	3	2	3	2	0	0	2	2	0	0	0	0	1
CO 5	2	0	0	0	0	0	2	2	0	0	0	0	1
CO 6	3	0	0	0	0	0	2	2	0	0	0	0	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**NONLINEAR DYNAMICS AND CHAOS**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 - 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Numerical Techniques, Classical Mechanics				
Course Summary	To understand the nonlinear dynamics and chaotic theory				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding of Nonlinear Dynamics	U	F	Internal Exam
CO2	Analyze the behavior of dynamical systems	Ap	P	Internal Exam
CO3	Exploration of Chaos Theory	U	C	Internal Exam

CO4	Numerical Analysis Skills	An	P	Internal Exam, Assignment
CO5	Apply the techniques of nonlinear dynamics to physical processes	Ap	P	Internal Exam, Assignment
CO6	Carry out simulation of Nonlinear systems	E	P	Assignemt,Internal Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (48 +12)**	**Marks (70)**
I	**ONE DIMENSIONAL FLOWS**		**12**	**16**
	1	Chaos, Fractals, Dynamics, Importance of Being Non linear	1	
	2	Flows on the line-Introduction, Geometric Way of thinking	1	
	3	Fixed points and Stability	2	
	4	Population Growth, Existence and Uniqueness	2	
	5	Saddle-Node,Transcritical, Pitch fork Bifurcations in One dimension	4	
	6	Imperfect Bifurcations and Catastrophes	2	
		Reference: Chapters 2, 3 of Book 1		
II	**TWO DIMENSIONAL FLOWS**		**12**	**18**

	7	Linear systems, Introduction, Definition and examples	2	
	8	Classification of linear systems	2	
	9	Phase Portraits, Fixed points and Linearization	2	
	10	Conservative systems	2	
	11	Reversible systems	1	
	12	Pendulum	3	
		Reference: Chapters 5, 6 of Book 1		
III		**LIMIT CYCLES AND BIFURCATIONS**	**12**	**18**
	13	Limit cycles-Introduction, Examples	2	
	14	Poincare-Bendixson Theorem	2	
	15	Relaxation Oscillators, Weakly Nonlinear Oscilaations	2	
	16	Saddle-Node, Transcritical, Pitchfork and Hopf Bifurcations	2	
	17	Global Bifurcations of Cycles, Poincare maps	4	
		Reference: Chapters 7, 8 of Book 1		
IV		**CHAOS**	**12**	**18**
	18	Lorenz equations:- Introduction to Chaos and Properties of Lorenz equations	2	
	19	Chaos on a strange attractor, Lorenz map	2	
	20	One-dimensional Maps:- Fixed Points and Cobwebs	2	
	21	Logistic Map	2	
	22	Liapunov Exponent, Universality and Experiments	2	
		Reference: Chapters 9, 10 of Book 1		
V		**OPEN ENDED MODULE: (ANALYTICAL AND/OR NUMERICAL TREATMENT OF NONLINEAR SYSTEMS)**	**12**	

		FIXED POINT AND STABILITY OF ONE DIMENSIONAL SYSTEMS(ANALYTICAL) Phase portraits- two dimensional systems Numerical solutions of Simple pendulum Numerical study of Saddle-Node, Transcritical, Pitchfork and Hopf Bifurcations Numerical Integration of Lorenz systems Logistic map-Coweb Logistic map- Bifurcations, Liapunov exponent		
	Reference: 1. Nonlinear Dynamics and Chaos by S.H Strogatz (Book 1) 2. Nonlinear Dynamics: Integrability, Chaos and Pattersby M Lakshmanan & S Rajasekar 3. NPTEL video lectures: https://nptel.ac.in/courses/115106059			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	2	2	3	2	1	2	2	2	3	3	2
CO 2	3	2	3	2	3	3	3	2	3	2	3	3	1
CO 3	3	2	2	2	1	2	3	2	1	2	3	3	1
CO 4	3	2	3	2	3	3	2	2	3	2	3	3	2
CO 5	3	2	1	2	3	3	3	2	3	2	3	3	1
CO 6	3	2	2	2	3	3	3	2	2	2	3	3	2

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">INTRODUCTORY GENERAL RELATIVITY</td></tr>
<tr><td>Type of Course</td><td colspan="5">Major Elective</td></tr>
<tr><td>Semester</td><td colspan="5">VIII</td></tr>
<tr><td>Academic Level</td><td colspan="5">400 – 499</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>4</td><td>-</td><td>-</td><td>60</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. Special relativity.
2. Tensors.</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course introduces Einstein’s general theory of relativity in a quantitative manner. The mathematical foundations required are developed before discussion of the theory. The mathematical concept behind black holes is also introduced.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Review of tensors, as well as understand tensor calculus	R, U	C	Instructor-created exams / Quiz
CO2	Understand the metric tensor and how curved spacetime is described by the metric tensor.	U, Ap	C	Instructor-created exams / Quiz
CO3	Understand Christoffel's symbols and the Riemann–Christoffel curvature tensor.	U, Ap	C	Instructor-created exams / Quiz / Home Assignments.
CO4	Understand how Parallel displacement can be used to detect curvature.	Ap	C	Instructor-created exams / Quiz
CO5	Understand equivalence principle and principle of general covariance to arrive at Einstein's equations	U	C, F	Instructor-created exams / Quiz
CO6	Understand the basic mathematical theory behind black holes.	U	C, F	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**INTRODUCTION**	**10**	**15**
	1	Introduction, Relativity as a co-ordinate symmetry, GR as a gravitational field theory.	1	

	2	Line element, Riemannian space, transformation of coordinates.	2	
	3	Contravariant and covariant vectors, summation convention.	1	
	4	The metric, the metric as a tensor, contravariant, covariant, and mixed tensors.	3	
	5	Multiplication of tensors—inner and outer products, contraction, fundamental tensors: $g_{\mu\nu}$, $g^{\mu\nu}$, and $g_{\mu}^{\ \nu}$, raising and lowering of indices.	3	
1. Section 1.1 (1.1.4 not required), 1.2 (upto and including 1.2.3. In 1.2.3, only Tensor formalism is required) from Book 1 2. Section 2.1-2.11 of Book 2.				
II		**COVARIANT DIFFERENTIATION AND THE METRIC TENSOR**	**10**	**15**
	6	Manifolds, the partial derivative of a tensor.	3	
	7	Covariant differentiation and the affine connection.	3	
	8	Christoffel's 3-index symbols and their transformation law.	2	
	9	Geodesics, covariant differentiation of vectors, covariant derivatives of tensors.	2	
Section 2.12-2.15 of Book 2				
III		**CURVATURE TENSOR AND EINSTEIN'S FIELD EQUATIONS**	**21**	**25**
	10	Riemannian coordinates, Riemann–Christoffel curvature tensor.	3	
	11	Symmetries and anti-symmetries of curvature tensor.	3	
	12	Number of independent components of the curvature tensor $R_{\lambda\mu\nu\sigma}$	1	
	13	The Bianchi Identities, The Ricci tensor	3	
	14	The Einstein tensor, the condition for flat space-time.	4	
	15	The equivalence principle.	3	
	16	The principle of general covariance.	1	
	17	Heuristic derivation of Einstein field equations.	2	

	18	Fundamental hypotheses and postulates of general relativity.	1	
Sections 2.18-2.21, 2.23-2.24, 3.1, 3.2 (3.2.1-3.2.3 not required), 3.5, 3.6 (final equation only) of Book 2				
IV		**SCHWARZSCHILD SOLUTION AND BLACK HOLES**	**7**	**15**
	19	Introduction.	1	
	20	A static, spherically symmetric space–time (general idea only, derivation not required),	2	
	21	The Schwarzschild line-element (general idea only, derivation not required), Schwarzschild Singularity.	2	
	22	Schwarzschild Black Holes—Singularities.	2	
Section 4.1-4.3 (upto and including 4.3.1), 7.1,7.2 of Book 2				
V		**OPEN ENDED MODULE: BASIC COSMOLOGY**	**12**	
		The cosmological principle, homogeneity and isotropy, different types of curvature, the Robertson-walker metric, Friedmann equation, three crucial tests of the general theory of relativity.		
	References 4-5			

Books and References:

1. Relativity Gravitation & Cosmology 2nd edition, Ta-Pei Cheng, Oxford University Press, 2010 (Book 1)
2. General Theory of Relativity, S. P. Puri, Pearson India, 2013 (Book 2)
3. An Introduction to Relativity by Jayant V. Narlikar, Cambridge University Press
4. Introduction to Cosmology by Jayant V. Narlikar, Cambridge University Press
5. Gravity: An Introduction to Einstein's General Relativity Hardcover by James Hartle

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PS O4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	1	2	0	2	2	3	2	3	1	2	3	3
CO 2	3	1	2	0	2	2	3	2	3	1	2	3	3
CO 3	3	1	2	0	2	2	3	2	3	1	2	3	3
CO 4	3	1	2	0	2	2	3	2	3	1	2	3	3
CO 5	3	1	2	0	2	2	3	2	3	1	2	3	3
CO 6	3	1	2	0	2	2	3	2	3	1	2	3	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**INTRODUCTORY QUANTUM FIELD THEORY**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 – 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY5CJ303- Quantum Mechanics I and PHY7CJ403- Quantum Mechanics II				
Course Summary	The course provides a comprehensive overview of classical field theory, followed by a detailed exploration of the quantization processes for scalar fields, Dirac fields, and the electromagnetic field, aiming to elucidate the fundamental principles underlying modern theoretical physics				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate an understanding of classical field theory and its applications in describing physical phenomena	Understand	Conceptual Understanding	Examinations, Assignments
CO2	Apply quantization techniques to scalar fields, Dirac fields, and the electromagnetic field	Apply	Application	Problem Sets, Lab Reports

CO3	Analyze the consequences of field quantization on particle interactions and quantum field theory	Analyze	Application	Research Papers, Projects
CO4	Evaluate the mathematical formalism of field quantization and its consistency with experimental observations	Evaluate	Conceptual Understanding	Presentations, Discussions
CO5	Explain the implications of field quantization for relativistic quantum mechanics and gauge theories	Understand	Conceptual Understanding	Written Reports, Essays
CO6	Synthesize knowledge of classical field theory and field quantization to propose solutions to theoretical problems in modern physics	Create	Synthesis	Capstone Projects, Oral Defenses
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (48 +12)**	**Marks (70)**
I		**CLASSICAL FIELD THEORY**	**10**	**15**
	1	Why Quantum Field Theory, Creation and annihilation operators	2	
	2	Special relativity, Space and time in relativistic quantum theory	2	
	3	A quick review of particle mechanics, Euler-Lagrange equations in field theory	2	
	4	Hamiltonian formalism	2	
	5	Noether's theorem	2	
	Sections 1.1 – 1.4, 2.1 – 2.4 of Book 1			
II		**QUANTIZATION OF SCALAR FIELDS**	**10**	**18**
	6	Equation of motion	2	
	7	The field and its canonical quantization	2	
	8	Fourier decomposition of the field	2	
	9	Ground state of the Hamiltonian and normal ordering	3	

	10	Fock space	1	
	Sections 3.1 – 3.5 of Book 1			
III	**QUANTIZATION OF DIRAC FIELDS**		**17**	**20**
	11	Dirac Hamiltonian	2	
	12	Dirac equation	2	
	13	Plane wave solutions of Dirac equation	2	
	14	Projection operators	4	
	15	Lagrangian for a Dirac field .	2	
	16	Fourier decomposition of the field	3	
	17	Propagator	2	
	Sections 4.1 – 4.7 of Book 1			
IV	**QUANTIZATION OF THE ELECTROMAGNETIC FIELD**		**11**	**17**
	18	Problems with quantization	3	
	19	Modifying the classical Lagrangian	2	
	20	Propagator	2	
	21	Fourier decomposition of the field	2	
	22	Physical states	2	
	Sections 8.2 – 8.6 of Book 1			
V	**OPEN ENDED MODULE**			
	QUANTUM ELECTRODYNAMICS		12	

Books and References:

1. A First Book of Quantum Field Theory by Amitabha Lahiri and Palash B Pal, 2nd Edn(Book 1)
2. Quantum Field theory, Lewis H. Ryder, (Cambridge University Press -1995)
3. Field Theory – A modern primer – Pierre Ramond (Bengamin – 1996)
4. Quantum Field theory, Itzyskon and Zuber (McGraw Hill – 1989)
5. Quantum Field theory, Karson Huang (Wiley)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	0	0	0	0	0	2	2	0	0	0	0	1
CO 2	2	1	0	0	0	0	2	2	0	0	0	0	1
CO 3	2	2	1	0	0	0	2	2	0	0	0	0	1
CO 4	2	1	1	0	0	0	2	2	0	0	0	0	1
CO 5	2	0	0	0	0	0	2	2	0	0	0	0	1
CO 6	2	0	0	0	0	0	2	2	0	0	0	0	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	B.Sc. Physics Honours				
Course Title	**NUCLEAR PHYSICS**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	**400 - 499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	PHY6CJ303: NUCLEAR AND PARTICLE PHYSICS				
Course Summary	This course explores advanced nuclear and particle physics.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Interpret the properties of nucleus, binding energy, angular momentum, two-nucleon scattering, spin dependence, tensor force, partial wave concept and theory of deuteron structure	An	C	Instructor-created exams / Quiz
CO2	Elucidate the theory of various types of nuclear decay, selection rules of transition, concept of parity and multipole moments.	U	C	Instructor-created exams / Quiz
CO3	Comparison of various nuclear models.	An	P	Instructor-created exams / Home Assignments

CO4	Comparison of nuclear processes like fission and fusion and the concept of nuclear reactor.	An	P	Instructor-created exams / Home Assignments
CO5	Demonstrate the working of one or two nuclear radiation detectors of different types	Ap	P	Seminar Presentation / Group Tutorial Work
CO6	Compare basic interactions and classify the elementary particles. Interactions are linked with the concept of symmetry and conservation laws. Understand Sakata model, Gellmann- Okubo mass formula, Quark mode and their significance.	An	P	Seminar Presentation / Group Tutorial Work / Group Project
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks
I	NUCLEAR FORCES		13	18
	1	Basic nuclear properties: nuclear size, shape, mass, binding energy, angular momentum and parity	3	
	2	Simple theory of deuteron	3	
	3	Low energy n-p scattering	2	
	4	Properties of Nuclear force	2	
	5	Scattering cross section, phase shift	1	
	6	Singlet and triplet potentials	1	
	7	p-p and n-n scattering	1	
	Sections 8.1 – 8.6 of chapter 8 of Book 1			
II	NUCLEAR MODELS, FISSION AND FUSION		12	18

	8	Shell model, Spin-orbit potential, Magnetic dipole and electric quadrupole moment, spin and parity	3	
	9	Collective structure, Nuclear Rotation and vibration	2	
	10	Liquid drop model and Semi-empirical mass formula	2	
	11	Energy and Characteristics of fission	1	
	12	Fission reactors	2	
	13	Basics and Characteristics of fusion	1	
	14	Solar fusion	1	
	Sections 5.1-5.2, 13.1-13.3,13.6, 14.1-14.3 of Book 1			
III	**NUCLEAR DECAY, FISSION AND FUSION**		**13**	**18**
	15	Theory of alpha decay	2	
	16	Energy Release in beta decay	1	
	17	Fermi theory of beta decay	2	
	18	Angular momentum and parity selection rules	2	
	19	Neutrino Physics	2	
	20	Energetics of Gamma decay	1	
	21	Angular momentum and parity selection rules	2	
	22	Internal Conversion	1	
	Sections 8.1-8.4, 9.1,9.2,9.4,9.6, 10.1,10.4,10.6 of Book 1			
IV	**NUCLEAR DETECTORS**		**10**	**16**
	23	Gas detectors	3	
	24	Scintillation Counter	2	
	25	Semiconductor detectors	3	
	26	Single channel analyser	1	
	27	Multichannel analyser	1	
	Relevant sections of Book 2			
V	**OPEN-ENDED MODULE: PARTICLE PHYSICS**		**12**	

Books and References:

1. Kenneth S Krane : Introductory Nuclear Physics (Wiley)
2. S S Kapoor and V S Ramamurthy : Nuclear Radiation Detectors (Wiley)
3. G F Knoll : Radiation Detection and Measurement (Fourth Edition, Wiley, 2011)
4. B.L.Cohen : Concepts of Nuclear Physics (Tata McGraw Hill)

5. S.B.Patel : An Introduction to Nuclear Physics (New Age International Publishers)
6. D C Thayal : Nuclear Physics (Himalaya Publishing House)

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO7
CO 1	3	-	2	-	2	-	3	-	1	-	2	-	-
CO 2	2	3	3	-	2	2	2	-	2	-	2	-	-
CO 3	2	2	2	-	2	2	1	-	1	-	1	-	-
CO 4	2	2	2	-	2	2	1	-	1	-	1	-	-
CO 5	-	2	3	1	2	-	-	-	1	-	1	-	1
CO 6	-	3	-	1	2	2	-	-	1	-	1	-	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Assignments
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	**Assignment**	**Practical / Computational Skill Evaluation**	**End Semester Examinations**
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

MINOR COURSES

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**MECHANICS AND OPTICS**				
Type of Course	**Minor (GROUP I: MATHEMATICS FOR PHYSICAL SYSTEMS)**				
Semester	**I**				
Academic Level	**100 – 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Fundamentals of vectors, calculus and kinematics.				
Course Summary	This course explores Newton's Laws of Motion and how they can be applied to solve different mechanical systems, and also discusses various phenomena exhibited by light.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply Newton's Laws of Motion to solve different mechanical systems	Ap	P	Instructor-created exams / Home Assignments
CO2	Apply work-energy theorem to solve different mechanical systems	Ap	P	Instructor-created exams / Home Assignments
CO3	Analyse conservative systems and solve them using the conservation of mechanical energy.	An	P	Instructor-created exams / Home Assignments
CO4	Understand the basic nature and different phenomena exhibited by light.	U	C	Instructor-created exams / Home Assignments

CO5	Develop a skill to analyse the behaviour of light beams in devices consisting of mirrors and lenses.	Ap	P	Seminar Presentation / Group Tutorial Work
CO6	Develop skills to set up and perform experiments to test Newton's Laws of Motion, work energy theorem and different phenomenon exhibited by light.	Ap & C	P	Practical Assignment / Observation of Practical Skills / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**NEWTON'S LAWS OF MOTION AND APPLICATIONS**	**12**	**19**
	1	Newton's first laws: particles in equilibrium, Inertial frames of reference	3	
	2	Newton's Second law: Dynamics of particles	3	
	3	Frictional forces	3	
	4	Dynamics of circular motion	2	
	5	Fundamental forces of nature	1	
	Sections 4.2, 5.1 – 5.5 of Book1			
II		**WORK AND ENERGY**	**11**	**17**
	6	Work, Kinetic energy and work energy theorem	3	
	7	Work and energy with varying forces	3	
	8	Gravitational potential energy	2	
	9	Elastic potential energy	1	

	10	Conservative and non-conservative forces	1	
	11	Force and potential energy	1	
	Sections 6.1- 6.3, 7.1 - 7.4 of Book 1			
III	**GEOMETRICAL OPTICS**		**11**	**17**
	12	Nature of light, reflection, refraction	2	
	13	Total internal reflection, Dispersion	2	
	14	Reflection and refraction at a plane surface, reflection at spherical surface	3	
	15	Refraction at a spherical surface	2	
	16	Thin lenses, camera	2	
	Sections 33.1 - 33.4 of chapter 33 and sections 34.1 - 34.5 of chapter 34 of Book 1			
IV	**INTERFERENCE AND DIFFRACTION**		**11**	**17**
	17	Interference and coherent source	1	
	18	Two source interference of light, intensity of interference pattern	3	
	19	Interference in thin films, Newtons rings	1	
	20	Diffraction, Fresnel and Fraunhofer diffraction	1	
	21	Single slit diffraction	3	
	22	Two slits, Multiple slits	2	
	Sections 35.1 - 35.4 of chapter 35 and sections 36.1- 36.4 of chapter 36 of book 1			
V	**PRACTICALS**		**30**	
	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6th experiment may also be selected from the given list. Other experiments			

	listed here may be used as demonstrations of the concepts taught in the course. ● Plot the graphs using GeoGebra. FitLine function may be used to get the slope. ● Smartphones are exclusively intended for educational lab use. Necessary care should be taken to safeguard them during the experiments. ● Smartphone experiments primarily serve demonstration purposes, with result accuracy contingent upon the precision of phone sensors and experimental setups.			
	1	**Coefficient of Static Friction.** ● Determine the coefficient of static friction between a wooden block and a wooden plane. ● Measure the angle at which the wooden block just starts to slide down an inclined wooden plane and hence calculate the static friction coefficient. ● https://www.youtube.com/watch?v=gt8mr6pFSFE **OR** ● Place the wooden block on a wooden plane surface and add mass to the pan attached to the block using a string through a frictionless pulley. ● Find the mass required to initiate the sliding of the block. ● Different trials can be done by adding mass on the top of the block and hence determine the coefficient of static friction. ● Example 5.13 of Book 1. ● https://www.youtube.com/watch?v=MSV6VafiUF4&t=443s		
	2	**Verification of Newton's First Law: Equilibrium of a Particle** ● Analyze the two dimensional equilibrium problems using spring/digital force gauges. ● Hang a weight from a chain that is linked at the ring to two other chains, one fastened to the ceiling and the other to the wall. Example 5.3 of Book 1. ● Measure the angle between the chain from the ceiling and the horizontal and the tension in each of the three chains using		

		spring/digital force gauges and verify with the theoretical predictions. ● https://www.youtube.com/watch?v=XI7E32BROp0		
	3	**Acceleration of a Freely Falling Body** ● Use the smartphone acoustic stopwatch to determine the duration of a free fall. ● Measure the time of flight of a steel ball for different heights and plot a graph of distance vs. time squared (s vs. t^2). Determine g from the graph. ● Experiment 2 of Book 2. ● Phyphox app may be used. https://phyphox.org/experiment/free-fall-2/ **OR** ● Use ExpEyes kit, electromagnet, and contact sensor to determine the duration of a free fall. https://expeyes.in/experiments/mechanics/tof.html		
	4	**Verification of the Relation of Angular Velocity and Centrifugal Acceleration** ● Use the smartphone gyroscope and the accelerometer. ● Attach the smartphone to some rotating arrangements and record the data from the gyroscope and accelerometer. ● Plot angular velocity Vs acceleration and verify the relation. ● Experiment 18 of Book 2. ● https://doi.org/10.1119/1.4872422 ● Phyphox app may be used. https://phyphox.org/experiment/centrifugal-acceleration/		
	5	**Analysis of Air Resistance and Terminal Speed to Determine the Drag Coefficient.** ● Record the motion of a light weight paper cup and analyse it with Tracker tool (https://physlets.org/tracker/). ● Plot acceleration, velocity, and position with time. ● Repeat the experiment with different mass (by simply stacking the paper cups)		

		• Determine the Drag Coefficient • Experiment 27 of Book 2. • https://www.youtube.com/watch?v=iujzK3uH1Yc		
	6	**Projectile Motion: Energy Conservation** • Analyse the motion of the tossing ball/ projectile in the Tracker tool. • Plot time vs the x-and y-components of velocity and acceleration. • Also plot the kinetic energy, potential energy (build data using define tool) and total energy. • https://www.youtube.com/watch?v=x0AWRLvgB28 • https://www.youtube.com/watch?v=i07HeUWo8xc		
	7	**Analysis of Bouncing Balls to Determine Gravitational Acceleration and Coefficient of Restitution.** • After doing the experiment, the student should be able to understand the concept of inelastic collision. • Measure the time interval between successive bounces using a digital acoustic stopwatch and hence calculate g and coefficient of restitution • Experiment 12 of Book 2 and section 3.3 of Book 1 • Phyphox app may be used. https://phyphox.org/experiment/inelastic-collision/		
	8	**The Nearly Parabolic Trajectories of a Bouncing Ball** • Perform Experiment 7 using Tracker tool. • Track the ball and plot the time vs position graph. • Measure the time interval between successive bounces and hence calculate g and coefficient of restitution. • Experiment 12 of Book 2 and section 3.3 of Book 1 • Tracker Autotracker Tutorial: https://www.youtube.com/watch?v=Dn0Zz7rtkZw		
	9	**Determine the refractive index of (a) given liquid and (b)the material of a lens, by forming a liquid lens.** • Through this experiment the students are expected to get the concepts of image formation, combination of lenses and radius of curvature of the surface of lens.		

		● Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices.		
	10	**Determine the focal length of the combination of two lenses separated by a distance.** ● Determine the focal lengths, f1 and f2 of the two lenses using an illuminated cross-slit screen holder, nodal slide(for placing the lenses) and plane mirror arrangement. ● Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation ● $\frac{1}{F} = \frac{1}{f1} + \frac{1}{f2} - \frac{d}{f1f2}$. ● The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study. ● https://www.youtube.com/watch?v=IOlEEtyNPBg ● https://www.youtube.com/watch?v=tNo4Ipk74SU		
	11	**Determination of the refractive index of the material of the prism** ● Familiarize the initial adjustments and measurements in the spectrometer. ● Find the angle of the prism and the angle of minimum deviation using the yellow line of a sodium lamp and calculate the refractive index.		
	12	**Determination of the dispersive power of a solid prism using a spectrometer.** ● Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer. ● Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths.		
	13	**Determination of wavelengths of mercury spectrum using diffraction grating and spectrometer.** ● Arrange the grating at normal incidence. ● Standardize the grating using the green line of mercury and then find the wavelengths of other prominent lines of the spectrum.		

	14	**Newton's rings-determination of the wavelength of sodium light** ● Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source. ● Determine the radius of curvature by Boy's method and determine the wavelength of the source.		
	15	**Air wedge-determination of the radius of a thin wire/human hair//thin foil.** ● Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates. ● Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given.		
	16	**Single slit diffraction using laser - Determination of slit width.** ● The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper. ● From the width of the central maxima or the position of minimum intensity points, calculate the slit width. ● Wavelength of laser can be found using diffraction grating of known N.		

Books and References:

1. University Physics with Modern Physics (Edn.15) by Young & Freedman (Book 1)
2. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 2)
3. https://phyphox.org/
4. https://physlets.org/tracker/
5. Berkeley Physics Course : Vol.1 : Mechanics, 2ndEdn. – Kittelet al. – McGraw-Hill
6. Optics by Ajoy Ghatak – 4th edition
7. A textbook of Optics by Subramaniam, Brijlal & Avadhanulu, 25th Edition- S Chand and Company Limited

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	1	2	0	2	2	2	0	0	2	2	0
CO 2	2	2	1	2	0	2	2	2	0	0	2	2	0
CO 3	2	2	2	2	0	2	2	2	0	0	2	2	0
CO 4	0	1	0	1	2	1	2	2	0	0	2	2	0
CO 5	0	0	0	0	2	0	2	2	0	0	2	2	0
CO 6	2	2	2	2	0	2	2	2	0	0	2	2	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ELECTROMAGNETISM AND NETWORK THEOREMS**				
Type of Course	**Minor (GROUP I: MATHEMATICS FOR PHYSICAL SYSTEMS)**				
Semester	**II**				
Academic Level	**100 – 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Fundamentals of vector algebra, calculus and basic electronics				
Course Summary	This course explores different characteristics of electric and magnetic fields, application of network theorems for solving various electrical networks and behaviour of circuit components in ac circuits.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Revise the concept of charge, coulomb force, electric field, electric dipole and apply Gauss theorem for calculating electric field.	U & Ap	C & P	Instructor-created exams / Home Assignments
CO2	Identify the sources of magnetism, explain properties of magnetic forces, behaviour of charged particles in magnetic field and apply Amperes law for calculating magnetic field.	U & Ap	C & P	Instructor-created exams / Home Assignments

CO3	Analyse various network theorems and apply these theorems for solving complex electrical circuits.	An & Ap	P	Instructor-created exams / Home Assignments
CO4	Analyse the behaviour of various electrical components like resistors, capacitors and inductors in pure ac circuit.	An	P	Instructor-created exams / Home Assignments
CO5	Design and analyse the behaviour of ac circuits with more than one electrical component.	An & Ap	P	Seminar Presentation / Group Tutorial Work
CO6	Develop skills to set up and perform experiments to analyse different properties of electric and magnetic field. Design and construct ac circuits consisting various circuit elements and analyse its properties.	Ap	M	Practical Assignment / Observation of Practical Skills / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**ELECTROSTATICS**	**12**	**19**
	1	Coulomb's law, superposition of forces, Electric field and electric forces	3	
	2	Electric field calculations, Electric field lines	2	
	3	Electric dipoles	2	
	4	Charge and electric flux,	1	
	5	Gauss's law	2	
	6	Applications of Gauss's law	2	

	Relevant topics of chapter 21, 22 of Book 1; sections 21.3 – 21.7 of chapter 21 and 22.1–- 22.4 of chapter 22 of Book 1			
II	**MAGNETISM**		**11**	**17**
	7	Magnetic field, magnetic flux, motion of charged particles in magnetic field.	3	
	8	Magnetic force on current carrying conductor, torque on a current loop.	2	
	9	Magnetic field of a moving charge, current element and a straight current carrying conductor.	2	
	10	Force between parallel conductors, Magnetic field of a circular current loop	2	
	11	Ampere's law, Applications ampere's law.	2	
	Sections 27.1- 27.4, 27.6, 27.7 (section 27.7 - till magnetic torque: loops and coils) of chapter 27 and sections 28.1 -28.7 of chapter 28 of Book 1			
III	**NETWORK THEOREMS**		**11**	**17**
	12	Electrical circuits, Kirchhoff's laws.	2	
	13	Solving simultaneous equations, solving equations with two and three unknowns.	2	
	14	Source conversion, Ideal constant voltage source, Ideal constant current source, Superposition theorem.	2	
	15	Thevenin theorem.	2	
	16	Norton's theorem.	2	
	17	Maximum power transfer theorem.	1	
	Sections 2.1 - 2.8, 2.14 – 2.20, 2.25 – 2.27 and 2.30 – 2.31 of chapter 2 of Book 2			
IV	**AC CIRCUITS**		**11**	**17**

	18	Generation of alternating voltage and current, equation of the alternating voltage and current, AC through pure resistance, pure inductance and pure capacitance alone.	3	
	19	mathematical representation of vectors	1	
	20	AC through resistance and inductance.	2	
	21	A.C. through resistance and capacitance.	2	
	22	Resistance, inductance and capacitance in series.	3	
	Sections 11.1 – 11.2, 11.28 – 11.30, 11.32, 12.1 – 12.7, 13.1 – 13.19 of chapter 11, Chapter 12 and 13 of book 2			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7^{th} experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Mapping of the magnetic field lines of a bar magnet.** ● Fix a paper on a drawing board kept on a table and place the bar magnet at the center along the magnetic meridian. ● Using a small compass needle, map the magnetic field lines of the magnet placed with north pole pointing south ● Mark the null points (where the horizontal component of Earth's magnetic field, Bh cancels the field due to magnet) along the axial/equatorial line and measure the distance, 2d, between them. ● Calculate the moment of the magnet. $m = \frac{4\pi}{\mu_0}\frac{(d^2-l^2)^2}{2d}B_h$		
	2	**Study the variation of the magnetic field strength of a bar magnet using a smartphone magnetometer.** ● Using a smartphone magnetometer, measure the strength of the magnetic field of a bar magnet, along the axial and equatorial lines and plot the data.		

		● Magnetometer in the Phyphox app may be used to get the data after locating the approximate position of the magnetometer sensor. https://phyphox.org/wiki/index.php?title=Sensor:_Magnetic_field ● Fit the theoretical formulae to the data and obtain magnetic dipole moment. Along the axial line $B = \frac{\mu_0}{4\pi}\frac{2md}{(d^2-l^2)^2}$ and along the equatorial line $B = \frac{\mu_0}{4\pi}\frac{m}{(d^2+l^2)^{3/2}}$		
	3	**Determine the moment of a bar magnet and Bh using a deflection magnetometer and a box type vibration magnetometer.** ● Determine m/Bh using deflection magnetometer in Tan A position and mBh using box type vibration magnetometer. Hence calculate the moment of the magnet and Bh. ● If the same magnet was used, compare the dipole moment with that of experiment 2 and 3.		
	4	**Circular coil- Verification of Biot Savart's law and determination of Bh** ● Move a compass through a platform along the axis of the coil carrying a study current. Note the deflection of the needle and plot magnetic flux density ($B = B_h tan\theta$) as a function of distance. ● Optional: Smartphone magnetometer may be used to measure the strength of the magnetic field along the axial line and plot the data. https://phyphox.org/experiment/magnetic-field/ ● Experiment 62 of Book 6 ● By varying current and (or) distance of the compass box along the axial line of the coil, note the deflection and hence determine the value of Bh.		
	5	**Reduction factor of TG using potentiometer.** ● Standardize the given potentiometer using a Danial cell or any other constant voltage source and use the standardized potentiometer to find the current through the TG. ● By observing the deflection in the TG for different currents, calculate the reduction factor.		

		• From the magnetic field at the center of a circular coil, deduce the value Bh.		
	6	**Verification of Kirchoff's laws/ Superposition theorem.** • Verify Kirchoff's current law at a junction where a minimum of three branches meet. • Verify Kirchoff's current law for a network with two loops. **OR** • Verify the superposition theorem for a network with two sources, S1 and S2. • First set particular voltage values in S1 and S2 and note down the ammeter reading. • Set the same voltage in S1 and short circuit S2 and vise versa, note down the ammeter readings and verify the superposition theorem.		
	7	**Verification of Thevenin's theorem and maximum power transfer theorem** **Thevenin's theorem** • Measure the current through the load resistance of the network. • Estimate the values of R_{TH} and V_{TH}, construct the Thevenin's equivalent circuit and measure the current through load resistance and compare the two results with the theoretical values. **Maximum power transfer theorem** • Measure the current through load resistance and estimate the power. Plot $R_L - P$ graph and find the R_L corresponding to the maximum power. • Calculate the % of error with the theoretical value.		
	8	**AC three phase generator** • Rotate a neodymium magnet about an axis perpendicular to its dipole axis and fix three coils displaced equally from each other, i.e., 120^o separated. • Analyze the induced emf developed in the coils using CRO/ExpEYES and the phase relationship between the three induced voltages. • https://expeyes.in/experiments/school-level/ac-generator.html		

	9	**RL and RC series AC circuits- Phase relationships of voltage across the elements.** ● Using a CRO/ ExpEYES, verify the phase relationship between voltage across the inductor/capacitor and the current. ● Note the phase difference between the applied voltage and current and determine the value of inductance/capacitance. **OR** ● Note the peak voltage and current and determine the value of inductance/capacitance. ● https://expeyes.in/experiments/electrical/rcsteady.html ● https://expeyes.in/experiments/electrical/rlsteady.html ● https://expeyes.in/experiments/school-level/ac-rc.html ● https://expeyes.in/experiments/school-level/ac-rl.html		
	10	**Series LCR circuits-Determination of resonance frequency, quality factor and bandwidth.** ● The frequency of the signal generator is changed in steps and the corresponding voltage across the resistance is noted. ● From the graph drawn for current against frequency, find the frequency corresponding to maximum voltage- resonant frequency. Also find the bandwidth and quality factor ● CRO/Multimeter/ExpEYES can be used. https://expeyes.in/experiments/electrical/rlcsteady.html		
	11	**Thomson's e/m experiment - Determination of the specific charge of the electron.** ● Measure the ratio of the electron charge-to-mass ratio (e/m) by studying the electron trajectories in a uniform magnetic field.		
	12	**Parallel plate capacitor. (a) verify the relationship between capacitance and the area of the plates (b) determination of dielectric constant of thin dielectric sheet** ● Form a parallel plate capacitor with dielectric material filled between the plates. ● Multimeter/ ExpEYES can be used to measure the capacitance. (For a significantly measurable value of the capacitance, use plates of dimension 10cmx10cm, or greater) ● Change the area of the capacitor plates and verify the relationship of the capacitance on the area (Using the same set		

		of plates, the area can be changed by varying the overlapping region of the plates) ● By measuring the capacitance for different areas of the capacitor plates and (or) thickness of the dielectric material,determine the dielectric constant of the given material/liquid. ● https://www.youtube.com/watch?v=lKfIkUuFT-U		
	13	**Verification of Faraday's law and Lenz's law of electromagnetic induction** ● Verify Faraday's law and Lenz's law by measuring the induced voltage across a coil subjected to the varying magnetic field. (section 7.2.1 of Book 1) ● Galvanometer/ExpEYES can be used to measure the induced emf. ● In the third experiment, for better coupling between the coils, use a high permeability material like iron or ferrite core, and observe the change in the induced emf. ● https://expeyes.in/experiments/school-level/mutual-induction.html ● Simulation: https://phet.colorado.edu/sims/html/faradays-law/latest/faradays-law_all.html		
	14	**Analysis of induced emf developed in a coil as a magnet dropping through it.** ● Drop a neodymium magnet through a coil, guided through a vertical tube. ● Repeat the experiment by dropping the magnet, through different heights from the coil and by changing the approaching pole. ● Capture the induced emf as a function of time using ExpEYES, note the maximum value of the emf and verify Faraday's law and Lenz's law of induced emf and flux change. ● Example 7.6 of Book 1 ● https://expeyes.in/experiments/school-level/em-induction.html		
	15	**Demonstration of Eddy currents** ● Mount aluminum/copper disk as a pendulum on a horizontal axis and observe the 'viscous drag' as it swings down and		

		passes between the poles of a magnet (Can be realized using two pieces of neodymium magnet. The demonstration illustrated in Fig. 7.16 of Book 3). • https://www.youtube.com/watch?v=qTkOpprVITM OR • Form a simple pendulum with a neodymium magnet and observe the 'viscous drag' as it swings down when an aluminium/copper sheet/block is placed under the pendulum. • https://www.youtube.com/watch?v=VK40utGgioI • https://www.youtube.com/watch?v=SF4xjO2RN1w OR • Drop a neodymium magnet through an aluminium/copper tube and observe the delay in the fall of the magnet. Tubes of different gauge may be used for the demonstration. • Keep the two probes at diametrically opposite points of the pipe and note the emf and current when a magnet is allowed to fall through the pipe. • https://www.youtube.com/watch?v=H31K9qcmeMU		

Books and References:

1. University Physics with Modern Physics (Edn.15) by Young & Freedman (Book 1)
2. A Textbook of Electrical Technology, Volume – I (Revised 23rd Edition) by B. L. Thereja and A. K. Thereja (Book 2)
3. Introduction to Electrodynamics-David J Griffith, 4th Edition, Pearson (Book 3)
4. Electricity and Magnetism by R. Murugesan- S Chand and Company Limited (Book 4)
5. Basic electrical engineering by V. K. Mehta and Rohit Mehta - S Chand and Company Limited (Book 5)
6. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 6)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	0	2	2	2	2	2	1	3	2	0
CO 2	2	1	2	0	2	2	2	2	2	1	3	2	0
CO 3	2	2	3	1	1	1	2	2	2	1	3	2	0
CO 4	0	0	2	3	1	1	2	2	2	1	3	2	0
CO 5	0	0	2	1	2	2	2	2	2	1	3	2	0
CO 6	2	3	2	2	1	1	2	2	2	1	3	2	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">MATHEMATICAL METHODS FOR PHYSICS</td></tr>
<tr><td>Type of Course</td><td colspan="5">Minor (GROUP I: MATHEMATICS FOR PHYSICAL SYSTEMS)</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 –299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Fundamentals of vectors, linear algebra, differential equations coordinate systems and familiarity with basic concepts in physics.</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course explores fundamental principles and applications of vector analysis, complex functions, differential equations and curvilinear coordinates in electromagnetism and engineering contexts.</td></tr>
</table>

Course Outcomes (CO):

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Students will attain a strong foundational understanding about vector calculus, complex numbers, differential equations and curvilinear coordinates	U	C	Instructor-created exams / Quiz

CO2	Students will develop analytical proficiency which enables them to analyse and interpret complex physical phenomena through the application of mathematical principles.	Ap	P & M	Practical Assignment / Observation of Practical Skills
CO3	Students will cultivate advanced problem-solving skills.	Ap	P	Practical Assignment / Observation of Practical Skills
CO4	Students will enhance their ability to model and represent physical systems mathematically for describing and understanding complex phenomena.	Ap	P M	Practical Assignment / Observation of Practical Skills / Home Assignments
CO5	Students will recognize and appreciate the interdisciplinary applications of mathematical methods.	Ap	C & M	Seminar Presentation / Group Discussion
CO6	Students will refine their critical thinking which encourages independent inquiry and problem-solving approaches in tackling challenging problems and scenarios.	Ap	P & M	Group Discussion/ Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evalu ate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**VECTOR CALCULUS**	**12**	**20**
	1	Scalar and Vector Point Functions, Gradient of a Scalar Function Geometrical Meaning of Gradient	4	
	2	Normal and Directional Derivative, Divergence of a Vector Function, Physical Interpretation of Divergence, Divergence and Curl of Electrostatic Fields	4	
	3	Curl, Physical Meaning of Curl, The Divergence and Curl of B	4	
		Sections 2.4, to 2.11 of book 2, Sections 2.2.1 – 2.2.4 of chapter 2 and Section 5.3.1 – 5.3.3 of chapter 5 of book 1		
II		**COMPLEX NUMBERS AND COMPLEX FUNCTIONS**	**11**	**15**
	4	Introduction, Complex Numbers	1	
	5	Geometrical Representation of Imaginary Numbers Argand Diagram	1	
	6	Equal Complex Numbers, Addition, Addition of Complex Numbers by Geometry	1	
	7	Subtraction, Powers of *i*, Multiplication, *i* (Iota) as an Operator, Conjugate of a Complex Number	1	
	8	Division, Division of Complex numbers by Geometry	1	
	9	Modulus and Argument, Polar form, Types of Complex Numbers	1	
	10	Resistance and Reactance	2	
	11	The L-R-C series Circuit	3	
		Sections 20.1 to 20.17 of book2, Sections 31.2 and 31.3 of book 3		
III		**ORDINARY DIFFERENTIAL EQUATIONS**	**12**	**20**
	12	Definition, order and Degree of a Differential Equation	1	
	13	Formation of Differential Equations, Solution of a Differential Equation	1	

	14	Geometrical Meaning of the Differential Equation of the First order and First Degree, Differential Equations of the First order and First Degree	2	
	15	Variables Separable, Homogeneous Differential Equations, Equations Reducible to Homogeneous form, Linear Differential Equations, Equations Reducible to the Linear form (Bernoulli Equation)	4	
	16	Non-Linear Differential Equations, Linear Differential Equations of Second order with Constant Coefficients	2	
	17	Periodic Motion- Simple Harmonic motion. Applications of simple Harmonic motion, Damped oscillations	2	
	Sections 12.1 to 12.11, 13.2, 13.3 of book 2, Sections 14.2, 14.4, 14.7 of Book 3			
IV	**CURVILINEAR COORDINATES**		**10**	**15**
	18	Curvilinear Coordinates	1	
	19	Cylindrical (Polar) Co-ordinates	2	
	20	Spherical Polar Co-ordinates	2	
	21	Relation Between Cylindrical and Spherical Co-ordinates	2	
	22	Applications of Gauss's Law in polar, cylindrical and spherical problems	3	
	Sections 4.1, 4.8, 4.9, 4.12 of book 2, Section 2.2.3 Application of Gauss's law of Book 1			
V	**PRACTICALS**		**30**	
	1	**Flywheel- Determination of the Moment of Inertia.** ● This experiment aims to help students grasp the concept of energy conservation and the dynamics of rotation. ● Do at least 9 trials for different masses and number of turns wound on the axil.		
	2	**Torsion Pendulum- Determination of the Moment of Inertia.** ● Using identical masses on the disc, determine the moment of inertia of the disc. ● Verify the moment of inertia by direct method, $I = \frac{1}{2}MR^2$		

	3	**Compound Pendulum- Acceleration Due to Gravity and Moment of Inertia and Verification of Parallel Axis Theorem.** ● Plot a graph of distance of knife edge from one end Vs period of oscillations. Using the measurement from the graph, calculate g. ● Calculate the radius of gyration and hence the moment of inertia about CM. Compare the result obtained by the direct calculation $I_{CM} = \frac{ML^2}{12}$		
	4	**Kater's Pendulum- Determination of Earth's Gravity.** ● To determine g and discuss the relative merits of both cases by estimation of error in the two cases.		
	5	**Sonometer - Determine the Frequency of AC.** ● Estimate the linear mass density of the wire. ● Draw $L^2 - m$ graph and from the slope calculate the frequency.		
	6	**Determination of the Velocity of Sound in Air.** ● Sound wave of known frequency is generated using a wave generator(WG) and piezo buzzer and are recorded using a microphone(MIC). ● Phase differences between the WG and MIC waveforms were analyzed in a CRO and the distance between them were adjusted to make both of them in phase and hence calculate velocity of sound. ● Phase difference can be analyzed from the Lissajous figure obtained by X-Y plotting of WG and MIC waves. ● ExpEYES may be used. ● https://expeyes.in/experiments/sound/velocity.html ● https://expeyes.in/experiments/electrical/xyplot.html		

	7	**Pendulum- Limits on Angular Displacement and Study of Damped Oscillations.** ● Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM. ● Study damped oscillations. Plot amplitude as a function of time and determine the damping coefficient and Q factor. ● Digitized data can be used for the study. ● https://www.youtube.com/watch?v=jcpvm95bhXw ● https://expeyes.in/experiments/school-level/sr04.html ● https://phyphox.org/experiment/pendulum/		
	8	**Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.** ● Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity, get λ_{max} and using Wein's law calculate the surface temperature. ● Pre recorded video of the solar spectra can be used.		
	9	**Analysis of Hydrogen spectra using the Tracker Video Analysis tool**. ● Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant. ● Estimate the %error. ● Pre recorded video of the Hydrogen spectra can be used. ● https://physlets.org/tracker/. ● https://www.youtube.com/watch?v=UCCPkJpUQEw		

	10	**RC and RL transients - determination of capacitance and inductance.** ● Apply a voltage step to a series RC/RL circuit and record the resulting voltage variation across the capacitor/inductor. ● Get the value of time constant by an exponential fit to the data. ● Repeat the experiment for different resistances. ● https://expeyes.in/experiments/electrical/rctransient.html ● https://expeyes.in/experiments/electrical/rltransient.html		
	11	**Determination of Plank's constant using LEDs** ● Observe the turn-on voltage, ● V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing) ● Plot $\frac{1}{\lambda} - V_0$ graph using Python, fit a straight line to get the slope and estimate the value of h. ● Calculate the %error. ● Programmable voltage source of ExpEYES may be used to find the turn-on voltage.		
	12	**Construction of the center tapped full wave rectifiers and regulated power supply** ● Construct a center tapped full wave rectifier without filter and with a filter. ● Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter. ● Observe the variation of the ripple factor with load resistance, when filter is used. ● Construct 5V/12V regulated power supply using 78XX IC.		
	13	**Construct Half adder using universal gates and study the operation.** ● Implement half adder using NAND/NOR gates and verify the truth table for each input/output combination.		

	14	**Verification of De-Morgan's Theorems using basic gates.** ● Realize the either side of the De-Morgan's Theorems using gates from appropriate ICs and verify the truth table for each input/output combination.		
	15	**Construction of the center tapped full wave rectifiers and regulated power supply.** ● Construct a center tapped full wave rectifier without filter and with a filter. ● Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter. ● Observe the variation of the ripple factor with load resistance, when filter is used. ● Construct 5V/12V regulated power supply using 78XX IC.		

Books and References:

1. Introduction to Electrodynamics by David J Griffiths, 5th Edition (Book 1)
2. Mathematical Physics by H K Das and Rama Verma, 7th Edition (Book 2)
3. University Physics With Modern Physics by Hugh D Young and Roger A Freedman 14th edition (Book 3)
4. Mathematical Physics by Satya Prakash - S Chand and Sons

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	2	0	2	2	3	2	2	1	3	2	1
CO 2	2	3	2	1	1	1	2	2	2	1	3	2	0
CO 3	1	2	3	1	2	1	2	2	2	1	3	2	1
CO 4	2	1	1	3	2	1	2	2	2	1	3	2	0
CO 5	2	2	2	1	3	1	2	2	2	1	3	2	1
CO 6	2	1	3	0	2	3	2	2	2	1	3	2	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignme nt /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**PROPERTIES OF MATTER & THERMODYNAMICS**				
Type of Course	**Minor (GROUP II: MATERIALS PHYSICS)**				
Semester	**I**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Awareness of Newton's first law, Hooke's law and static friction				
Course Summary	understanding of fundamental concepts of Equilibrium and Elasticity and their applications				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concept of the center of gravity and its significance in determining stability. Solve problems involving the equilibrium of rigid bodies subjected to various forces and torques. Apply principles of equilibrium to analyze real world scenarios. Get the concept of elastic moduli and their significance in characterizing material properties.	U	C	Instructor-created exams / Quiz
CO2	Understand density and pressure in a fluid and their effects in fluid behaviour. Explain the principle of buoyancy and its application in determining the behavior of floating and submerged objects.	Ap	P	Practical Assignment / Observation of Practical Skills

	Understand Bernoulli's principle and its significance in describing the behaviour of fluids in motion. Analyse viscosity and turbulence.			
CO3	Get the concepts of temperature and thermal equilibrium. Demonstrate a clear understanding of the first law of thermodynamics, including the principles of conservation of energy and the relationships between heat, work, and internal energy. analyze various thermodynamic processes, including the work done during volume changes and the paths between thermodynamic states.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Calculate and interpret the internal energy of ideal gases, understanding the heat capacities and behavior of ideal gases under different conditions, including adiabatic processes.	U	C	Instructor-created exams / Home Assignments
CO5	Grasp the significance of the second law of thermodynamics in determining the direction of thermodynamic processes. Analyze heat engines and refrigerators, applying the principles of the second law to evaluate their efficiency.	Ap	P	One Minute Reflection Writing assignments
CO6	understand fundamental concepts in thermodynamics and apply them in practical situations.	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**Equilibrium and Elasticity**		**10**	**15**
	1	Conditions of Equilibrium, Center of Gravity	2	
	2	Solving Rigid body Equilibrium Problems	3	
	3	Stress, Strain and Elastic moduli	4	
	4	Elasticity and Plasticity	1	

	Sections from References: 11.1, 11.2, 11.3, 11.4, 11.5, Book 1			
II	**Fluid Mechanics**		**10**	**15**
	5	Gases, liquids and Density, Pressure in a Fluid	2	
	6	Buoyancy, Fluid flow	3	
	7	Bernoulli's Equation	3	
	8	Viscosity and Turbulence	2	
	Sections from References:12.1, 12.2, 12.3, 12.4, 12.5, 12.6, Book 1			
III	**Temperature, Heat and First Law of Thermodynamics**		**15**	**25**
	9	Temperature and Thermal Equilibrium	1	
	10	Thermodynamic systems	1	
	11	Work done during volume changes	2	
	12	Paths between Thermodynamic states	1	
	13	Internal Energy and First law of Thermodynamics	2	
	14	Kinds of Thermodynamic processes	2	
	15	Internal Energy of an ideal gas,	2	
	16	Heat capacities of an ideal gas	1	
	17	Adiabatic process for an ideal gas	3	
	Sections from References:17.1, 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.8, Book 1			
IV	**The Second law of thermodynamics**		**10**	**15**
	18	Directions of thermodynamic processes	1	
	19	Heat Engines, Refrigerators	2	
	20	Second law of thermodynamics	2	
	21	The Carnot Cycle	3	
	22	Entropy	2	
	Sections from References:20.1, 20.2, 20.4, 20.5, 20.6, 20.7, Book 1			
V	**PRACTICALS**		**30**	

	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6th experiment may also be selected from the given list. ● Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Young's Modulus of the Material of a Given Bar: Uniform Bending** ● Use optic lever and telescope. Take measurements for minimum two lengths. Obtain the elevation (e) from the shift (s) in the telescope reading and calculate Y from it. ● For each length of the bar, plot the load-elevation graph (using GeoGebra) and obtain m/e, and then calculate Y from it. ● Estimate the random error in the measurements and the error of the result using propagation of error formulae.		
	2	**Young's Modulus of the Material of a Given Bar: Nonuniform Bending** ● Use pin and microscope. Take measurements for minimum two lengths. Obtain the depression (e) from the shift in the microscope reading and calculate Y from it. ● For each length of the bar, plot the load-depression graph (using GeoGebra) and obtain m/e, and then calculate Y from it. ● Estimate the random error in the measurements and the error of the result using propagation of error formulae.		
	3	**Torsion Pendulum- Determination of the Moment of Inertia and Rigidity Modulus.** ● Using identical masses on the disc, determine the moment of inertia of the disc. ● Verify the moment of inertia by direct method, $I = \frac{1}{2}MR^2$ ● Using I, calculate rigidity modulus of the material of the wire, $n = \frac{8\pi I}{r^4}\frac{L}{T^2}$		
	4	**Static torsion - Rigidity modulus** ● Using Searle's static torsion apparatus, determine the rigidity modulus of the material of the rod.		
	5	**Viscosity of a liquid - Poiseuille's Method** ● Fill the liquid in a vertically fixed burette with its lower end attached to a capillary tube, placed in horizontal position using a rubber tube.		

		• Note the time taken to reach each 10cc of water and the height of the corresponding marking. • Also measure the radius of the capillary tube using the traveling microscope and estimate the viscosity of the liquid.		
	6	**Viscosity of a liquid - Falling Ball Viscometer** • Drop a polished steel ball into a glass tube of a somewhat larger diameter containing the liquid. • Record the time required for the ball to fall at constant velocity through a specified distance between reference marks. • Use the Stoke's law for the sphere falling in a fluid under effect of gravity, to estimate the viscosity of the liquid.		
	7	**Surface tension of liquid - Capillary rise method** • Clamp a clean capillary tube by dipping its lower end into the liquid in the beaker. • Measure the rise of water in the tube using a traveling microscope. • Also measure the radius of the capillary tube using the traveling microscope and estimate the surface tension of the liquid. • Density of the liquid can be determined using Hare's apparatus of can be given		
	8	**Density of the liquid using manometer** • Fill a manometer tube partially with water. Pour the given oil (or any liquid which does not mix with water) into the left arm of the tube until the oil–water interface is at the midpoint. Both arms of the tube are open to the air. • Measure the heights of the oil and water using a traveling microscope and hence estimate the density of the oil assuming that of water. • Example 12.4 of book 1		
	9	**Verification of Boyle's law and Charle's law** • Boyle's law (PV= a constant) states that at a constant temperature, volume of a gas is inversely proportional to pressure. • Determine the volume - pressure relation at constant temperature using the water column. • Plot the pressure versus volume graph and verify Boyle's law. • Verify the law at minimum two different temperatures. • Charle's law (V/T = a constant) states that at constant pressure, volume is directly proportional to temperature. • In this experiment determine the temperature - volume relation at constant pressure using the water column. • Plot the temperature versus volume graph and verify the Charle's law.		

		● Verify the law at minimum two different pressures.		
	10	**Verification of Gay-Lussac's law** ● Gay-Lussac's law (P/T = a constant) states that at constant volume, pressure is directly proportional to temperature. ● In this experiment determine the temperature - pressure relation at constant pressure using metallic bulb and water column or pressure gauge or using Jolly's bulb apparatus. ● Plot the temperature versus volume graph and verify the Charle's law.		
	11	**Thermal conductivity by Searle's method** ● Determine the thermal conductivity of copper or any other metal using Searle's method / apparatus.		
	12	**Temperature coefficient of resistance of a metal** ● Resistance of metals increases with increase in temperature. ● Measure the resistance of the metal coil, using Carey Foster's bridge or Potentiometer or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature. ● Plot graph and find the temperature coefficient of resistance.		
	13	**Thermo emf of a Thermocouple** ● Study the variation of thermo emf of a thermocouple as a function of temperature of the hot junction while maintaining the cold junction at 0 degree Celsius.		
	14	**Newton's law of cooling** ● According to Newton's law of cooling, the rate of heat loss of a hot body is proportional to the difference in temperature between the body and the surroundings. ● The calorimeter is filled with hot water and the variation in temperature is noted as a function of time. ● Cooling rate graph is plotted and law is verified. ● Emissivity of the surface of the calorimeter can also be determined. ● ExpEYES with PT1000 sensor may be used to record the temperature. https://expeyes.in/experiments/thermal/cooling.html		
	15	**Characteristics of NTC thermistor**		

		• Resistance of Negative Temperature Coefficient (NTC) thermistors decreases with increase in temperature. • Measure the resistance of the thermistor, using Carey Foster's bridge or Potentiometer or ExpEYES or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature. • Plot the graph and study the characteristics.		
	16	**Melting point of wax** • Fill a test tube with wax until half and use a thermometer inside the wax / test tube to measure wax temperature. Avoid the thermometer touching the test tube. • Immerse the test tube in a water bath with the help of a stand, in such a way that the wax is below the water level. • Use a suitable flame / heating rate and measure the wax temperature as a function of time at a suitable time interval. • Plot temperature versus time graph. ExpEYES and PT1000 sensor may be used to record the temperature. https://expeyes.in/experiments/thermal/cooling.html • The temperature increases initially and remains constant until the wax melts completely. The flat temperature gives the melting point of wax (The melting point depends on the type of wax used)		

Books and References:

1.University Physics with Modern Physics- Hugh D. Young, Roger A. Freedman,15th Edition (Book 1)

2.Intermediate Dynamics (Edn.2) by Patrick Hamill

3.An Introduction to Mechanics" by Daniel Kleppner and Robert J. Kolenkow

4.Mechanics" by Keith R. Symon

5.Concepts in Thermal Physics by Stephen J Blundell and Katherine M. Blundell

6.Thermal Physics by Charles Kittel and Herbert Kroemer

7.An Introduction to Thermal Physics by Daniel V. Schroeder

8.Heat and Thermodynamics by Mark Zemansky, Richard Dittman.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	3	2	2	3	2	2	1	2	2	0
CO 2	1	3	2	1	2	1	2	3	2	1	2	2	0
CO 3	1	1	3	3	3	1	2	2	3	2	3	2	0
CO 4	3	1	2	1	1	2	3	2	2	2	2	2	0
CO 5	1	2	1	1	2	2	2	1	2	2	3	2	0
CO 6	2	2	1	1	1	3	2	2	2	2	2	3	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**MODERN PHYSICS AND NUCLEAR PHYSICS**				
Type of Course	**Minor (GROUP II: MATERIALS PHYSICS)**				
Semester	**II**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1.Foundational understanding of classical physics, particularly in mechanics and electromagnetism. 2. Proficiency in algebra, calculus and trigonometry.				
Course Summary	This course explores the dual nature of particles and waves, as well as the structure and behavior of atomic and nuclear systems. Through theoretical discussions and practical applications, students will investigate electromagnetic waves, particle-wave duality phenomena, atomic structure, nuclear composition, and nuclear transformations.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the duality of particles and waves, Describe experimental evidence supporting the wave-particle duality, including the photoelectric effect and Compton effect.	U	C	Instructor-created exams / Quiz
CO2	Define pair production and its significance in quantum	U, Ap	P	Seminar Presentation /

	mechanics, Understand the concept of matter waves proposed by Louis de Broglie.			Group Tutorial Work
CO3	Explain the structure of the atom according to the nuclear model, Understand Energy Levels and Spectra	Ap	P	Practical Assignment / Observation of Practical Skills
CO4	Investigate Nuclear Structure Understand stable nuclei, binding energy, and models such as the liquid drop model and shell model	U	C	Instructor-created exams / Home Assignments
CO5	Understand radioactive decay processes and their implications for nuclear stability,	Ap	P	One Minute Reflection Writing assignments
CO6	Analyse nuclear reactions, including fission and fusion, and their relevance in energy production and stellar evolution.	Ap	P	Writing assignments /Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**Particle properties of waves & Wave properties of particles**	**12**	**15**
	1	Electromagnetic Waves, Black body Radiation	3	
	2	Photoelectric Effect	2	
	3	Compton Effect	2	
	4	Pair Production	3	
	5.	De Broglie Waves	2	
	Sections from References: 2.1, 2.2, 2.3, 2.7,2.8, 3.1, Book 1			
II		**Atomic Structure**	**10**	**22**
	6	The Nuclear Atom	2	
	7	Electron Orbits	2	

	8	Atomic Spectra	2	
	9	The Bohr Atom	2	
	10	Energy Levels and Spectra	2	
	Sections from References:4.1, 4.2, 4.3, 4.4, 4.5, Book 1			
III	**Nuclear Structure**		**13**	**20**
	11	Nuclear composition	2	
	12	Nuclear properties	2	
	13	Stable nuclei	2	
	14	Binding energy	2	
	15	Liquid drop model, Shell model	2	
	16	Magic numbers	1	
	17	Meson theory of nuclear forces.	2	
	Sections from References:11.1, 11.2, 11.3, 11.4, 11.5, 11.6, 11.7, Book 1			
IV	**Nuclear Transformations**		**10**	**13**
	18	Radioactive decay, radioactivity and the Earth	1	
	19	Half-life, Radiometric dating	2	
	20	Alpha decay, Beta decay, Gamma decay	3	
	21	Nuclear reactions, Nuclear fission	3	
	22	Nuclear fusion in stars	1	
	Sections from References: 12.1, 12.2, 12.4 (Tunnel theory concept only), 12.5, 12.6, 12.8, 12.9, 12.10, 12.11, Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Determination of Plank's constant using LEDs**		

		• Observe the turn-on voltage, V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing) • Plot $\frac{1}{\lambda} - V_0$ graph using Python, fit a straight line to get the slope and estimate the value of h. • Calculate the %error. • Programmable voltage source of ExpEYES may be used to find the turn-on voltage.		
	2	**Continuous and line spectra- Determination of the wavelengths and photon energy.** • Familiarize the initial adjustments and measurements in the spectrometer. • Mount the grating at normal incidence on the spectrometer. • Determine the wavelengths of the sodium vapor lamp and calculate the associated photon energy. • Determine the approximate range of the wavelengths of the continuous spectrum of incandescent/white LED lamp or any one coloured LED and calculate the associated photon energy. • The readings of the first order spectrum will be enough. Number of lines/m of the grating can be given.		
	3	**Mercury spectrum- Determination of wavelength and photon energy.** • Determine wavelength of any four prominent lines and associated photon energy of the mercury spectrum using a spectrometer with grating at normal incidence. • The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	4	**Hydrogen spectrum - Determination of wavelengths and calculation of the Rydberg's constant.** • Determine the wavelengths and photon energy in eV of the prominent lines of the Balmer series of the Hydrogen spectrum using a spectrometer with grating at normal incidence. • Calculate the Rydberg's constant and estimate the % error. • The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	5	**Wave Packets - Analysis of beats in sound.** • The experiment is intended to understand the concept of wave packet, phase and group velocities. • Generate sounds waves of two near frequencies using smartphone/ExpEYES/Function generator and the superimposed wave can be recorded and analysed using smartphone/ExpEYES/CRO • Change the separation between the frequencies and compare the results with the theoretical values. • https://expeyes.in/experiments/sound/beats.html		

		• Multi Tone generator and Audio scope tools of Phyphox may be used https://phyphox.org/experiment/tone-generator/		
	6	**7. Analysis of Hydrogen spectra using the Tracker Video Analysis tool**. • Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. • Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant. • Estimate the %error. • Pre recorded video of the Hydrogen spectra can be used. • https://physlets.org/tracker/. • https://www.youtube.com/watch?v=UCCPkJpUQEw		
	7	**Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.** • Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. • Plot wavelength vs intensity, get λ_{max} and using Wein's law calculate the surface temperature. • Pre recorded video of the solar spectra can be used.		
	8	**Verification of Wein's displacement law and Stefan's law using incandescent bulb.** • Calibrate the video of the spectra of the incandescent bulb in the Tracker tool using two laser wavelengths/lines of mercury spectra. • Plot wavelength vs intensity and note λ_{max} . • Repeat the experiment by increasing the operating voltage of the incandescent bulb(hence increasing the temperature of the source) • From the plots, verify the Wein's displacement law and Stefan's law.		
	9	**Study the specific rotation of the sugar solution using a polarimeter.** • Determine the specific rotation corresponding to different concentrations of the sugar dissolved in water. • Draw a graph between rotation and concentrations and verify the linear relationship.		
	10	**Verification of Malus's law using polarizer, analyzer and photo detector** • Unpolarized light is allowed to pass through a polarizer and is observed through an analyzer. • Vary the angle between the axes of polarizer and analyzer and measure the intensity of the light (current output of the photodetector). • Plot $\theta - I$ and $cos^2\theta - I$ graphs and verify the Malus's law.		

		● A flat computer monitor (or LCD TV screen) in plain white color can be used as the source of linear polarized light. ● The ambient light sensor of the smartphone and the orientation sensor of the smartphone can be used to measure the illuminance and the angles respectively. ● A small piece of polarizer (a square of about 1 cm side) from an old calculator's display was placed over the ambient light sensor as analyser. ● https://arxiv.org/pdf/1607.02659		
	11	**Brewster's law experiment, determination of angle of polarisation and refractive index.** ● Experimental arrangement- Sodium vapour lamp, Spectrometer, Polarizer (Graduated on 360° rotating) coupled in front of the spectrometer telescope, prism or glass plate. ● Get the angle of incidence corresponding to the minimum intensity of light and hence calculate the refractive index of the material. ● https://www.youtube.com/watch?v=f2A8sM1xhbQ		
	12	**Mapping of the magnetic field lines of a bar magnet.** ● Fix a paper on a drawing board kept on a table and place the bar magnet at the center along the magnetic meridian. ● Using a small compass needle, map the magnetic field lines of the magnet placed with north pole pointing south ● Mark the null points (where the horizontal component of Earth's magnetic field, Bh cancels the field due to magnet) along the axial/equatorial line and measure the distance, 2d, between them. ● Calculate the moment of the magnet. $m = \frac{4\pi}{\mu_0}\frac{(d^2-l^2)^2}{2d}B_h$		
	13	**Circular coil- Verification of Biot Savart's law and determination of Bh.** ● Move a compass through a platform along the axis of the coil carrying a study current. Note the deflection of the needle and plot magnetic flux density ($B = B_h tan\theta$) as a function of distance. ● Optional: Smartphone magnetometer may be used to measure the strength of the magnetic field along the axial line and plot the data. https://phyphox.org/experiment/magnetic-field/ ● Experiment 62 of Book 2 ● By varying current and (or) distance of the compass box along the axial line of the coil, note the deflection and hence determine the value of Bh.		
	14	**Calibrate the ammeter using potentiometer** ● Standardize the potentiometer using a Danial cell or any other standard voltage source.		

		● Determine the current for at least 8 trials and draw the calibration graph.		
	15	**Parallel plate capacitor. (a) verify the relationship between capacitance and the area of the plates (b) determination of dielectric constant of thin dielectric sheet.** ● Form a parallel plate capacitor with dielectric material filled between the plates. ● Multimeter/ ExpEYES can be used to measure the capacitance. (For a significantly measurable value of the capacitance, use plates of dimension 10cmx10cm, or greater) ● Change the area of the capacitor plates and verify the relationship of the capacitance on the area (Using the same set of plates, the area can be changed by varying the overlapping region of the plates) ● By measuring the capacitance for different areas of the capacitor plates and (or) thickness of the dielectric material,determine the dielectric constant of the given material/liquid. http://www.indosawedu.com/dielectric-constant.php https://www.youtube.com/watch?app=desktop&v=sx0tzAj-Dm4 https://www.youtube.com/watch?v=lKfIkUuFT-U		

Books and References:

1. Concepts of Modern Physics, Arthur Beiser 6th Edition (Book 1)
2. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 2)
3. Modern Physics for Scientists and Engineers" by John Morrison
4. Modern Physics by Raymond A. Serway
5. Introduction to Nuclear and Particle Physics - V K Mittal, R C Verma and S C Gupta
6. Introductory Nuclear Physics by Kenneth S. Krane
7. Principles of Nuclear Physics by A. B. Migdal
8. https://phyphox.org/
9. https://physlets.org/tracker/
10. https://expeyes.in/

Mapping of COs with PSOs and POs :

	PS O1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	2	1	1	0	3	2	1	1	2	0	0
CO 2	2	3	2	1	1	1	3	3	1	0	2	0	0
CO 3	1	2	3	3	1	1	2	2	2	2	2	0	0

CO 4	1	1	1	3	2	2	2	1	2	2	3	0	0
CO 5	1	2	1	1	3	1	2	2	2	2	3	0	0
CO 6	1	2	1	1	3	2	2	1	2	2	3	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**SOLID STATE PHYSICS AND SPECTROSCOPY**				
Type of Course	**Minor (GROUP II: MATERIALS PHYSICS)**				
Semester	**III**				
Academic Level	**200 - 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge calculus, atomic theory and electromagnetic spectrum				
Course Summary	This course discusses the concepts of quantum mechanics, band theory and different types of spectroscopy at a fundamental level.				

Course Outcomes (CO):

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Define quantum mechanics and its fundamental principles, explain the concept of			

	quantization, understand the mathematical representation of wave functions and their interpretation. Application of Schrodinger equation for solving different physical systems.	U & Ap	P	Instructor-created exams / Quiz/Assignments
CO2	Understanding of Crystalline and Amorphous Solids and distinguishing between them. Understand the relationship between bonding and properties in different types of crystals	U	C	Instructor created Assignment / Exams/Seminars
CO3	Explain band theory of solids and apply it in explaining the electronic structure of materials. Describe the formation of energy bands and band gaps in solids and their influence on material properties.	Ap	P	Seminar/Presentation / Group Tutorial Work
CO4	Explain the concept of quantization of energy and its importance in spectroscopy. Identify the types of molecular energies. Describe the process of absorption and emission of radiation and understand the Einstein coefficients governing these processes and their relation.	U	C	Instructor-created exams / Home Assignments
CO5	Classify various spectroscopic methods used for sample analysis, like microwave spectroscopy, Infrared Spectroscopy, Electronic spectroscopy, Raman spectroscopy and analyse the possibility of applying these techniques to identify material properties.	An	P	One Minute Reflection Writing assignments and exams
CO6	Develop practical skills to perform spectra and material property related experiments and analyse characteristics of different spectras.	E & C	M	Practical Assignment / Observation of Practical Skills / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Quantum Mechanics**	**16**	**22**
	1	Quantum Mechanics	2	
	2	The Wave Equation	2	
	3	Schrodinger's equation : Time Dependent form	2	
	4	Expectation Values	3	
	5	Operators	2	
	6	Schrodinger's Equation : Steady state form	3	
	7	Particle in a box problem	2	
	Sections 5.1, 5.2, 5.3, 5.5, 5.6, 5.7, 5.8 of chapter 5 of Book 1			
II		**Bonding in Solids and Energy Bands**	**11**	**18**
	8	Crystalline and amorphous solids	2	
	9	Ionic Crystal	2	
	10	Covalent Crystal	1	
	11	Van der Waal's bond	2	
	12	Metallic bond	2	
	13	Band Theory of Solids	2	
	Sections 10.1, 10.2, 10.3, 10.4, 10.5, 10.6 of Book 1			
III		**Introduction to Spectroscopy**	**10**	**16**
	14	Electromagnetic spectrum and Quantization of energy	1	

	15	Types of molecular energies and spectroscopic methods	3	
	16	Spectral line width	2	
	17	Absorption and emission of radiation, Einstein coefficient (excluding derivation)	2	
	18	Lasers	2	
	Sections 1.1 - 1.7 of chapter 1 of Book 2 (Chapter 1 complete)			
IV	**Spectroscopic Methods of sample analysis**		**8**	**14**
	19	Microwave spectroscopy	2	
	20	Infrared Spectroscopy (vibration spectra only)	2	
	21	Electronic spectroscopy	2	
	22	Raman spectroscopy: Introduction, Quantum theory of Raman scattering, Rotational Raman spectra of linear molecules	2	
	Sections 8.6, 8.7, 8.8 of chapter 8 of Book1, sections 8.1, 8.2.2 and 8.3.1 of chapter 8 of Book 2			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Band gap of a semiconductor** ● Measure the reverse bias current/resistance of a semiconductor diode as a function of temperature, using Carey Foster's bridge or Potentiometer or ExpEYES or any other suitable method. ● Plot the logarithm of resistance/current against the inverse of temperature.		

		● From the slope, the band gap from the semiconductor can be obtained.		
	2	**Wavelength of laser using grating** ● The laser light diffracted from the transmission grating is allowed to fall on a screen and record the maxima points in a paper and calculate the wavelength of the laser. ● Determine the number of lines/ meter of the grating using the green line of the mercury.		
	3	**Single slit diffraction using laser - Determination of slit width.** ● The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper. ● From the width of the central maxima or the position of minimum intensity points, calculate the slit width. ● Verify the slit width using a traveling microscope. ● Wavelength of laser can be found using diffraction grating of known N.		
	4	**Determine the numerical aperture (NA) of an optical fiber using a laser** ● Couple the light from the laser source onto one of the fiber ends and the light coming from the other end is allowed to fall on a screen(sheet having circular markings) placed perpendicular to the axis of the fiber. ● Measure the diameter of the laser beam on the screen and the distance between the screen and fiber output end and hence calculate the NA.		
	5	**Determination of the dispersive power of a solid prism using a spectrometer** ● Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer.		

		● Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths.		
	6	**Spectrometer-Determination of the Cauchy's constants of the given prism** ● Find the angle of the prism, the minimum deviation angles of the prominent lines of the mercury spectrum and hence calculate the refractive indices for the colors. ● Determine A and B from the $\mu - \frac{1}{\lambda^2}$ graph.		
	7	**Determine the refractive index of (a) given liquid and (b)the material of a lens, by forming a liquid lens.** ● Through this experiment the students are expected to get the concepts of image formation, combination of lenses and radius of curvature of the surface of lens. ● Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices.		
	8	**Determine the focal length of the combination of two lenses separated by a distance.** ● Determine the focal lengths, f1 and f2 of the two lenses using an illuminated cross-slit screen holder, nodal slide(for placing the lenses) and plane mirror arrangement. ● Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation ● $\frac{1}{F} = \frac{1}{f1} + \frac{1}{f2} - \frac{d}{f1f2}$. ● The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study. ● https://www.youtube.com/watch?v=IOlEEtyNPBg ● https://www.youtube.com/watch?v=tNo4Ipk74SU		

	9	**Air wedge-determination of the radius of a thin wire/human hair/thin foil.** ● Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates. ● Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given.		
	10	**Newton's rings-determination of the wavelength of sodium light** ● Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source. ● Determine the radius of curvature by Boy's method and determine the wavelength of the source.		
	11	**Construction of the center tapped full wave rectifiers and regulated power supply** ● Construct a center tapped full wave rectifier without filter and with a filter. ● Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter. ● Observe the variation of the ripple factor with load resistance, when filter is used. ● Construct 5V/12V regulated power supply using 78XX IC.		
	12	**Study the characteristics of Zener diode and construct a voltage regulator** ● Study the V-I characteristics of zener diode and hence determine the breakdown voltage. ● https://expeyes.in/experiments/electronics/zenerIV.html ● Construct a voltage regulator using a zener diode and determine the percentage of voltage regulation.		
	13	**Flywheel- Determination of the Moment of Inertia**		

		● This experiment aims to help students grasp the concept of energy conservation and the dynamics of rotation. ● Do at least 9 trials for different masses and number of turns wound on the axil.		
	14	**Compound Pendulum- Acceleration Due to Gravity and Moment of Inertia and Verification of Parallel Axis Theorem** ● Plot a graph of distance of knife edge from one end Vs period of oscillations. Using the measurement from the graph, calculate g. ● Calculate the radius of gyration and hence the moment of inertia about CM. Compare the result obtained by the direct calculation $I_{CM} = \frac{ML^2}{12}$		
	15	**Sonometer - Determine the Frequency of AC** ● Estimate the linear mass density of the wire. ● Draw $L^2 - m$ graph and from the slope calculate the frequency.		

Books and References:

1.Concepts of Modern Physics, Arthur Beiser 6th Edition (Book 1)

2. Molecular structure and spectroscopy, (Second edition) G. Aruldhas (Book 2)

3.Kittel's Introduction to Solid State Physics, Wiley India Edition

4.Solid State Physics Structure and properties of materials by M.A.Wahab (Third Edition)

5.Solid State Physics" by Neil W. Ashcroft and N. David Mermin.

6.Solid State Physics: Essential Concepts by David W. Snoke.

7.Principles of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash

8. Spectra of Atoms and Molecules by Peter F. Bernath

9.Molecular Spectroscopy by Jeanne L. McHale

10. https://phyphox.org/

11 https://physlets.org/tracker/

12. https://expeyes.in/

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	2	1	2	2	3	2	2	2	3	3	0
CO 2	1	3	2	2	2	1	2	3	2	1	3	2	0
CO 3	1	2	3	2	2	2	2	2	3	1	3	3	0
CO 4	2	1	2	2	2	1	2	2	2	1	3	2	0
CO 5	2	1	3	2	3	1	2	1	2	2	3	3	0
CO 6	2	3	1	2	3	3	2	2	2	1	3	3	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**SEMICONDUCTOR PHYSICS AND ELECTRONICS**				
Type of Course	**Minor (GROUP III: SEMICONDUCTOR PHYSICS)**				
Semester	**I**				
Academic Level	**100 – 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1.Basic understanding of physics and mathematics, including algebra and calculus. 2.Familiarity with fundamental concepts in electricity and magnetism.				
Course Summary	This course covers fundamental concepts in electronics, focusing on both theoretical understanding and practical applications. The syllabus includes topics such as atomic models, semiconductor physics, diode and transistor circuits, voltage stabilization, amplifiers, and digital electronics. The course aims to equip students with the necessary knowledge and skills to analyze, design, and troubleshoot electronic circuits.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Master the energy band structure of semiconductors, differentiate between intrinsic and extrinsic semiconductors, grasp majority and minority carrier concepts, and proficiently analyse pn junctions.	U	F	Instructor-created exams / Quiz
CO2	Analyse diode rectifiers and filtering circuits, understand transistor basics and various configurations and load line analyse	U & An	C	Practical Assignment / Observation of Practical Skills
CO3	Gain insight into voltage stabilisation using Zener diodes. Design and understand the working of CE amplifiers. Get introduced to operational amplifiers.	U, Ap & C	P	Seminar Presentation / Group Tutorial Work
CO4	Understand Boolean algebra basics, the functioning of OR, AND, NOT gates, and the fundamental theorems. Master truth tables, symbolic representation, universal gates, XOR gates and adder circuits.	U & Ap	C	Instructor-created exams / Home Assignments
CO6	Practical session will help in understanding the working of pn junction diode, transistors. Will comprehend the working of logic gates in digital electronics	Ap & C	M	One Minute Reflection Writing assignments

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge (F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+ 30)	Marks 70
I		**Semiconductor Physics**	**8**	**12**
	1	Bohr's atomic model and energy levels, Energy bands and classification of solids, silicon	2	
	2	Semiconductors and the influence of temperature	1	
	3	Intrinsic and extrinsic semiconductors, n type and p type, majority and minority carriers	2	
	4	pn junction and its properties	2	
	5	Biasing of junction	1	
		Sections 4.1 - 4.6 of chapter 4, sections 5.1 - 5.20 of chapter 5, Book 1		
II		**Analog Electronics**	**16**	**25**
	6	Diode as rectifiers- half wave and full wave- Efficiency and ripple factor calculations	6	
	7	Filter circuits	2	
	8	Introduction to transistor and its action	2	
	9	Transistor configurations- CE in detail (CB and CC as comparison with CE)	3	
	10	Load line analysis and operating point	2	
	11	Testing of transistor	1	
		Sections: 6.2,6.3, 6.6-6.21 (excluding 6.16) of chapter 6, sections 8.1-8.22, (Excluding 8.11) (Derivation of expression of Ic may be avoided in CE, CB and CC), 8.27 of chapter 8, Book 1		

		Voltage stabiliser and amplifier	**13**	**21**
III	12	Zener diode, voltage stabilisation, equivalent circuit of zener diode, zener diode as voltage stabilizer.	3	
	13	Faithful amplification, transistor biasing, inherent variations in transistor parameters, stabilization, voltage divider bias method	3	
	14	Designing of transistor biasing circuits, Mid - point biasing	1	
	15	CE amplifier – circuit, working, phase reversal, frequency response, voltage gain.	3	
	16	Operational amplifier: basic operation, inverting and noninverting modes, voltage follower.	2	
	17	Summing amplifier, applications of summing amplifiers	1	
		Sections: 6.24-6.28 of chapter 6, 9.1-9.5, 9.12, 9.14-9.15 of chapter 9, 10.1-10.5 of chapter 10, 11.3-11.4, of chapter 11, 25.15- 25.17, 25.22-25.24, 25.26, 25.27, 25.32 - 25.33 of chapter 25, Book 1		
IV		**Digital Electronic**	**8**	**12**
	18	Basic logic gates	3	
	19	Combination gates and XOR gates	1	
	20	Boolean Algebra and Boolean theorems	2	
	21	De Morgan's theorems	1	
	22	Electronic adder circuits	1	
		Sections: 26.11-26.17, 26.20-26.22, 26.32 of chapter 26, Book 1		
V		**PRACTICALS**	**30**	
	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			

	Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Study the V-I characteristics of diodes.** • Characteristics of Ge/Si diodes, and LEDs. • ExpEYES may be used. https://expeyes.in/experiments/electronics/diodeIV.html • Optional: Plot and fit the experimental data with the diode equation in GeoGebra or any other application and calculate the value of the ideality factor of the PN junction.		
	2	**Study the characteristics of Zener diode and construct a voltage regulator.** • Study the V-I characteristics of zener diode and hence determine the breakdown voltage. • https://expeyes.in/experiments/electronics/zenerIV.html • Construct a voltage regulator using a zener diode and determine the percentage of voltage regulation.		
	3	**Construction of the center tapped full wave rectifiers and regulated power supply.** • Construct a center tapped full wave rectifier without filter and with a filter. • Connections may be realized through soldering, to get an experience of soldering. • Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter. • Observe the variation of the ripple factor with load resistance, when filter is used. • Optional: Construct 5V/12V regulated power supply using 78XX IC.		
	4	**Transistor input, output & transfer characteristics in CE configuration.**		

		● Draw the static characteristics of the transistor in common emitter configuration and calculate input/output resistance and the current gain. ● ExpEYES may be used https://expeyes.in/experiments/electronics/npn.html		
	5	**Construction of CE transistor amplifier and the study of frequency response** ● Design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias. ● Study the frequency response and find the bandwidth.		
	6	**Operational Amplifier –inverting, non inverting amplifier and voltage follower.** ● Design inverting and non inverting amplifiers of different voltage gain. ● Measure and verify the gain using CRO/ExpEYES. ● Construct a voltage follower and verify that the gain is unity.		
	7	**Operational Amplifier- adder, subtractor** ● Design arithmetic circuits(adder and subtractor) using OP AMP, with two input voltages and measure the result using multimeter/CRO/ExpEYES.		
	8	**Construction of basic gates using diodes (AND, OR) & transistor (NOT)** ● Realize the logic AND and OR gates using diodes and NOT gate using a transistor and verify the truth table. Logic output can be checked using a multimeter or LED.		
	9	**Construct Half adder using universal gates and study the operation.** ● Implement half adder using NAND/NOR gates and verify the truth table for each input/output combination.		
	10	**Verification of De-Morgan's Theorems using basic gates.**		

		• Realize the either side of the De-Morgan's Theorems using gates from appropriate ICs and verify the truth table for each input/output combination.		
	11	**Acceleration of a Freely Falling Body** • Use the smartphone acoustic stopwatch to determine the duration of a free fall. • Measure the time of flight of a steel ball for different heights and plot a graph of distance vs. time squared (s vs. t^2). Determine g from the graph. • Experiment 2 of Book 2. • Phyphox app may be used. https://phyphox.org/experiment/free-fall-2/ **OR** • Use ExpEyes kit, electromagnet, and contact sensor to determine the duration of a free fall. https://expeyes.in/experiments/mechanics/tof.html		
	12	**Verification of the Relation of Angular Velocity and Centrifugal Acceleration** • Use the smartphone gyroscope and the accelerometer. • Attach the smartphone to some rotating arrangements and record the data from the gyroscope and accelerometer. • Plot angular velocity Vs acceleration and verify the relation. • Experiment 18 of Book 2. • Phyphox app may be used. https://phyphox.org/experiment/centrifugal-acceleration/		
	13	**Analysis of Bouncing Balls to Determine Gravitational Acceleration and Coefficient of Restitution.** • After doing the experiment, the student should be able to understand the concept of inelastic collision.		

		• Measure the time interval between successive bounces using a digital acoustic stopwatch and hence calculate g and coefficient of restitution • Experiment 12 of Book 2 • Phyphox app may be used. https://phyphox.org/experiment/inelastic-collision/		
	14	**Analysis of Air Resistance and Terminal Speed to Determine the Drag Coefficient.** • Record the motion of a light weight paper cup and analyse it with Tracker tool (https://physlets.org/tracker/). • Plot acceleration, velocity, and position with time. • Repeat the experiment with different mass (by simply stacking the paper cups) • Determine the Drag Coefficient • Experiment 27 of Book 2. • https://www.youtube.com/watch?v=iujzK3uH1Yc		
	15	**Projectile Motion: Energy Conservation** • Analyse the motion of the tossing ball/ projectile in the Tracker tool. • Plot time Vs the x-and y-components of velocity and acceleration. • Also plot the kinetic energy, potential energy (build data using define tool) and total energy. • https://www.youtube.com/watch?v=x0AWRLvgB28 • https://www.youtube.com/watch?v=i07HeUWo8xc		

Books and References:

1. V K Mehta and Rohit Mehta -Principles of electronics (Book 1)
2. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 2)
3. https://phyphox.org/
4. https://physlets.org/tracker/
5. 3. Digital principles and applications - Leach and Malvino (Tata McGraw Hill)
6. Electronic Principles by Malvino - (Tata McGraw Hill)
7. Digital Computer Fundamentals (Thomas. C. Bartee)

8. Physics of Semiconductor Devices- Second Edition – Dilip K Roy – Universities Press
9. Digital Fundamentals –Thomas L Floyd – Pearson Education
10. The Art of Electronics-Paul Herowitz & Winfield Hill

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	3	0	2	1	3	1	1	0	2	3	0
CO 2	2	1	1	1	2	1	2	2	2	1	2	3	0
CO 3	2	3	2	1	1	2	2	3	2	1	2	3	0
CO 4	0	2	1	0	0	0	1	1	1	0	2	3	0
CO 5	1	1	2	0	2	2	2	2	3	1	3	3	0
CO 6	2	2	1	0	2	2	2	2	2	1	3	3	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignm ent /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**FUNDAMENTALS OF OPTICS**				
Type of Course	**Minor (GROUP III: SEMICONDUCTOR PHYSICS)**				
Semester	**II**				
Academic Level	**100 – 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basics of Physics and Chemistry (Plus Two Level)				
Course Summary	This syllabus explores how light behaves, from reflection and bending to creating specific light sources and transmitting them through thin cables.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyze the principles of reflection and refraction, applying them to explain image formation by mirrors and lenses.	An	C	Instructor-created exams / Quiz/ Practical Assignment

CO2	Describe the phenomenon of wave interference and diffraction, and solve problems using concepts like the double-slit experiment.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Explain the concept of polarization and its applications, including the use of polarizers and analyzers.	U	C	Instructor-created exams / Quiz/ Practical Assignment
CO4	Describe the operating principles of lasers, including stimulated emission and population inversion, and identify different laser types.	U	C	Instructor-created exams / Home Assignments
CO5	Explain the concept of total internal reflection and apply it to understand light propagation through optical fibers.	Ap	F	Seminar Presentation / Group Tutorial Work
CO6	Able to explain the advantages and applications of optical fibers in communication and sensing.	U	C	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**Reflection and Refraction**	**10**	**15**
	1	Reflection at plane Mirrors, Reflection at spherical mirror: Basic terms, paraxial rays and paraxial approximation, sign convention, spherical mirror equation, Focal point and focal length	3	
	2	Spherical mirror equation applied to concave mirror, Conjugate points, extended object, lateral magnification, convex mirror and plane mirror	3	
	3	Refraction at spherical surfaces, Gaussian relation	2	

	4	Lens equation, Lens maker's equation.	2	
	Section 3.3, 3.4, 3.12, 4.8 - 4.10 of chapter 3 and chapter 4 of Book 1			
II	**Wave optics**		**19**	**25**
	5	Interference, Young double slit experiment	2	
	6	Coherence and conditions for interference	1	
	7	Interference in thin parallel films	2	
	8	Interference in wedge shaped film, Angle of wedge and thickness of spacer, Colour of thin films	2	
	9	Newton's rings: determination of wavelength of light	2	
	10	Diffraction: Difference between diffraction and interference, Fresnel and Fraunhoffer type diffraction	1	
	11	Fraunhoffer diffraction at a single slit, double slit (Calculus method is excluded), Plane diffraction grating.	3	
	12	Polarization: Types of polarization, Brewster's law, Production of plane polarized light	2	
	13	Polarizer and analyser, Malu’s law, Double refraction	2	
	14	Optical activity and specific rotation	2	
	Section 14.4 – 14.7,15.2, 15.5, 15.6 (upto 15.6.7), 17.6 - 17.7, 18.1, 18.2, 18.4, 18.7, 20.1, 20.2, 20.5, 20.6, 20.8 - 20.11, 20.27 - 20.29, Book 1			
III	**Lasers**		**8**	**15**
	15	Lasers, Thermal equilibrium, Absorption of a Photon, Spontaneous emission, Stimulated emission, Population inversion	2	

	16	Components of Laser and lasing action	3	
	17	Ruby laser, Nd-YAG laser, Helium Neon laser, Carbon dioxide laser, semiconductor laser.	3	
	Sections 22.1, 22.3, 22.4, 22.7, 22.8, 22.9, 22.14, 22.15, Book 1			
IV		**Fiber Optics**	**8**	**15**
	18	Introduction, Optical fiber, Total internal reflection	2	
	19	Propagation of light through optical fiber	1	
	20	Critical angle, Acceptance angle, Numerical Aperture, Modes of propagation	2	
	21	Classification of optical fibers, Losses in optical fiber, Applications	2	
	22	Fiber optic communication systems, fiber optic sensors.	1	
	Sections 24.1 - 24.6, 24.8, 24.10, 24.11, 24.15, 24.20 - 24.21, 24.23 (24.23.1-24.23.2), Book 1			
V		**PRACTICALS**	**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Determine the refractive index of (a) given liquid and (b)the material of a lens, by forming a liquid lens.** ● Through this experiment the students are expected to get the concepts of image formation, combination of lenses and radius of curvature of the surface of lens.		

		• Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices.		
	2	**Determine the focal length of the combination of two lenses separated by a distance.** • Determine the focal lengths, f1 and f2 of the two lenses using an illuminated cross‑slit screen holder, nodal slide(for placing the lenses) and plane mirror arrangement. • Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation • $\frac{1}{F} = \frac{1}{f1} + \frac{1}{f2} - \frac{d}{f1f2}$. • The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study. • https://www.youtube.com/watch?v=IOlEEtyNPBg • https://www.youtube.com/watch?v=tNo4Ipk74SU		
	3	**Determination of the dispersive power of a solid prism using a spectrometer.** • Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer. • Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths.		
	4	**Refractive indices of quartz prism using spectrometer.** • Determine the refractive indices of quartz for the ordinary and extraordinary rays of a sodium vapour lamp by arranging the quartz prism at minimum deviation position in the spectrometer. • Verify the polarizations of the ordinary and extraordinary rays using a polaroid.		

	5	**Determination of wavelengths of mercury spectrum using diffraction grating and spectrometer.** ● Arrange the grating at normal incidence. ● Standardize the grating using the green line of mercury and then find the wavelengths of other prominent lines of the spectrum.		
	6	**Newton's rings-determination of the wavelength of sodium light** ● Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source. ● Determine the radius of curvature by Boy's method and determine the wavelength of the source. ● Optional: In experiment 5 and 6, record a short video of the interference pattern, calibrate the video using scale marked on the glass plate, analyse the video using Tracker tool. From the intensity profile get the locations of the dark rings and calculate the wavelength of the source/thickness of the sample https://physlets.org/tracker/. https://www.youtube.com/watch?v=UCCPkJpUQEw		
	7	**Air wedge-determination of the radius of a thin wire/human hair/thin foil.** ● Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates. ● Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given.		
	8	**Single slit diffraction using laser - Determination of slit width.** ● The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper.		

		• From the width of the central maxima or the position of minimum intensity points, calculate the slit width. • Verify the slit width using a traveling microscope. • Wavelength of laser can be found using diffraction grating of known N.		
	9	**Study the specific rotation of the sugar solution using a polarimeter.** • Determine the specific rotation corresponding to different concentrations of the sugar dissolved in water. • Draw a graph between rotation and concentrations and verify the linear relationship.		
	10	**Verification of Malus's law using polarizer, analyzer and photo detector** • Unpolarized light is allowed to pass through a polarizer and is observed through an analyzer. • Vary the angle between the axes of polarizer and analyzer and measure the intensity of the light (current output of the photodetector). • Plot $\theta - I$ and $cos^2\theta - I$ graphs and verify the Malus's law. • A flat computer monitor (or LCD TV screen) in plain white color can be used as the source of linear polarized light. • The ambient light sensor of the smartphone and the orientation sensor of the smartphone can be used to measure the illuminance and the angles respectively. • A small piece of polarizer (a square of about 1 cm side) from an old calculator's display was placed over the ambient light sensor as analyser. • https://arxiv.org/pdf/1607.02659		
	11	**Spectrometer-Determination of the Cauchy's constants of the given prism** • Find the angle of the prism, the minimum deviation angles of the prominent lines of the mercury spectrum and hence calculate the refractive indices for the colors. • Determine A and B from the $\mu - \frac{1}{\lambda^2}$ graph.		

	12	**Viscosity of a liquid - Falling Ball Viscometer** ● Drop a polished steel ball into a glass tube of a somewhat larger diameter containing the liquid. ● Record the time required for the ball to fall at constant velocity through a specified distance between reference marks. ● Use the Stoke's law for the sphere falling in a fluid under effect of gravity, to estimate the viscosity of the liquid.		
	13	**Surface tension of liquid - Capillary rise method** ● Clamp a clean capillary tube by dipping its lower end into the liquid in the beaker. ● Measure the rise of water in the tube using a traveling microscope. ● Also measure the radius of the capillary tube using the traveling microscope and estimate the surface tension of the liquid. ● Density of the liquid can be determined using Hare's apparatus of can be given		
	14	**Viscosity of a liquid - Poiseuille's Method** ● Fill the liquid in a vertically fixed burette with its lower end attached to a capillary tube, placed in horizontal position using a rubber tube. ● Note the time taken to reach each 10cc of water and the height of the corresponding marking. ● Also measure the radius of the capillary tube using the traveling microscope and estimate the viscosity of the liquid.		
	15	**Static torsion Rigidity modulus** ● Using Searle's static torsion apparatus, determine the rigidity modulus of the material of the rod.		

Books and References:

1) A Textbook of Optics by N. Subramanyam, Brij Lal, M N Avadhanulu, 25TH Edition (Book 1)
2) Optics by Ajoy Ghatak, Tata McGrow-Hill (Book 2)

3) Optics by Eugene Hecht, Addison-Wesley (Book 3)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	2	1	2	0	3	1	1	0	2	1	0
CO 2	3	2	2	1	2	1	3	3	2	1	2	1	0
CO 3	3	2	3	2	2	1	3	2	2	1	2	1	0
CO 4	3	2	2	1	2	0	3	2	2	1	2	1	0
CO 5	2	3	2	1	2	1	3	2	2	1	3	1	0
CO 6	2	3	2	1	2	2	3	2	2	1	3	1	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ELECTRONIC COMMUNICATION**				
Type of Course	**Minor (GROUP III: SEMICONDUCTOR PHYSICS)**				
Semester	**III**				
Academic Level	**200 – 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Fundamentals of EM wave characteristics and electronics				
Course Summary	This course explores the characteristics of the EM wave spectrum, various communication systems and there implementation.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain main parts and different types of electronic communication system. Define electromagnetic spectrum and its application in communication systems.	U & Ap	P	Instructor-created exams / Home Assignments
CO2	Calculate voltage gain, current gain, attenuation. Explain relation between Q, resonant frequency and bandwidth.	Ap	P	Instructor-created exams / Home Assignments
CO3	Explain the basic concepts of AM and FM. Compare AM and FM and calculate parameters such as modulation index, band width.	U & An	P	Instructor-created exams / Home Assignments
CO4	Explain the fundamental concepts in digital communication such as		C	Instructor-created exams / Home

	quantizing error, analog to digital conversion, sampling, PAM, PWM, PPM, difference between asynchronous and synchronous data transmission.	U		Assignments
CO5	Explain the reasons for the growing use of microwaves and millimetre waves in communications. Identify the microwave and millimetre-wave band segments and various microwave components used in this communication system.	U & An	P	Seminar Presentation / Group Tutorial Work
CO6	Design and construct various circuit elements useful in communication systems. Design experiments to identify different characteristics of electromagnetic spectrum.	Ap	P	Practical Assignment / Observation of Practical Skills / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**INTRODUCTION TO COMMUNICATION SYSTEM**	**13**	**20**
	1	The significance of human communication, communication system, Types of communication systems.	2	
	2	Modulation and multiplexing, the electromagnetic spectrum	2	
	3	Bandwidth, survey of communication application	2	
	4	Gain, Tuned Circuits	3	
	5	Filters: Passive RC filters, Active filters (advantages, qualitative discussion on op-amp based active filters using circuit diagrams)	2	
	6	Fourier theory	2	
		Relevant topics of chapter 2 of Book 1; sections 1.1-1.7, 2.1, 2.2, 2.3 (selected topics), 2.4 of chapter 2 of Book 1		

II		**AMPLITUDE AND FREQUENCY MODULATION**	**12**	**18**
	7	AM modulation concepts, Modulation index and percentage of modulation	2	
	8	Sideband and frequency domain, pulse modulation	2	
	9	AM power, Single sideband modulation	2	
	10	Basic principles of frequency modulation, principles of phase modulation	2	
	11	Modulation index and side bands, Bessel functions	2	
	12	Frequency suppression effect of FM, AM versus FM	2	
		Relevant topics of chapter 3 and 5 of Book 1; Sections: 3.1 to 3.5, 5.1 to 5.5 of chapter 3 and chapter 5 of Book 1		
III		**DIGITAL COMMUNICATION**	**10**	**16**
	13	Digital transmission of data, serial and parallel transmission	2	
	14	Data conversion, Basic principles of data conversion, General discussion on DA converters and AD converters	2	
	15	Pulse modulation, pulse code modulation	2	
	16	Digital signal processing	2	
	17	Principles of digital transmission	2	
		Relevant topics of chapter 7 and 11 of Book 1; Sections: 7.1 to 7.5, 11.1, 11.2 of chapter 7 and chapter 11 of Book 1		
IV		**MICROMETRE AND MILLIMETRE COMMUNICATION**	**10**	**16**
	18	Microwave concepts, microwave frequencies and band, advantages and disadvantages of microwave transmission, microwave communication system.	2	
	19	Microwave lines and devices	2	
	20	Microwave semiconductor diode	2	
	21	Microwave tubes	2	

	22	Microwave antenna: Low frequency antenna, horn antenna, Microwave and millimetre wave applications	2	
	Relevant topics of chapter 16 of Book 1; Sections: 16.1 to 16.5, 16.7 of chapter 16 of Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Design and construct passive RC filters** ● Measure the frequency responses of low-pass and high-pass RC circuits and plot frequency response graphs (Bode plots) of the amplitude and the phase.		
	2	**Construct amplitude modulator circuit** ● Design and construct an amplitude modulator circuit. ● Study the response for suitable modulation depths.		
	3	**Construction of D/A converter** ● Construct a 4 bit D/A converter using R-2R ladder network. ● Plot a graph of analog output voltage versus binary number.		
	4	**Determine the numerical aperture (NA) of an optical fiber using a laser** ● Couple the light from the laser source onto one of the fiber ends and the light coming from the other end is allowed to fall on a screen(sheet having circular markings) placed perpendicular to the axis of the fiber. ● Measure the diameter of the laser beam on the screen and the distance between the screen and fiber output end and hence calculate the NA.		

	5	**Attenuation and bandwidth of optical fibre** ● Determine the attenuation and bandwidth of the given optical fibre specimen		
	6	**Fourier analysis of the modes of vibration in a stretched string.** ● Record the sound produced by guitar string (or similar arrangement) using a microphone and analyze the spectrum by taking FFT. ● Audio Spectrum in the Pyphox, Audacity, ExpEYES or any other tools can be used to record the sound and to take FFT. ● Vary the length and tension of the string and analyze the harmonics. ● https://phyphox.org/experiment/audio-spectrum/ ● https://www.youtube.com/watch?v=bl7jf2myEvM ● https://expeyes.in/experiments/sound/beats.html		
	7	**Construct Half adder using universal gates and study the operation.** ● Implement half adder using NAND/NOR gates and verify the truth table for each input/output combination.		
	8	**Verification of De-Morgan's Theorems using basic gates.** ● Realize the either side of the De-Morgan's Theorems using gates from appropriate ICs and verify the truth table for each input/output combination.		
	9	**Construct and study the operations of the RS and JK Flip-Flops using IC's** ● Realize RS Flip-Flop using NAND gates and verify the truth table ● Realize JK Flip-Flop using NAND gates from appropriate ICs and verify the truth table		
	10	**Construction of the center tapped full wave rectifiers and regulated power supply.** ● Construct a center tapped full wave rectifier without filter and with a filter. ● Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter.		

		• Observe the variation of the ripple factor with load resistance, when filter is used. • Construct 5V/12V regulated power supply using 78XX IC.		
	11	**Study the frequency response of common emitter(CE) transistor amplifier.** • Design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias. • Analyse the frequency response, draw the curve and find the bandwidth, without feedback.		
	12	**Construction of LC oscillator (Hartley or Colpitt's)** • Construct a LC oscillator (Hartley or Colpitt's) and measure the frequency using CRO/ExpEYES for different values of L and C. Compare with the theoretical values.		
	13	**Determination of Plank's constant using LEDs** • Observe the turn-on voltage, • V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing) • Plot $\frac{1}{\lambda} - V_0$ graph using Python, fit a straight line to get the slope and estimate the value of h. • Calculate the %error. • Programmable voltage source of ExpEYES may be used to find the turn-on voltage.		
	14	**Analysis of Hydrogen spectra using the Tracker Video Analysis tool**. • Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. • Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant. • Estimate the %error. • Pre recorded video of the Hydrogen spectra can be used. • https://physlets.org/tracker/. • https://www.youtube.com/watch?v=UCCPkJpUQEw		

	15	**Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.** ● Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity, get λ_{max} and using Wein's law calculate the surface temperature. ● Pre recorded video of the solar spectra can be used.		

Books and References:

1. Principles of electronic communication system, 4th Edition by Louis E. Frenzel (Book 1)
2. Electronic communication systems, 5th Edition by y George Kennedy, Brendan Davis, Srm Prasanna- Mc-Graw Hill(Book 2)
3. Electronic Communications System, 5th Edition by Wayne Tomasi, Pearson (Book 3)
4. Principles of Electronics, 11th edition by V.K. Mehta and Rohith Mehta, S Chand & Company (Book 4)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	1	0	0	2	3	3	3	2	1	1	0
CO 2	3	2	1	0	0	2	3	3	3	2	1	1	0
CO 3	3	2	1	0	0	2	3	3	3	2	1	1	0
CO 4	3	2	1	0	0	2	3	3	3	2	1	1	0
CO 5	3	2	1	0	0	2	3	3	3	2	1	1	0
CO 6	3	2	2	0	0	3	3	3	3	2	1	1	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Assignments
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical Skill Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ELECTRICITY AND MAGNETISM**				
Type of Course	**Minor (GROUP IV: OPTICAL PHYSICS)**				
Semester	**I**				
Academic Level	**100-199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	A strong foundation in introductory physics, including mechanics, thermodynamics, and basic concepts of electricity and magnetism. Proficiency in algebra, trigonometry				
Course Summary	This paper provides students with a solid foundation in the principles of electricity and magnetism, enabling them to apply theoretical concepts to practical scenarios and develop problem-solving skills in electromagnetism.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and grasp the concept of electric charge, its properties, including quantization and conservation principles.	U	C	Instructor-created exams / Quiz
CO2	Students will analyze electric fields produced by various charge distributions, including point charges, electric dipoles, and charged infinite sheets. students will develop the ability	Ap	P	Practical Assignment / Observation of Practical Skills

	to visualize electric fields and understand their behavior in different spatial configurations.			
CO3	Understand the concept of electric dipoles, analyze the forces and torques acting on them in uniform electric fields, and relate these to practical applications.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Apply Gauss's law to calculate electric flux through closed surfaces, understand its implications for charge distribution, and analyze the behavior of electric fields in various scenarios.	U	C	Instructor-created exams / Home Assignments
CO5	calculate electric potential due to point charges, charged conductors, and other charge distributions, and analyze the concept of electric potential energy.	Ap	P	One Minute Reflection Writing assignments
CO6	Through practical experiments and theoretical analysis, students will explore applications of Gauss's law, such as determining charges on conductors and understanding electric potential distributions.	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**Electric charge and Electric field**	**10**	**16**
	1	Electric charge	3	
	2	Coulomb's law	2	
	3	Electric field and electric force, Electric field calculation- electric dipole and charged infinite sheet	2	
	4	Electric field lines	1	
	5	Electric dipole: upto force and torque on electric dipole	2	
	Sections 21.1, 21.3 - 21.7, Book 1			
II		**Gauss's law and Electric potential**	**16**	**25**

	6	Charge and electric flux	2	
	7	Calculating electric flux	3	
	8	Gauss's law	2	
	9	Application of Gauss's law	2	
	10	Charges on conductors-testing Gauss's law experimentally	1	
	11	Electric potential energy	3	
	12	Electric potential: upto electric potential of charged conducting sphere	3	
	Sections 22.1-22.5, 23.1- 23.3, Book 1			
III	**Current resistance and electromotive force**		**12**	**18**
	13	Current, resistivity and resistance	4	
	14	EMF and circuits	2	
	15	Energy and power in electric circuits: upto power input to a pure resistance	1	
	16	Theory of metallic conduction	1	
	17	Resistance in series and parallel	2	
	18	Kirchoff law and Power distribution system	2	
	Sections 25.1- 25.6, 26.1, 26.2, 26.5, Book 1			
IV	**Magnetic field and magnetic forces**		**7**	**11**
	19	Magnetism, Magnetic field	2	
	20	Magnetic field lines and magnetic flux	2	
	21	Motion of charged particle in a magnetic field	1	
	22	Magnetic force on a current carrying conductor-straight conductor	2	
	Sections 27.1-27.4, 27.6, Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6^{th} experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			

	Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Mapping of the magnetic field lines of a bar magnet.** • Fix a paper on a drawing board kept on a table and place the bar magnet at the center along the magnetic meridian. • Using a small compass needle, map the magnetic field lines of the magnet placed with north pole pointing south. • Mark the null points (where the horizontal component of Earth's magnetic field, Bh cancels the field due to magnet) along the axial/equatorial line and measure the distance, 2d, between them. • Calculate the moment of the magnet. (a) $m = \frac{4\pi}{\mu_0}\frac{(d^2-l^2)^2}{2d}B_h$		
	2	**Study the variation of the magnetic field strength of a bar magnet using a smartphone magnetometer** • Using a smartphone magnetometer, measure the strength of the magnetic field of a bar magnet, along the axial and equatorial lines and plot the data. • Magnetometer in the Phyphox app may be used to get the data after locating the approximate position of the magnetometer sensor. https://phyphox.org/wiki/index.php?title=Sensor:_Magnetic_field • Fit the theoretical formulae to the data and obtain magnetic dipole moment. Along the axial line $B = \frac{\mu_0}{4\pi}\frac{2md}{(d^2-l^2)^2}$ and along the equatorial line $B = \frac{\mu_0}{4\pi}\frac{m}{(d^2+l^2)^{3/2}}$		
	3	**Determine the moment of a bar magnet and Bh using a deflection magnetometer and a box type vibration magnetometer** • Determine m/Bh using deflection magnetometer in Tan A position and mBh using box type vibration magnetometer. Hence calculate the moment of the magnet and Bh. • If the same magnet was used, compare the dipole moment with that of experiment 2 and 3.		
	4	**Circular coil- Verification of Biot Savart's law and determination of Bh** • Move a compass through a platform along the axis of the coil carrying a study current. Note the deflection of the needle and plot magnetic flux density ($B = B_h tan\theta$) as a function of distance. • Optional: Smartphone magnetometer may be used to measure the strength of the magnetic field along the axial line and plot the data. https://phyphox.org/experiment/magnetic-field/ • Experiment 62 of Book 2		

		• By varying current and (or) distance of the compass box along the axial line of the coil, note the deflection and hence determine the value of Bh.		
	5	**Reduction factor of TG using potentiometer.** • Standardize the given potentiometer using a Danial cell or any other constant voltage source and use the standardized potentiometer to find the current through the TG. • By observing the deflection in the TG for different currents, calculate the reduction factor. • From the magnetic field at the center of a circular coil, deduce the value Bh.		
	6	**Verification of Kirchoff's laws/ Superposition theorem.** • Verify Kirchoff's current law at a junction where a minimum of three branches meet. • Verify Kirchoff's current law for a network with two loops.		
	7	**Thomson's e/m experiment - Determination of the specific charge of the electron.** • Measure the ratio of the electron charge-to-mass ratio (e/m) by studying the electron trajectories in a uniform magnetic field.		
	8	**Parallel plate capacitor. (a) verify the relationship between capacitance and the area of the plates (b) determination of dielectric constant of thin dielectric sheet** • Form a parallel plate capacitor with dielectric material filled between the plates. • Multimeter/ ExpEYES can be used to measure the capacitance. (For a significantly measurable value of the capacitance, use plates of dimension 10cmx10cm, or greater) • Change the area of the capacitor plates and verify the relationship of the capacitance on the area (Using the same set of plates, the area can be changed by varying the overlapping region of the plates) • By measuring the capacitance for different areas of the capacitor plates and (or) thickness of the dielectric material,determine the dielectric constant of the given material/liquid. • https://www.youtube.com/watch?v=lKfIkUuFT-U		
	9	**Calibrate the ammeter using potentiometer** • Standardize the potentiometer using a Danial cell or any other standard voltage source. • Determine the current for at least 8 trials and draw the calibration graph.		
	10	**Conversion of Galvanometer to voltmeter and calibration using potentiometer**		

		• Determine the value of high resistance required to connect in series with the galvanometer so as it can read 0.1V or 0.2V per scale division. • Standardize the potentiometer using a Danial cell or any other standard voltage source. • Determine the voltage for at least 6 trials and draw the calibration graph.		
	11	**Determination of resistivity of a thin wire using Carey-Foster's Bridge** • Find the resistance per unit length of the bridge wire. • Determine resistance of the thin wire using the bridge, thickness of the wire using screw gauge and hence determine		
	12	**Acceleration of a Freely Falling Body** • Use the smartphone acoustic stopwatch to determine the duration of a free fall. • Measure the time of flight of a steel ball for different heights and plot a graph of distance vs. time squared (s vs. t^2). Determine g from the graph. • Experiment 2 of Book 2. • Phyphox app may be used. https://phyphox.org/experiment/free-fall-2/ **OR** • Use ExpEyes kit, electromagnet, and contact sensor to determine the duration of a free fall. https://expeyes.in/experiments/mechanics/tof.html		
	13	**Verification of the Relation of Angular Velocity and Centrifugal Acceleration** • Use the smartphone gyroscope and the accelerometer. • Attach the smartphone to some rotating arrangements and record the data from the gyroscope and accelerometer. • Plot angular velocity Vs acceleration and verify the relation. • Experiment 18 of Book 2. • Phyphox app may be used. https://phyphox.org/experiment/centrifugal-acceleration/		
	14	**Analysis of Bouncing Balls to Determine Gravitational Acceleration and Coefficient of Restitution.** • After doing the experiment, the student should be able to understand the concept of inelastic collision. • Measure the time interval between successive bounces using a digital acoustic stopwatch and hence calculate g and coefficient of restitution • Experiment 12 of Book 2		

		• Phyphox app may be used. https://phyphox.org/experiment/inelastic-collision/		
	15	**Projectile Motion: Energy Conservation** • Analyse the motion of the tossing ball/ projectile in the Tracker tool. • Plot time vs the x-and y-components of velocity and acceleration. • Also plot the kinetic energy, potential energy (build data using define tool) and total energy. • https://www.youtube.com/watch?v=x0AWRLvgB28 • https://www.youtube.com/watch?v=i07HeUWo8xc		

Books and References:

1. University Physics with Modern Physics- Hugh D. Young, Roger A. Freedman,15th Edition (Book 1)
2. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 2)
3. https://phyphox.org/
4. https://physlets.org/tracker/
5. Introduction to Electrodynamics-David J Griffith, 5th Edition- Pearson

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	1	1	0	1	1	1	1	1	1	2	1	1
CO 2	2	2	2	1	1	1	1	1	1	1	2	1	1
CO 3	2	2	2	0	1	1	1	1	1	1	2	1	1
CO 4	2	1	3	1	0	1	1	1	1	1	2	1	1
CO 5	2	1	1	0	2	1	1	1	1	1	3	1	1
CO 6	2	3	2	2	1	2	1	1	1	1	2	1	1

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**OPTICS AND LASERS**				
Type of Course	**Minor (GROUP IV: OPTICAL PHYSICS)**				
Semester	**II**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Basics of Physics and Chemistry (Plus Two Level)				
Course Summary	This course explores light's properties, reflection, refraction, and applications in phenomena like interference, diffraction, polarization, and lasers.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the fundamental properties of light, including reflection, refraction, and the electromagnetic spectrum.	U	C	Instructor-created exams / Quiz
CO2	Apply the laws of reflection and refraction to solve problems involving mirrors and lenses.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Analyze the behavior of light waves using concepts like interference and diffraction.	An	C	Practical Assignment/ Seminar Presentation / Group Tutorial Work

CO4	Distinguish between Fresnel and Fraunhofer diffraction and explain how they affect light propagation.	An	C	Instructor-created exams / Home Assignments
CO5	Recognize different types of polarization and explain methods for producing and manipulating polarized light.	U	P	Instructor-created exams / Home Assignments
CO6	Apply the knowledge of optics and lasers to understand real-world applications in different fields.	E	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Introduction**	**7**	**15**
	1	Properties of light, Laws of reflection, laws of refraction	2	
	2	Refractive index, Optical path, Electromagnetic spectrum and visible light	3	
	3	Photons, Dual nature of light	2	
	Sections 1.5 – 1.12, Book 1			
II		**Ray optics**	**10**	**15**
	4	Reflection at plane Mirrors	1	
	5	Reflection at spherical mirror: Basic terms and sign convention, spherical mirror equation (No derivation) , Focal point and focal length	2	
	6	spherical mirror equation Applied to concave mirror convex mirror and plane mirror	3	
	7	Refraction at spherical surfaces, Gaussian relation	2	
	8	Lens equation, Lens maker's equation.	2	
	Sections 3.3, 3.4, 3.12, 4.8 - 4.10, Book 1			
III		**Wave optics**	**20**	**25**

	9	Interference, Young double slit experiment	2	
	10	Coherence and conditions for interference	1	
	11	Interference in thin parallel films	2	
	12	Interference in wedge shaped film, Angle of wedge and thickness of spacer, Colour of thin films	2	
	13	Newton's rings: determination of wavelength of light	2	
	14	Diffraction: Difference between diffraction and interference, Fresnel and Fraunhoffer type diffraction	1	
	15	Fraunhoffer diffraction at a single slit, double slit (Calculus method is excluded), Plane diffraction grating.	3	
	16	Polarization: Types of polarization, Brewster's law	2	
	17	Production of plane polarized light	1	
	18	Polarizer and analyser, Malu's law, Double refraction	2	
	19	Optical activity and specific rotation	2	
	Section 14.4 – 14.7,15.2, 15.5, 15.6, 17.6 - 17.7, 18.1, 18.2, 18.4, 18.7, 20.1, 20.2, 20.5, 20.6, 20.8 - 20.11, 20.27 - 20.29, Book 1			
IV	**Quantum optics**		**8**	**15**
	20	Lasers, Thermal equilibrium, Absorption of a Photon, Spontaneous emission, Stimulated emission, Population inversion	3	
	21	Components of Laser and lasing action	2	
	22	Ruby laser, Nd-YAG laser, Helium Neon laser, Carbon dioxide laser, semiconductor laser.	3	
	Sections 22.1, 22.3, 22.4, 22.7, 22.8, 22.9, 22.14, 22.15, Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course. Necessary theory of experiments can be given as Assignment/ Seminar.			

	1	**Determine the refractive index of (a) given liquid and (b)the material of a lens, by forming a liquid lens.** ● Through this experiment the students are expected to get the concepts of image formation, combination of lenses and radius of curvature of the surface of lens. ● Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices.		
	2	**Determine the focal length of the combination of two lenses separated by a distance.** ● Determine the focal lengths, f1 and f2 of the two lenses using an illuminated cross-slit screen holder, nodal slide(for placing the lenses) and plane mirror arrangement. ● Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation ● $\frac{1}{F} = \frac{1}{f1} + \frac{1}{f2} - \frac{d}{f1f2}$. ● The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study. ● https://www.youtube.com/watch?v=IOlEEtyNPBg ● https://www.youtube.com/watch?v=tNo4Ipk74SU		
	3	**Determination of the dispersive power of a solid prism using a spectrometer.** ● Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer. ● Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths.		
	4	**Refractive indices of quartz prism using spectrometer.** ● Determine the refractive indices of quartz for the ordinary and extraordinary rays of a sodium vapour lamp by arranging the quartz prism at minimum deviation position in the spectrometer. ● Verify the polarizations of the ordinary and extraordinary rays using a polaroid.		
	5	**Determination of wavelengths of mercury spectrum using diffraction grating and spectrometer.** ● Arrange the grating at normal incidence. ● Standardize the grating using the green line of mercury and then find the wavelengths of other prominent lines of the spectrum.		
	6	**Newton's rings-determination of the wavelength of sodium light** ● Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source.		

		● Determine the radius of curvature by Boy's method and determine the wavelength of the source. ● Optional: In experiment 5 and 6, record a short video of the interference pattern, calibrate the video using scale marked on the glass plate, analyse the video using Tracker tool. From the intensity profile get the locations of the dark rings and calculate the wavelength of the source/thickness of the sample https://physlets.org/tracker/. https://www.youtube.com/watch?v=UCCPkJpUQEw		
	7	**Air wedge-determination of the radius of a thin wire/human hair/thin foil.** ● Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates. ● Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given.		
	8	**Wavelength of laser using grating** ● The laser light diffracted from the transmission grating is allowed to fall on a screen and record the maxima points in a paper and calculate the wavelength of the laser. ● Determine the number of lines/ meter of the grating using the green line of the mercury		
	9	**Single slit diffraction using laser - Determination of slit width.** ● The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper. ● From the width of the central maxima or the position of minimum intensity points, calculate the slit width. ● Verify the slit width using a traveling microscope. ● Wavelength of laser can be found using diffraction grating of known N.		
	10	**Study the specific rotation of the sugar solution using a polarimeter.** ● Determine the specific rotation corresponding to different concentrations of the sugar dissolved in water. ● Draw a graph between rotation and concentrations and verify the linear relationship.		
	11	**Verification of Malus's law using polarizer, analyzer and photo detector** ● Unpolarized light is allowed to pass through a polarizer and is observed through an analyzer. ● Vary the angle between the axes of polarizer and analyzer and measure the intensity of the light (current output of the photodetector).		

		• Plot $\theta - I$ and $cos^2\theta - I$ graphs and verify the Malus's law. • A flat computer monitor (or LCD TV screen) in plain white color can be used as the source of linear polarized light. • The ambient light sensor of the smartphone and the orientation sensor of the smartphone can be used to measure the illuminance and the angles respectively. • A small piece of polarizer (a square of about 1 cm side) from an old calculator's display was placed over the ambient light sensor as analyser. • https://arxiv.org/pdf/1607.02659		
	12	**Spectrometer-Determination of the Cauchy's constants of the given prism** • Find the angle of the prism, the minimum deviation angles of the prominent lines of the mercury spectrum and hence calculate the refractive indices for the colors. • Determine A and B from the • $\mu - \frac{1}{\lambda^2}$ graph.		
	13	**Determine the numerical aperture (NA) of an optical fiber using a laser** • Couple the light from the laser source onto one of the fiber ends and the light coming from the other end is allowed to fall on a screen(sheet having circular markings) placed perpendicular to the axis of the fiber. • Measure the diameter of the laser beam on the screen and the distance between the screen and fiber output end and hence calculate the NA.		
	14	**Determination of the Velocity of Sound in Air.** • Sound wave of known frequency is generated using a wave generator(WG) and piezo buzzer and are recorded using a microphone(MIC). • Phase differences between the WG and MIC waveforms were analyzed in a CRO and the distance between them were adjusted to make both of them in phase and hence calculate velocity of sound. • Phase difference can be analyzed from the Lissajous figure obtained by X-Y plotting of WG and MIC waves. • ExpEYES may be used. • https://expeyes.in/experiments/sound/velocity.html • https://expeyes.in/experiments/electrical/xyplot.html		
	15	**Transformation of Energy from One Form to Another.** • Roll a hollow cylinder from a height, in an inclined plane, without pushing. • Measure radius of the cylinder and record the velocity of the cylinder using the gyroscope of the phone inserted into the cylinder.		

		● Calculate the total energy before the cylinder starts to roll (Potential Energy, mgh) ● Calculate the total energy (Translational KE + Rotational KE) when the cylinder reaches the bottom of the plane. ● Estimate the energy lost as heat and sound. Repeat the experiment for different heights. ● Experiment 23 for Book 4 ● https://phyphox.org/experiment/roll/#more-509		

Books and References:

1) A Textbook of Optics by N. Subramanyam, Brij Lal, M N Avadhanulu (25TH EDITION) (Book 1)
2) Optics by Ajoy Ghatak, Tata McGrow-Hill (Book 2)
3) Optics by Eugene Hecht, Addison-Wesley (Book 3)
4) Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 4)
5) https://phyphox.org/
6) https://physlets.org/tracker/

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	1	0	0	1	1	2	1	0	1	0	1	0
CO 2	2	2	1	0	1	1	2	1	0	1	0	1	0
CO 3	2	2	2	0	2	2	2	1	0	1	1	1	0
CO 4	2	1	1	0	1	1	2	1	0	1	1	1	0
CO 5	2	1	1	0	2	2	2	1	0	1	1	1	0
CO 6	2	2	1	0	3	2	2	1	1	1	1	1	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ATOMIC STRUCTURE AND SPECTROSCOPY**				
Type of Course	**Minor (GROUP IV: OPTICAL PHYSICS)**				
Semester	**III**				
Academic Level	**200 - 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic concepts related to optics, electromagnetism, wave mechanics, and electronics.				
Course Summary	This course provides a foundational understanding of quantum phenomena and spectroscopic methods. Students will explore topics such as electromagnetic waves, black body radiation, photoelectric effect, X-ray production, diffraction, De Broglie waves, atomic structure, and spectroscopy.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Studying electromagnetic waves, black body radiation, photoelectric effect, X-ray production, diffraction, and De Broglie waves.	U	C	Instructor-created exams / Quiz
CO2	Understands the dual nature of light and matter, leading to insights into quantum phenomena like particle confinement and uncertainty	Ap	P	Practical Assignment / Observation of Practical Skills

	principles in position, momentum, energy, and time.			
CO3	Understanding the nuclear atom model, electron orbits, and atomic spectra, including the Bohr atom's energy levels and line spectra,	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Elucidates the fundamental structure and behavior of atoms, offering insights into their spectral characteristics and origins.	U	C	Instructor-created exams / Home Assignments
CO5	Exploring spectroscopy introduces the electromagnetic spectrum's quantized energy, various molecular energies, and spectroscopic techniques, addressing spectral line width, absorption emission phenomena, EinstAssignmentein coefficients, and laser principles.	U	C, P	Practical skills/ Assignments
CO6	Important spectroscopic techniques used for sample analysis, like microwave spectroscopy, Infrared Spectroscopy, Electronic spectroscopy and Raman spectroscopy are introduced	U	C, P	Assignments/ Internal Exams

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Particle properties of waves & Wave properties of particles**	**17**	**28**
	1	Electromagnetic Waves, Black body Radiation	3	
	2	Photoelectric Effect and Nature of light	2	
	3	X- ray production and diffraction	2	
	4	Pair Production	2	
	5	De Broglie waves and wave function, Wave formula, concept of phase velocity and group velocity (derivation not required)	3	
	6	Particle Diffraction	1	

	7	Particle in a box	2	
	8	Uncertainty principle: position – momentum, Energy-time (concept alone)	2	
	Sections : 2.1-2.6, 2.8, 3.1-3.6, 3.8, 3.9, Book 1			
II	**Atomic Structure**		**10**	**15**
	9	Nuclear atom	2	
	10	Electron orbits	2	
	11	Atomic spectra	2	
	12	Bohr atom	2	
	13	Energy levels and spectra	2	
	Sections: 4.1- 4.5, Book 1			
III	**Introduction to Spectroscopy**		**10**	**15**
	14	Electromagnetic spectrum and Quantization of energy	1	
	15	Types of molecular energies and spectroscopic methods	3	
	16	Spectral line width	2	
	17	Absorption and emission of radiation, Einstein coefficient (excluding derivation)	2	
	18	Lasers	2	
	Sections 1.1 - 1.7, Book 2			
IV	**Spectroscopic Methods of sample analysis**		**8**	**12**
	19	Microwave spectroscopy	2	
	20	Infrared Spectroscopy (vibration spectra only)	2	
	21	Electronic spectroscopy	2	
	22	Raman spectroscopy: Introduction, Quantum theory of Raman scattering, Rotational Raman spectra of linear molecules	2	
	Sections 8.6 - 8.8, Book 1, Sections 8.1, 8.2.2 and 8.3.1, Book 2			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments			

	listed here may be used as demonstrations of the concepts taught in the course. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Determination of Plank's constant using LEDs** ● Observe the turn-on voltage, V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing) ● Plot $\frac{1}{\lambda} - V_0$ graph using Python, fit a straight line to get the slope and estimate the value of h. ● Calculate the %error. ● Programmable voltage source of ExpEYES may be used to find the turn-on voltage.		
	2	**Continuous and line spectra- Determination of the wavelengths and photon energy.** ● Familiarize the initial adjustments and measurements in the spectrometer. ● Mount the grating at normal incidence on the spectrometer. ● Determine the wavelengths of the sodium vapor lamp and calculate the associated photon energy. ● Determine the approximate range of the wavelengths of the continuous spectrum of incandescent/white LED lamp or any one coloured LED and calculate the associated photon energy. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating can be given.		
	3	**Mercury spectrum- Determination of wavelength and photon energy.** ● Determine wavelength of any four prominent lines and associated photon energy of the mercury spectrum using a spectrometer with grating at normal incidence. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	4	**Hydrogen spectrum - Determination of wavelengths and calculation of the Rydberg's constant.** ● Determine the wavelengths and photon energy in eV of the prominent lines of the Balmer series of the Hydrogen		

		spectrum using a spectrometer with grating at normal incidence. ● Calculate the Rydberg's constant and estimate the % error. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	5	**Wave Packets - Analysis of beats in sound.** ● The experiment is intended to understand the concept of wave packet, phase and group velocities. ● Generate sounds waves of two near frequencies using smartphone/ExpEYES/Function generator and the superimposed wave can be recorded and analysed using smartphone/ExpEYES/CRO ● Change the separation between the frequencies and compare the results with the theoretical values. ● https://expeyes.in/experiments/sound/beats.html ● Multi Tone generator and Audio scope tools of Phyphox may be used https://phyphox.org/experiment/tone-generator/		
	6	**Analysis of Hydrogen spectra using the Tracker Video Analysis tool**. ● Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant. ● Estimate the %error. ● Pre recorded video of the Hydrogen spectra can be used. ● https://physlets.org/tracker/. ● https://www.youtube.com/watch?v=UCCPkJpUQEw		
	7	**Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.** ● Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity, get λ_{max} and using Wein's law calculate the surface temperature. ● Pre recorded video of the solar spectra can be used.		

	8	**Verification of Wein's displacement law and Stefan's law using incandescent bulb.** • Calibrate the video of the spectra of the incandescent bulb in the Tracker tool using two laser wavelengths/lines of mercury spectra. • Plot wavelength vs intensity and note λ_{max} . • Repeat the experiment by increasing the operating voltage of the incandescent bulb(hence increasing the temperature of the source) • From the plots, verify the Wein's displacement law and Stefan's law.		
	9	**Study the characteristics of Zener diode and construct a voltage regulator.** • Study the V-I characteristics of zener diode and hence determine the breakdown voltage. • https://expeyes.in/experiments/electronics/zenerIV.html • Construct a voltage regulator using a zener diode and determine the percentage of voltage regulation.		
	10	**Construction of the center tapped full wave rectifiers and regulated power supply.** • Construct a center tapped full wave rectifier without filter and with a filter. • Connections may be realized through soldering, to get an experience of soldering. • Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter. • Observe the variation of the ripple factor with load resistance, when filter is used. • Construct 5V/12V regulated power supply using 78XX IC.		
	11	**Study the characteristics of LDR.** • Measure the dark resistance of LDR • Place LDR at different distances from an electric lamp and measure its resistance. Plot light intensity($E \alpha \frac{1}{r^2}$) vs LDR resistance. • Optional: Construct a dark sensor using LDR and transistor. In order to turn on the LED in the desired light intensity, an adjustable resistor can be used in the circuit.		

	12	**Surface tension of liquid - Capillary rise method** ● Clamp a clean capillary tube by dipping its lower end into the liquid in the beaker. ● Measure the rise of water in the tube using a traveling microscope. ● Also measure the radius of the capillary tube using the traveling microscope and estimate the surface tension of the liquid. ● Density of the liquid can be determined using Hare's apparatus of can be given		
	13	**Static torsion Rigidity modulus** ● Using Searle's static torsion apparatus, determine the rigidity modulus of the material of the rod.		
	14	**Viscosity of a liquid - Falling Ball Viscometer** ● Drop a polished steel ball into a glass tube of a somewhat larger diameter containing the liquid. ● Record the time required for the ball to fall at constant velocity through a specified distance between reference marks. ● Use the Stoke's law for the sphere falling in a fluid under effect of gravity, to estimate the viscosity of the liquid.		
	15	**Viscosity of a liquid - Poiseuille's Method** ● Fill the liquid in a vertically fixed burette with its lower end attached to a capillary tube, placed in horizontal position using a rubber tube. ● Note the time taken to reach each 10cc of water and the height of the corresponding marking. ● Also measure the radius of the capillary tube using the traveling microscope and estimate the viscosity of the liquid.		

Books and references:

1. Concepts of Modern Physics, Arthur Beiser 6th Edition (Book 1)
2. Molecular structure and spectroscopy, (Second edition) by G. Aruldhas (Book 2)
3. University Physics with Modern Physics (Edn.15) by Young & Freedman (Book 3)
4. Fundamentals of - Molecular Spectroscopy - THIRD EDITION, by C N Banwell (Book 4)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	0	0	1	1	2	1	1	1	1	1	1
CO 2	2	2	1	0	1	1	2	1	1	1	1	1	1
CO 3	2	1	1	0	2	1	2	1	1	1	1	1	1
CO 4	2	0	1	0	2	1	2	1	1	1	1	1	1
CO 5	2	1	1	0	3	1	2	1	1	2	1	1	1
CO 6	2	2	1	0	3	1	2	1	1	2	1	1	1

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**NON-CONVENTIONAL ENERGY SOURCES**				
Type of Course	**Minor (GROUP V: ENERGY PHYSICS)**				
Semester	**I**				
Academic Level	**100 - 109**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of different forms of energy.				
Course Summary	This course provides a comprehensive introduction to various renewable energy resources with a focus on non-conventional sources. Students will explore the principles, technologies, advantages, disadvantages, and practical applications of solar, wind, geothermal, ocean, and biomass energy.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Develop a foundational understanding of energy resources, focusing on non-conventional sources such as solar energy, and	U	C	Instructor-created exams / Quiz

	grasp key terms and concepts including solar constant, radiation measurements, collectors, and practical applications of solar power.			
CO2	Discover wind energy comprehensively, covering utilization, advantages, disadvantages, environmental impact, sources, conversion principles, components, pros and cons, wind-electric power plants, economics, and operational challenges of large generators.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Gain insight into geothermal energy, exploring Earth's interior structure, geothermal systems like hot springs and various resources, and understanding the advantages, disadvantages, and applications of geothermal energy in comparison to other forms.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Explore ocean energy, focusing on tidal and wave energy, understanding tidal power plant components, economic aspects, OTEC working principles, efficiency, types, and applications, considering advantages and disadvantages.	U	C	Instructor-created exams / Home Assignments
CO5	Understand biomass with its resources and conversion	Ap	P	Writing assignments

	processes, explore biogas applications and plants			
CO6	Study fuel cells, hydrogen energy, government schemes, and subsidies, and conduct plant visits for performance analysis.	Ap	P	Seminar Presentation /Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**SOLAR ENERGY**	**10**	**20**
	1	Introduction to Energy Resources-Non Conventional Energy Sources-Renewable and Non-Renewable energy sources.	1	
	2	Measurement of Solar radiation, Principles of the conversion of solar energy into heat. Collection systems, Characteristic features of a collecting system,	2	
	3	Types of collectors, Flat - Plate collectors, Selective absorber coatings/surfaces, Advantages Disadvantages and applications of flat plate collectors.	2	
	4	Concentrating collectors (Performance analysis not needed) ,Solar air heaters and drying, solar cooking, solar furnaces,	2	
	5.	Solar greenhouses and global warming, solar power plants, Solar photovoltaic cells (no need of mathematical equations)	3	

	Sections 1.3, 1.4, 1.5, 2.2.1, 2.2.2, 2.3, 3.1.3 - 3.1.5, 3.2, 3.3.1 - 3.3.3. 3.4 - (excluding 3.4.11), 4.16, 4.17, 4.18, 4.19, 4.20, 4.21.4, Book 1			
II	**Wind Energy**		**9**	**18**
	6	Introduction, Utilisation aspects of wind energy, Characteristics of wind,	2	
	7	Advantages and Disadvantages of wind energy, Environmental impact of wind energy, Sources/Origins of wind	2	
	8	Principle of wind energy conversion and wind power, Basic components of wind energy conversion system(WECS)	3	
	9	Advantages and Disadvantages of WECS, Wind-Electric Generating Power Plant	1	
	10	Problems in operating large wind power generators.	1	
	Sections 5.1-5.6, 5.8, 5.10, 5.11, 5.20, 5.26, Book 1			
III	**Geo Thermal Energy, Fuel Cells**		**11**	**16**
	11	Introduction to Geothermal energy, Important aspects of Geothermal Energy, Structure of Earth's interior, Geothermal system-Hot Spring structure,	2	
	12	Geothermal Resources -Hydrothermal, Geopressured	3	
	13	Geothermal Resources - Petro-thermal system, Magma Resources	3	
	14	Advantages and disadvantages of geothermal energy over other energy forms, application of geothermal energy	2	
	15	Fuel cells, Advantages, Disadvantages and applications of fuel cells, Hydrogen energy, properties of hydrogen, Advantages of Hydrogen as a fuel.	3	
	Sections 7.1, 7.2, 7.3, 7.5, 7.8.1, 7.8.2, 7.8.3, 7.8.4, 7.9, 7.10, , 9.7.1, 9.7.2, 9.7.3, 10.1, 10.2, 10.3, Book 1			

IV		**Energy from Ocean and Biomass**	**15**	**16**
	16	Ocean Energy, Ocean Energy Sources, Tidal energy	2	
	17	Components of a Tidal Power Plant, Advantages and disadvantages of tidal power, Economic aspects of tidal energy conversion,	2	
	18	Wave energy, Advantages and disadvantages, Factors affecting Wave energy	2	
	19	Ocean Thermal Energy Conversion (OTEC), Working principle of OTEC, Efficiency of OTEC, Closed cycle system, open cycle system, Advantages, Disadvantages and applications of OTEC	2	
	20	Ocean Energy, Ocean Energy Sources, Tidal energy	2	
	21	Introduction to biomass, Biomass resources, Biomass conversion process and applications	2	
	22	Biogas, Biogas applications, biogas plants, Raw materials used in biogas plants, Main components of a biogas plant,	3	
	Sections 8.1, 8.2, 8.3.1, 8.3.8, 8.3.14, 8.4.1, 8.4.2, 8.4.3, 8.5.1, 8.5.3, 8.5.4, 8.5.5.1,8.5.5.2, 8.5.5.5, 8.5.6, 6.1, 6.2, 6.5, 6.6.1,6.6.2, 6.7.1, 6.7.2 , 6.7.3, Book 1			
V		**PRACTICALS**	**30**	
	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6th experiment may also be selected from the given list. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Energy audit of home/institution** ● Estimate the energy use, identify the areas where energy is wasted and identify areas of improvement.		
	2	**Study power output of solar cell.**		

		- Plot the V-I characteristics of solar cell under dark and illuminated conditions and get the open circuit voltage and short circuit current. - Plot voltage-power graph and get the maximum output power point. - Optional: find the efficiency of the solar cell, if a standardized light source is available. - ExpEYES may be used. Solar cell of voltage rating 3V and current rating of the order of 100mA is desirable for the study. - https://expeyes.in/experiments/electronics/diodeIV.html		
	3	**Study the characteristics of LDR.** - Measure the dark resistance of LDR - Place LDR at different distances from an electric lamp and measure its resistance. Plot light intensity(E $\alpha \frac{1}{r^2}$) vs LDR resistance. - Optional: Construct a dark sensor using LDR and transistor. In order to turn on the LED in the desired light intensity, an adjustable resistor can be used in the circuit.		
	4	**Construction of the center tapped full wave rectifiers and regulated power supply.** - Construct a center tapped full wave rectifier without filter and with a filter. - Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter. - Observe the variation of the ripple factor with load resistance, when filter is used. - Construct 5V/12V regulated power supply using 78XX IC.		
	5	**Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.** - Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. - Plot wavelength vs intensity, get λ_{max} and using Wein's law calculate the surface temperature. - Pre recorded video of the solar spectra can be used. - https://physlets.org/tracker/. - https://www.youtube.com/watch?v=UCCPkJpUQEw		

	6	**Acceleration of a Freely Falling Body** • Use the smartphone acoustic stopwatch to determine the duration of a free fall. • Measure the time of flight of a steel ball for different heights and plot a graph of distance vs. time squared (s vs. t^2). Determine g from the graph. • Experiment 2 of Book 4. • Phyphox app may be used. https://phyphox.org/experiment/free-fall-2/ **OR** • Use ExpEyes kit, electromagnet, and contact sensor to determine the duration of a free fall. https://expeyes.in/experiments/mechanics/tof.html		
	7	**Analysis of Bouncing Balls to Determine Gravitational Acceleration and Coefficient of Restitution.** • After doing the experiment, the student should be able to understand the concept of inelastic collision. • Measure the time interval between successive bounces using a digital acoustic stopwatch and hence calculate g and coefficient of restitution • Experiment 12 of Book 4 • Phyphox app may be used. https://phyphox.org/experiment/inelastic-collision/		
	8	**The Nearly Parabolic Trajectories of a Bouncing Ball** • Perform Experiment 7 using Tracker tool. • Track the ball and plot the time Vs position graph. • Measure the time interval between successive bounces and hence calculate g and coefficient of restitution. • Experiment 12 of Book 4 • Tracker Autotracker Tutorial: https://www.youtube.com/watch?v=Dn0Zz7rtkZw		
	9	**Analysis of Air Resistance and Terminal Speed to Determine the Drag Coefficient.** • Record the motion of a light weight paper cup and analyse it with Tracker tool (https://physlets.org/tracker/). • Plot acceleration, velocity, and position with time.		

		● Repeat the experiment with different mass (by simply stacking the paper cups) ● Determine the Drag Coefficient ● Experiment 27 of Book 4. ● https://www.youtube.com/watch?v=iujzK3uH1Yc		
	10	**Projectile Motion: Kinematics** ● Analyse projectile motion as a combination of horizontal motion with constant velocity and vertical motion with constant acceleration. ● Drop two balls from a height, one from rest, and other simultaneously projected horizontally. ● Analyse the motion of both in the Tracker tool. ● https://www.youtube.com/watch?v=zMF4CD7i3hg ● https://www.youtube.com/watch?v=Mi01anodoDE ● https://www.youtube.com/watch?v=5I0NLNthJGc		
	11	**Projectile Motion: Energy Conservation** ● Analyse the motion of the tossing ball/ projectile in the Tracker tool. ● Plot time Vs the x-and y-components of velocity and acceleration. ● Also plot the kinetic energy, potential energy (build data using define tool) and total energy. ● https://www.youtube.com/watch?v=x0AWRLvgB28 ● https://www.youtube.com/watch?v=i07HeUWo8xc		
	12	**Verification of Faraday's law and Lenz's law of electromagnetic induction** ● Verify Faraday's law and Lenz's law by measuring the induced voltage across a coil subjected to the varying magnetic field. ● Galvanometer/ExpEYES can be used to measure the induced emf. ● In the third experiment, for better coupling between the coils, use a high permeability material like iron or ferrite core, and observe the change in the induced emf. ● https://expeyes.in/experiments/school-level/mutual-induction.html		

		● Simulation: https://phet.colorado.edu/sims/html/faradays-law/latest/faradays-law_all.html		
	13	**Analysis of induced emf developed in a coil as a magnet dropping through it.** ● Drop a neodymium magnet through a coil, guided through a vertical tube. ● Repeat the experiment by dropping the magnet, through different heights from the coil and by changing the approaching pole. ● Capture the induced emf as a function of time using ExpEYES, note the maximum value of the emf and verify Faraday's law and Lenz's law of induced emf and flux change. ● https://expeyes.in/experiments/school-level/em-induction.html		
	14	**AC three phase generator.** ● Rotate a neodymium magnet about an axis perpendicular to its dipole axis and fix three coils displaced equally from each other, i.e., 120^o separated. ● Analyze the induced emf developed in the coils using CRO/ExpEYES and the phase relationship between the three induced voltages. ● Optional: Realize star connection (three phase four wire system) and verify the p.d. between the wires. ● https://expeyes.in/experiments/school-level/ac-generator.html		

Books and References:

1. Non- Conventional Energy Sources and Utilisation by R.K.Rajput, S.Chand Publishers, 1st Edition (Book 1)
2. Nonconventional energy resources by G. D. Rai, Khanna publishers-2008 (Book 2)
3. Solar Energy by S. B. Sukhatme-Tata McGraw-Hill Publishing Company Ltd - 1997 (Book 3)
4. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 4)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	1	1	0	2	1	2	0	0	1	1	0	0

CO 2	2	1	1	0	2	1	2	0	0	1	1	0	0
CO 3	2	2	2	0	2	1	2	0	0	1	1	0	0
CO 4	2	1	2	0	2	1	2	0	1	1	1	0	0
CO 5	2	2	2	0	2	2	2	0	0	1	1	0	0
CO 6	2	3	2	1	2	3	2	0	0	1	1	0	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**FLUID MECHANICS & THERMODYNAMICS**				
Type of Course	**Minor (GROUP V: ENERGY PHYSICS)**				
Semester	**II**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1.Basic knowledge in units, vectors, pressure, work, mechanical energy and internal energy 2. Basic knowledge about specific heat and molar specific heat capacity				
Course Summary	Students will understand the behavior of fluids, including gas and liquid dynamics, density, pressure, buoyancy, fluid flow, and applications of Bernoulli's equation. Students will also understand the first and second laws of thermodynamics, including entropy, and analyze the directions of thermodynamic processes and will analyze the principles behind heat engines and refrigerators and solve numerical problems based on these topics.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fluid behavior, the properties of gasses and liquids dynamics including density and pressure in a fluid., buoyancy and fluid flow, applications of Bernoulli's equation.	U	C	Instructor-created exams / Quiz

CO2	Analyze Viscosity and Turbulence in fluids , identifying their effects on fluid behavior.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Grasp the concepts of temperature and thermal equilibrium as well as thermal equilibrium and apply it to calculate the quantity of heat transferred in various processes .	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Understand the first law of thermodynamics and Second law of thermodynamics, and entropy. Analyze the directions of thermodynamic processes and calculate the change in entropy indifferent thermodynamic processes	U	C	Instructor-created exams / Home Assignments
CO5	Analyze the principles behind Heat engines and Refrigerators and solve numerical problems based on these topics.	Ap	P	One Minute Reflection Writing assignments
CO6	Demonstrate comprehension of the second law of thermodynamics, including its application to the Carnot cycle.	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**Fluid Mechanics**		**10**	**15**
	1	Gasses, liquids and Density, Pressure in a Fluid	2	
	2	Buoyancy, Fluid flow	3	
	3	Bernoulli's Equation	3	
	4	Viscosity and Turbulence	2	
	Sections 12.1, 12.2, 12.3, 12.4, 12.5 and 12.6, Book 1			
II	**Temperature and Heat**		**10**	**15**
	5.	Temperature and Thermal Equilibrium,	1	

	6	thermometers and temperature scales	1	
	7	Thermal Expansion	2	
	8	Quantity of Heat	3	
	9	Mechanisms of Heat Transfer	3	
	Sections 17.1,17.2, 17.3, 17.4, 17.6. Book 1			
III	**First Law of Thermodynamics**		**15**	**25**
	10	Thermodynamic systems	1	
	11	Work done during volume changes	1	
	12	Paths between Thermodynamic states	2	
	13	Internal Energy and First law of Thermodynamics	3	
	14	Kinds of Thermodynamic processes	2	
	15	Internal Energy of an ideal gas	2	
	16	Heat capacities of an ideal gas	1	
	17	Adiabatic process for an ideal gas	3	
	Sections: 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.8, Book 1			
IV	**The Second law of thermodynamics**		**10**	**15**
	18	Directions of thermodynamic processes	1	
	19	Heat Engines, Refrigerators	2	
	20	Second law of thermodynamics	2	
	21	The Carnot Cycle	3	
	22	Entropy	2	
	Sections 20.1, 20.2, 20.4, 20.5, 20.6, 20.7, Book 1			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Viscosity of a liquid - Poiseuille's Method**		

		• Fill the liquid in a vertically fixed burette with its lower end attached to a capillary tube, placed in horizontal position using a rubber tube. • Note the time taken to reach each 10cc of water and the height of the corresponding marking. • Also measure the radius of the capillary tube using the traveling microscope and estimate the viscosity of the liquid.		
	2	**Viscosity of a liquid - Falling Ball Viscometer** • Drop a polished steel ball into a glass tube of a somewhat larger diameter containing the liquid. • Record the time required for the ball to fall at constant velocity through a specified distance between reference marks. • Use the Stoke's law for the sphere falling in a fluid under effect of gravity, to estimate the viscosity of the liquid.		
	3	**Surface tension of liquid - Capillary rise method** • Clamp a clean capillary tube by dipping its lower end into the liquid in the beaker. • Measure the rise of water in the tube using a traveling microscope. • Also measure the radius of the capillary tube using the traveling microscope and estimate the surface tension of the liquid. • Density of the liquid can be determined using Hare's apparatus of can be given		
	4	**Density of the liquid using manometer** • Fill a manometer tube partially with water. Pour the given oil (or any liquid which does not mix with water) into the left arm of the tube until the oil–water interface is at the midpoint. Both arms of the tube are open to the air. • Measure the heights of the oil and water using a traveling microscope and hence estimate the density of the oil assuming that of water. • Example 12.4 of book 1		
	5	**Verification of Boyle's law and Charle's law**		

		• Boyle's law (PV= a constant) states that at a constant temperature, volume of a gas is inversely proportional to pressure. • Determine the volume - pressure relation at constant temperature using the water column. • Plot the pressure versus volume graph and verify Boyle's law. • Verify the law at minimum two different temperatures. • Charle's law (V/T = a constant) states that at constant pressure, volume is directly proportional to temperature. • In this experiment determine the temperature - volume relation at constant pressure using the water column. • Plot the temperature versus volume graph and verify the Charle's law. • Verify the law at minimum two different pressures.		
	6	**Verification of Gay-Lussac's law** • Gay-Lussac's law (P/T = a constant) states that at constant volume, pressure is directly proportional to temperature. • In this experiment determine the temperature - pressure relation at constant pressure using metallic bulb and water column or pressure gauge or using Jolly's bulb apparatus. • Plot the temperature versus volume graph and verify the Charle's law.		
	7	**Thermal conductivity by Searle's method** • Determine the thermal conductivity of copper or any other metal using Searle's method / apparatus.		
	8	**Temperature coefficient of resistance of a metal** • Resistance of metals increases with increase in temperature. • Measure the resistance of the metal coil, using Carey Foster's bridge or Potentiometer or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature.		

		● Plot graph and find the temperature coefficient of resistance.		
	9	**Thermo emf of a Thermocouple** ● Study the variation of thermo emf of a thermocouple as a function of temperature of the hot junction while maintaining the cold junction at 0 degree Celsius.		
	10	**Newton's law of cooling** ● According to Newton's law of cooling, the rate of heat loss of a hot body is proportional to the difference in temperature between the body and the surroundings. ● The calorimeter is filled with hot water and the variation in temperature is noted as a function of time. ● Cooling rate graph is plotted and law is verified. ● Emissivity of the surface of the calorimeter can also be determined. ● ExpEYES with PT1000 sensor may be used to record the temperature. https://expeyes.in/experiments/thermal/cooling.html		
	11	**Characteristics of NTC thermistor** ● Resistance of Negative Temperature Coefficient (NTC) thermistors decreases with increase in temperature. ● Measure the resistance of the thermistor, using Carey Foster's bridge or Potentiometer or ExpEYES or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature. ● Plot the graph and study the characteristics.		
	12	**Melting point of wax** ● Fill a test tube with wax until half and use a thermometer inside the wax / test tube to measure wax temperature. Avoid the thermometer touching the test tube. ● Immerse the test tube in a water bath with the help of a stand, in such a way that the wax is below the water level. ● Use a suitable flame / heating rate and measure the wax temperature as a function of time at a suitable time interval. ● Plot temperature versus time graph. ExpEYES and PT1000 sensor may be used record the temperature. https://expeyes.in/experiments/thermal/cooling.html		

		• The temperature increases initially and remains constant until the wax melts completely. The flat temperature gives the melting point of wax (The melting point depends on the type of wax used)		
	13	**Young's Modulus of the Material of a Given Bar: Uniform Bending** • Use an optic lever and telescope. Take measurements for a minimum of two lengths. Obtain the elevation (e) from the shift (s) in the telescope reading and calculate Y from it. • For each length of the bar, plot the load-elevation graph (using GeoGebra) and obtain m/e, and then calculate Y from it.		
	14	**Torsion Pendulum- Determination of the Moment of Inertia and Rigidity Modulus.** • Using identical masses on the disc, determine the moment of inertia of the disc. • Verify the moment of inertia by direct method, $I = \frac{1}{2}MR^2$ • Using I, calculate rigidity modulus of the material of the wire, $n = \frac{8\pi I}{r^4}\frac{L}{T^2}$		
	15	**Static torsion Rigidity modulus** • Using Searle's static torsion apparatus, determine the rigidity modulus of the material of the rod.		

Books and References:

1. University Physics with Modern Physics (Edn.15) by Hugh D. Young & Roger A. Freedman (Book 1)
2. Heat and Thermodynamics, 7th Edn.- Mark W Zemansky and Richard H Dittman - McGraw-Hill (Book 2)
3. Heat and Thermodynamics - D. S. Mathur - S Chand Publishers (Book 3)
4. Berkeley Physics Course : Vol.1 : Mechanics, 2ndEdn. – Kittelet al. – McGraw-Hill (Book 4)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	0	0	1	1	2	0	0	1	0	0	0
CO 2	2	2	1	0	1	1	2	0	0	1	0	0	0

CO 3	2	1	2	0	2	1	2	0	0	1	1	0	0
CO 4	2	1	2	0	2	1	2	0	0	1	1	0	0
CO 5	2	2	2	0	2	2	2	1	0	1	1	0	0
CO 6	2	2	1	0	2	2	2	0	0	1	1	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**OPTICS AND SPECTROSCOPY**				
Type of Course	**Minor (GROUP V: ENERGY PHYSICS)**				
Semester	**III**				
Academic Level	**200 – 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basics of Physics and Chemistry (Plus Two Level)				
Course Summary	This course explores the fundamental properties of light, its interaction with matter, and spectroscopic techniques used to analyze molecules.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the laws of reflection and refraction, and how they influence light behavior.	U	F	Instructor-created exams / Quiz
CO2	Describe the electromagnetic spectrum and differentiate between wave and particle properties of light.	U	C	Seminar Presentation / Group Tutorial Work
CO3	Analyze the principles of interference and apply them to phenomena like Young's double slit experiment.	An	P	Practical Assignment / Observation of Practical Skills
CO4	Explain the concept of polarization and apply it to phenomena like Brewster's Law.	Ap	P	Instructor-created exams /

				Home Assignments
CO5	Discuss the principles of optical activity and how it relates to specific rotation.	Ap	C	Practical Assignment / Observation of Practical Skills
CO6	Explain the fundamental concepts of spectroscopy, including energy quantization, absorption/emission, and different spectroscopic methods like microwave and infrared spectroscopy.	An	P	Instructor created exam/Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**Introduction**	**8**	**15**
	1	Properties of light, Laws of reflection, laws of refraction	3	
	2	Refractive index, Optical path	2	
		Electromagnetic spectrum and visible light	1	
	3	Photons, Dual nature of light	2	
	Sections 1.5 – 1.12, Book 1			
II		**Interference and Polarization**	**19**	**25**
	4	Interference, Young double slit experiment	2	
	5	Coherence and conditions for interference	2	
	6	Interference in thin parallel films	3	
	7	Interference in wedge shaped film, Angle of wedge and thickness of spacer,	3	
	8	Colour of thin films		
	9	Polarization: Types of polarization	1	
	10	Brewster's law	1	
	11	Production of plane polarized light	2	

	12	Polarizer and analyser, Malu's law	2	
	13	Double refraction	1	
	14	Optical activity and specific rotation	2	
	Section 14.4 – 14.7,15.2, 15.5, 20.1, 20.2, 20.5, 20.6, 20.8 - 20.11, 20.27 - 20.29 , Book 1			
III	**Introduction to Spectroscopy**		**7**	**15**
	15	Electromagnetic spectrum and Quantization of energy	2	
	16	Types of molecular energies and spectroscopic methods	2	
	17	Spectral line width	1	
	18	Absorption and emission of radiation, Einstein coefficient (excluding derivation)	2	
	Sections : 1.1 - 1.6, Book 2			
IV	**Spectroscopic Methods of sample analysis**		**11**	**15**
	19	Microwave spectroscopy	3	
	20	Infrared Spectroscopy (vibration spectra only)	2	
	21	Electronic spectroscopy	3	
	22	Raman spectroscopy: Introduction, Quantum theory of Raman scattering, Rotational Raman spectra of linear molecules	3	
	Sections 8.6 - 8.8, Book 3, Sections 8.1, 8.2.2 , 8.3.1, Book 2			
V	**PRACTICALS**		**30**	
	1	**Determine the focal length of the combination of two lenses separated by a distance.** ● Determine the focal lengths, f1 and f2 of the two lenses using an illuminated cross-slit screen holder, nodal slide(for placing the lenses) and plane mirror arrangement. ● Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation $\frac{1}{F} = \frac{1}{f1}+\frac{1}{f2} - \frac{d}{f1f2}$. ● The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study. ● https://www.youtube.com/watch?v=IOlEEtyNPBg		

		• https://www.youtube.com/watch?v=tNo4Ipk74SU		
	2	**Determine the refractive index of (a) given liquid and (b)the material of a lens, by forming a liquid lens.** • Through this experiment the students are expected to get the concepts of image formation, combination of lenses and radius of curvature of the surface of lens. • Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices.		
	3	**Determination of the dispersive power of a solid prism using a spectrometer.** • Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer. • Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths.		
	4	**Refractive indices of quartz prism using spectrometer.** • Determine the refractive indices of quartz for the ordinary and extraordinary rays of a sodium vapour lamp by arranging the quartz prism at minimum deviation position in the spectrometer. • Verify the polarizations of the ordinary and extraordinary rays using a polaroid.		
	5	**Determination of wavelengths of mercury spectrum using diffraction grating and spectrometer.** • Arrange the grating at normal incidence. • Standardize the grating using the green line of mercury and then find the wavelengths of other prominent lines of the spectrum.		
	6	**Newton's rings-determination of the wavelength of sodium light** • Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source. • Determine the radius of curvature by Boy's method and determine the wavelength of the source. • Optional: In experiment 5 and 6, record a short video of the interference pattern, calibrate the video using scale marked on the glass plate, analyse the video using Tracker tool. From the		

		intensity profile get the locations of the dark rings and calculate the wavelength of the source/thickness of the sample https://physlets.org/tracker/. https://www.youtube.com/watch?v=UCCPkJpUQEw		
	7	**Air wedge-determination of the radius of a thin wire/human hair/thin foil.** ● Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates. ● Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given.		
	8	**Single slit diffraction using laser - Determination of slit width.** ● The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper. ● From the width of the central maxima or the position of minimum intensity points, calculate the slit width. ● Verify the slit width using a traveling microscope. ● Wavelength of laser can be found using diffraction grating of known N.		
	9	**Study the specific rotation of the sugar solution using a polarimeter.** ● Determine the specific rotation corresponding to different concentrations of the sugar dissolved in water. ● Draw a graph between rotation and concentrations and verify the linear relationship.		
	10	**Verification of Malus's law using polarizer, analyzer and photo detector** ● Unpolarized light is allowed to pass through a polarizer and is observed through an analyzer. ● Vary the angle between the axes of polarizer and analyzer and measure the intensity of the light (current output of the photodetector). ● Plot $\theta - I$ and $cos^2\theta - I$ graphs and verify the Malus's law.		

		• A flat computer monitor (or LCD TV screen) in plain white color can be used as the source of linear polarized light. • The ambient light sensor of the smartphone and the orientation sensor of the smartphone can be used to measure the illuminance and the angles respectively. • A small piece of polarizer (a square of about 1 cm side) from an old calculator's display was placed over the ambient light sensor as analyser. • https://arxiv.org/pdf/1607.02659		
	11	**Spectrometer-Determination of the Cauchy's constants of the given prism** • Find the angle of the prism, the minimum deviation angles of the prominent lines of the mercury spectrum and hence calculate the refractive indices for the colors. • Determine A and B from the $\mu - \frac{1}{\lambda^2}$ graph.		
	12	**Determine the numerical aperture (NA) of an optical fiber using a laser** • Couple the light from the laser source onto one of the fiber ends and the light coming from the other end is allowed to fall on a screen(sheet having circular markings) placed perpendicular to the axis of the fiber. • Measure the diameter of the laser beam on the screen and the distance between the screen and fiber output end and hence calculate the NA.		
	13	**Determination of Plank's constant using LEDs** • Observe the turn-on voltage, • V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing) • Plot $\frac{1}{\lambda} - V_0$ graph using Python, fit a straight line to get the slope and estimate the value of h. • Calculate the %error. • Programmable voltage source of ExpEYES may be used to find the turn-on voltage.		

	14	**Continuous and line spectra- Determination of the wavelengths and photon energy.** ● Familiarize the initial adjustments and measurements in the spectrometer. ● Mount the grating at normal incidence on the spectrometer. ● Determine the wavelengths of the sodium vapor lamp and calculate the associated photon energy. ● Determine the approximate range of the wavelengths of the continuous spectrum of incandescent/white LED lamp or any one coloured LED and calculate the associated photon energy. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating can be given.		
	15	**Analysis of Hydrogen spectra using the Tracker Video Analysis tool**. ● Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant. ● Estimate the %error. ● Pre recorded video of the Hydrogen spectra can be used. ● https://physlets.org/tracker/. ● https://www.youtube.com/watch?v=UCCPkJpUQEw		

Books and References:

1. A Textbook of Optics by N. Subramanyam, Brij Lal, M N Avadhanulu 25TH Edition (Book 1)
2. Molecular structure and spectroscopy, (Second edition) by G. Aruldhas (Book 2)
3. Concepts of Modern Physics by Arthur Beiser, 6th edition
4. Optics by Eugene Hecht
5. Fundamentals of - Molecular Spectroscopy - THIRD EDITION, by C N Banwell

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	0	0	0	2	0	2	0	0	1	1	0	0
CO 2	2	0	0	0	2	0	2	0	0	1	1	0	0
CO 3	2	1	1	0	2	0	2	0	0	1	1	0	0

CO 4	2	0	1	0	2	0	2	0	0	1	1	0	0
CO 5	2	0	1	0	2	0	2	0	0	1	1	0	0
CO 6	2	1	2	0	2	1	2	0	0	1	1	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

VOCATIONAL MINOR COURSES

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**INTRODUCTORY MATERIALS SCIENCE**				
Type of Course	**Vocational Minor** **(GROUP: TECHNIQUES IN MATERIALS PHYSICS)**				
Semester	**I**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Basics of Physics and Chemistry (Higher Secondary Level)				
Course Summary	Explore the diverse world of materials and their properties through experimentation and analysis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate a fundamental understanding of the different classes of materials (metals,	U	F	Instructor-created exams / Quiz

	ceramics, polymers, and composites) and their properties.			
CO2	Apply electrical and magnetic property concepts to analyze and design materials for various applications.	Ap	C	Instructor-created exams / Quiz
CO3	Explain the interaction of light with materials and its impact on optical properties.	An	C	Seminar Presentation / Group Tutorial Work
CO4	Relate thermal properties of materials to their behaviour in different temperature environments.	An	C	Instructor-created exams / Home Assignments
CO5	Develop practical skills in using laboratory equipment to measure and characterize material properties.	An	P	Practical Assignment / Observation of Practical Skills
CO6	Analyze and interpret experimental data to draw meaningful conclusions.	An	P	Practical Assignment / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	**Introduction to Materials and Properties**		**5**	**13**
	1	Introduction to Materials science: Scope, applications, and interdisciplinary connections	1	

	2	Classification of materials: metals, ceramics, polymers, and composites.	2	
	3	Advanced materials: Semiconductors, Bio materials, Smart Materials, Nanomaterials, Modern Materials' Need	2	
	Sections 1.2 to 1.6, Book 1			
II	**Electrical and Magnetic Properties**		**17**	**17**
	4	Electrical properties: Ohm's law, electrical conductivity and resistivity	1	
	5	Ionic conduction	1	
	6	Electric conduction in terms of Band and atomic bonding models	2	
	7	Electron mobility	1	
	8	Semiconductors- intrinsic and extrinsic	2	
	9	Temperature dependence of carrier concentration, Hall Effect	3	
	10	Magnetic properties: diamagnetism and paramagnetism, ferromagnetism, antiferromagnetism and ferrimagnetism	3	
	11	Magnetic domains, magnetic hysteresis, soft and hard magnetic materials, Magnetic storage.	4	
	Sections 18.1 to 18.14, 20.1 to 20.12, Book 1			
III	**Optical properties**		**14**	**25**
	12	Electromagnetic radiation, light interaction with solids	2	
	13	Optical properties of metals- absorption and emission	3	
	14	Optical properties of nonmetals - refraction reflection absorption and transmission	3	
	15	Colour of transparent materials	2	
	16	Luminescence, photoconductivity	2	

	17	Light emitting diodes, lasers	2	
	Sections 21.1 to 21.13, Book 1			
IV	**Thermal properties**		**9**	**15**
	18	Heat capacity	2	
	19	Temperature dependence of heat capacity	2	
	20	Thermal expansion	2	
	21	Thermal conductivity	2	
	22	Thermal stress	1	
	Sections 19.1 to 19.5, Book 1			
V	**PRACTICALS**		**30**	
	1	Familiarization with laboratory equipment and safety protocols		
	2	Measuring resistivity of different materials using simple equipment		
	3	Measuring the refractive index of various samples		
	4	Measuring thermal conductivity using Lees disc method		

Books and References:

1) Materials Science and Engineering, An introduction by William D. Callister, Jr. David G. Rethwisch (Book 1)
2) Introduction to Materials Science for Engineers by James F. Shackelford
3) The Science and Engineering of Materials, by Donald R. Askeland and Pradeep P. Phulé

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	0	1	0	2	0	1	1	1	1	1	1	1
CO 2	2	1	2	0	1	0	1	1	1	1	2	1	1
CO 3	2	0	1	0	2	0	1	1	1	1	2	1	1

CO 4	2	0	1	0	1	0	1	1	1	1	1	1	1
CO 5	2	2	0	0	1	1	1	1	2	1	1	1	1
CO 6	2	2	1	0	0	1	1	1	1	1	2	1	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**SYNTHESIS OF NANOMATERIALS**				
Type of Course	**Vocational Minor** **(GROUP I: TECHNIQUES IN MATERIALS PHYSICS)**				
Semester	**II**				
Academic Level	**100 – 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. PHY1VN101- Introductory Materials Science				
Course Summary	This course gives an introduction to the fascinating world of nanomaterials and diverse synthesis methods.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and classify nanomaterials and explain size-dependent properties.	U	F	Instructor-created exams / Quiz

CO2	Analyze various physical and chemical methods for nanomaterial synthesis, including their advantages, limitations, and applications.	An	C	Instructor-created exams / Home Assignments
CO3	Explain nanofabrication techniques: Grasp the concepts and applications of different nanolithography techniques like electron beam and photonic methods.	Ap	C	Seminar Presentation / Group Tutorial Work
CO4	Select appropriate synthesis methods: Analyze material requirements and choose suitable synthesis methods for specific applications.	Ap	P	Instructor-created exams / Home Assignments
CO5	Perform basic nanomaterial synthesis: Conduct laboratory experiments to prepare nanomaterials using different techniques learned.	E	P	Practical Assignment/ Observation of Practical Skills
CO6	Work collaboratively: Successfully participate in team-based projects and experiments related to nanomaterials.	E	P	Practical Assignment / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Introduction to Nanomaterials**	**10**	**15**
	1	Definition and classification of nanomaterials (0D, 1D, 2D, 3D),	2	
	2	Specific surface area of nanomaterials	2	

	3	Size-dependent properties of nanomaterials (Thermal, Electrical, Mechanical, Magnetic, Optical)	6	
	Sections 1.1 to 1.4, 2.1 to 2.3, 3.1 to 3.7, Book 1			
II	**Synthesis of Nanomaterials (Physical Methods)**		**10**	**15**
	4	High energy ball milling, melt mixing,	2	
	5	Physical vapour deposition	1	
	6	Ionized cluster beam deposition,	1	
	7	laser ablation, laser pyrolysis		
	8	Sputter deposition, chemical vapour deposition, electric Arc deposition	3	
	9	Ion beam technique, molecular beam epitaxy.	3	
	Section 3.1 to 3.8, Book 2			
III	**Synthesis of Nanomaterials (Chemical Methods)**		**10**	**25**
	10	Synthesis of metal nanoparticles by colloidal route	2	
	11	Synthesis of semiconductor nanoparticles by colloidal route	3	
	12	Sol-gel method,	1	
	13	Hydrothermal synthesis	2	
	14	Sonochemical synthesis	1	
	15	Microwave synthesis	1	
	Section 4.1 to 4.5, 4.8 to 4.11, Book 2			
IV	**Synthesis of Nanomaterials (Other Methods)**		**15**	**15**
	16	Synthesis Using Microorganisms	2	
	17	Synthesis Using Plant Extracts	2	
	18	Synthesis of Nanoparticles Using DNA	2	

	19	Nanolithography, Lithography Using Photons, Use of X-rays in Lithography	5	
	20	Lithography Using Particle Beams, Electron Beam Lithography	2	
	21	Ion Beam Lithography	1	
	22	Neutral Beam Lithography	1	
	Section 5.1 to 5.5, 9.1 to 9.3.3, Book 2			
V	**PRACTICALS**		**30**	
	1	Preparation of samples using two different techniques discussed in Module II - IV		

Books and References:

1) Nanomaterials and Nanocomposites: Synthesis, Properties, Characterization Techniques, and Applications by Rajendra Kumar Goyal (Book 1)
2) Nanotechnology_ Principles and Practices by Sulabha K. Kulkarni, 3rd Edition (Book 2)
3) Springer Handbook of Nanomaterials by Robert Vajtai

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	0	1	0	0	0	3	3	2	0	3	3	1
CO 2	1	2	1	2	3	2	3	3	2	2	3	3	2
CO 3	1	1	3	2	2	2	3	3	2	2	3	3	2
CO 4	2	1	2	3	3	2	3	3	2	3	3	3	2
CO 5	3	2	2	3	3	3	3	3	3	3	3	3	3
CO 6	3	3	2	2	2	2	3	3	2	3	3	3	3

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low

2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">CHARACTERIZATIONS AND APPLICATIONS OF NANOMATERIALS
(GROUP I: TECHNIQUES IN MATERIALS PHYSICS)</td></tr>
<tr><td>Type of Course</td><td colspan="5">Vocational Minor</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 – 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. PHY1VN101- Introductory Materials Science
2. PHY3VN201- Characterizations and Applications of Nanomaterials</td></tr>
<tr><td>Course Summary</td><td colspan="5">Master the art of characterizing nanomaterials with microscopy, diffraction, and spectroscopy techniques, unlocking their secrets and exploring their diverse applications.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO 1	Describe various microscopic techniques: Understand the principles and applications of optical, confocal, SEM, TEM, SPM, STM, and AFM for nanomaterial characterization.	U	F	Instructor-created exams / Quiz
CO 2	Explain diffraction principles: Grasp Bragg's law, crystal structure factors,	Ap	C	Instructor-created exams /

	and how X-ray diffraction (XRD) reveals nanomaterial structure.			Home Assignments
CO 3	Select appropriate characterization technique: Analyze nanomaterial properties and choose suitable techniques for specific information needs.	An	P	Seminar Presentation / Group Tutorial Work
CO 4	Operate characterization instruments: Gain practical experience using microscopy, diffraction, and spectroscopy tools for data acquisition.	E	P	Practical Assignment / Observation of Practical Skills
CO 5	Interpret characterization data: Analyze data from different techniques to extract information about size, morphology, structure, and composition.	E	P	Practical Assignment / Observation of Practical Skills
CO 6	Communicate characterization results: Effectively present findings using figures, graphs, and scientific language in written and oral formats.	E	P	Seminar Presentation / Writing Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Microscopic Techniques**	9	15
	1	Optical microscope, Confocal microscope	2	
	2	Scanning Electron Microscopy (SEM)	2	
	3	Transmission Electron Microscopy (TEM)	2	
	4	Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM)	3	
	Section 7.1 to 7.4, Book 1			
II		**Diffraction Techniques**	9	15
	5	X-ray Diffraction (XRD), Atomic scattering factor	2	
	6	Bragg’s law	2	
	7	Crystal Structure factor, Diffraction from nanoparticles	2	

	8	X-ray diffractometer	2	
	9	Dynamic Light Scattering (DLS).	1	
	Section 7.5.1 to 7.5.8, Book 1			
III	**Spectroscopic Methods**		**12**	**25**
	10	Optical spectroscopy	2	
	11	UV-Visible spectroscopy	1	
	12	Infrared spectroscopy, FT-IR spectroscopy	3	
	13	Raman Spectroscopy	2	
	14	Photoluminescence Spectroscopy	1	
	15	X-Ray and Ultra Violet Photoelectron Spectroscopies	3	
	Section 7.6.1 to 7.6.8, Book 1			
IV	**Applications of Nanomaterials**		**15**	**15**
	16	Nanofluids, Hydrogen Storage	2	
	17	Solar Energy, Antibacterial Coating	3	
	18	Gaint Magnetoresistace	2	
	19	Single electron Transistor	2	
	20	Self cleaning coating, nanotextiles, biomedical applications	2	
	21	Nanopore filters, water treatment	2	
	22	Nanodiamond, catalysts	2	
	Section 14.1 to 14.15, Book 2			
V	**PRACTICALS**		**30**	
	1	Characterization of prepared samples by any one of the techniques discussed in the syllabus		

Books and References:

1) Nanotechnology_ Principles and Practices by Sulabha K. Kulkarni (Book 1)
2) Nanomaterials and Nanocomposites: Synthesis, Properties, Characterization Techniques, and Applications by Rajendra Kumar Goyal (Book 2)
3) Springer Handbook of Nanomaterials by Robert Vajtai

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	1	0	2	1	1	1	1	1	2	1	1
CO 2	2	1	2	0	2	1	1	1	1	1	2	1	1
CO 3	2	1	3	1	2	1	1	1	1	1	3	1	1
CO 4	2	2	1	1	1	2	1	1	1	1	2	1	1
CO 5	2	2	2	0	2	1	1	1	1	1	2	1	1
CO 6	2	1	1	0	1	2	1	2	1	1	3	1	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">SCIENTIFIC DOCUMENTATION</td></tr>
<tr><td>Type of Course</td><td colspan="5">Vocational Minor
(GROUP I: TECHNIQUES IN MATERIALS PHYSICS)</td></tr>
<tr><td>Semester</td><td colspan="5">VIII</td></tr>
<tr><td>Academic Level</td><td colspan="5">300 – 399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>4</td><td>-</td><td>-</td><td>60</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Basic computer operating knowledge</td></tr>
<tr><td>Course Summary</td><td colspan="5">Master the art of characterizing nanomaterials with microscopy, diffraction, and spectroscopy techniques, unlocking their secrets and exploring their diverse applications.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Create professional-quality scientific documents, including research papers, reports, and theses, using LaTeX typesetting system.	Ap	P	Practical Assignment / Observation of Practical Skills
CO2	Develop proficiency in formatting and structuring scientific content effectively, adhering to established conventions and guidelines	Ap	P	Instructor-created exams / Home Assignments
CO3	Gain skills in incorporating complex mathematical equations, figures, and	An	P	Practical Assignment /

	tables seamlessly into LaTeX documents to enhance clarity and understanding.			Observation of Practical Skills
CO4	Learn to manage citations and references efficiently using BibTeX or BibLaTeX, ensuring accuracy and consistency in academic writing.	An	P	Practical Assignment / Observation of Practical Skills
CO5	Acquire techniques for designing and delivering engaging presentations and posters for scientific conferences and academic events using LaTeX Beamer class.	Ap	P	Seminar Presentation / Writing Assignment
CO6	Develop collaborative writing and version control skills, enabling them to work effectively with co-authors and collaborators on LaTeX documents for scientific communication and publication.	E	P	Seminar Presentation / Group Tutorial Work
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (48 +12)**	**Marks (70)**
I		**INTRODUCTION TO SCIENTIFIC WRITING AND LaTeX**	**11**	**15**
	1	Understanding the importance of clear communication in science Overview of the scientific writing process	1	
	2	History and purpose of LaTeX Setting up LaTeX environment (installing LaTeX distribution, editor)	2	
	3	Creating a simple LaTeX document Sections, subsections, and paragraphs	2	
	4	Formatting text (fonts, styles, sizes), special characters, text alignment	2	
	5	Writing mathematical equations and symbols	2	

	6	Arrays and matrices	2	
II	**ADVANCED LaTeX TECHNIQUES**		**11**	**15**
	7	Inserting figures and tables into LaTeX documents Captioning and referencing figures and tables	2	
	8	Explore different properties like rotate, scale, etc, wrap fingers	2	
	9	Cross-referencing sections, equations, figures, and tables Managing citations with BibTeX or BibLaTeX	3	
	10	Customizing page layout (margins, headers, footers) Creating custom document classes and styles, numbering, footnotes	2	
	11	Generating bullet and numbered lists Customizing list styles	2	
III	**CREATING PRESENTATIONS WITH BEAMER**		**13**	**20**
	12	Introduction to Beamer class for presentations	2	
	13	Creating slides, adding frames	2	
	14	Dividing the slide into multiple columns, adding different blocks, etc	2	
	15	Table of contents	2	
	16	Overlays - Pause, Slide Transitions	2	
	17	Designing posters with LaTeX	3	
IV	**WRITING SCIENTIFIC DOCUMENTS**		**13**	**20**
	17	Structuring a research paper (abstract, introduction, methods, results, discussion)	3	
	18	Structuring reports, theses and books	2	
	19	Defining custom environments for specialized content Creating macros for frequently used commands	2	
	20	Understanding journal-specific formatting requirements Tips for submitting articles to scientific journals	2	
	21	Collaborating on LaTeX documents with co-authors and editors	2	
	22	Citing references and inserting the bibliography	2	
V	**OPEN ENDED MODULE**		**12**	
	Hands-on training to prepare some of the following documents, poster, presentation or any other relevant designs.			

	1	Prepare a document presenting the mathematical proof of a theorem in physics		
	2	Prepare a document showing examples of different matrix operations.		
	3	Design a model question paper for this course		
	4	Prepare a neat presentation using beamer demonstrating its various features.		
	5	Designing a scientific posters for conferences and presentations		
	6	Prepare a scientific paper for specific journal (Use the document class of Physical Review, Science Direct etc.)		

Books and References:

1) A Short Introduction to Latex: A Book for Beginners by Firuza Karmali Aibara
2) LaTeX: A Document Preparation System" by Leslie Lamport
3) The LaTeX Companion" by Frank Mittelbach, Michel Goossens, Johannes Braams, David Carlisle, Chris Rowley
4) LaTeX Beginner's Guide" by Stefan Kottwitz

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	0	3	0	0	0	0	2	2	2	0	0	0	0
CO 2	0	3	0	0	0	0	2	2	2	0	0	0	0
CO 3	0	3	0	0	0	0	2	2	2	0	0	0	0
CO 4	0	3	0	0	0	0	2	2	2	0	0	0	0
CO 5	0	3	0	0	0	0	2	2	2	0	0	0	0
CO 6	0	3	0	0	0	0	2	2	2	0	0	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1		✓	✓	✓
CO 2	✓	✓		✓
CO 3		✓	✓	✓
CO 4		✓	✓	✓
CO 5	✓	✓		✓
CO 6	✓	✓	✓	✓

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**PYTHON BASICS**				
Type of Course	**Vocational Minor (GROUP II: DATA ANALYSIS IN PHYSICS)**				
Semester	**I**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic computer knowledge				
Course Summary	This course introduces Python programming for data analysis in Physics with the aid of machine learning. As the first step, Python language is introduced with emphasis on Numpy and matplotlib modules, for future use in machine learning.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the significance of algorithm & flowchart in development of computer programs	U	F	Instructor-created exams
CO2	Understand and apply basic Python syntax	U, Ap	F, P	Instructor-created exams, Practical Assignment / Observation of Practical Skills
CO3	Understand and apply various conditional statements, as well as	U, Ap	F, P	Instructor-created exams, Practical Assignment /

	understand the modular nature of a program using functions in Python.			Observation of Practical Skills
CO4	Apply various modules for several tasks in Python	Ap	P	Instructor-created exams, Practical Assignment / Observation of Practical Skills/ Home Assignments
CO5	Understand in detail and apply the Numpy module in data analysis of physical data.	U, Ap	F, P	Instructor-created exams, Practical Assignment / Observation of Practical Skills
CO6	Understand and apply the matplotlib module for graphical representation of data in various pictorial formats.	U, Ap, C	F, P	Instructor-created exams, Practical Assignment / Observation of Practical Skills/ Home Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (45 +30)**	**Marks (70)**
I		**Introduction to Python**	**12**	**15**
	1	Use of algorithm and flowchart in computation.	2	
	2	Introduction to python, interactive and script mode, operators	2	
	3	Data types: numeric, string, list, tuple, set, dictionary (basics)	2	
	4	List operations, input() function, print() function, different formatted print statements, type() and eval() functions.	3	
	5	Files in Python & file operations: opening in different modes, read and write operations	3	

<table>
<tr><td colspan="5">Chapter 2: p.31-33 (including Python's IDLE Graphics window), Chapter 3,4, Chapter 5: p.95-108 (upto and excluding Command Line Arguments), Chapter 17: p.441-452 (including with statement), from Core Python Programming.</td></tr>
<tr><td rowspan="5">II</td><td colspan="2">Control statements, Functions and Modules</td><td>10</td><td rowspan="5">15</td></tr>
<tr><td>6</td><td>Conditional & control statements: if, if…else, if…elif else statements,</td><td>2</td></tr>
<tr><td>7</td><td>while and for loops, range() function. Nested loops. break & continue statements.</td><td>3</td></tr>
<tr><td>8</td><td>Functions: built-in functions & user defined functions,</td><td>3</td></tr>
<tr><td>9</td><td>Modules and Packages, lambda expressions. Calendar Module, Math Module, time module, date module, zip()</td><td>2</td></tr>
<tr><td colspan="5">Chapter 6: p.117-139, Chapter 9: p.237-270, Chapter 20: p.515-526 of Book 1</td></tr>
<tr><td rowspan="10">III</td><td colspan="2">Numpy</td><td>15</td><td rowspan="10">25</td></tr>
<tr><td>10</td><td>Numpy Arrays: creating arrays using array(), linspace, logspace, arrange(), zeros() and ones() functions.</td><td>2</td></tr>
<tr><td>11</td><td>Mathematical operations on arrays.</td><td>2</td></tr>
<tr><td>12</td><td>Indexing and slicing arrays, dimension of array</td><td>1</td></tr>
<tr><td>13</td><td>Attributes of arrays: ndim, shape, size, itemsize, dtype, nbytes</td><td>1</td></tr>
<tr><td>14</td><td>reshape() and flatten() methods for arrays</td><td>1</td></tr>
<tr><td>15</td><td>Multi-dimensional arrays using array(), zeros() and ones() functions</td><td>2</td></tr>
<tr><td>16</td><td>Indexing and slicing multi-dimensional arrays.</td><td>2</td></tr>
<tr><td>17</td><td>Numpy matrix: creation, access, mathematical operations.</td><td>2</td></tr>
<tr><td>18</td><td>Matrix operations (eigenvalues, dot, determinant, transpose, inverse), random numbers, shape(), reshape() functions.</td><td>2</td></tr>
<tr><td colspan="5">Chapter 6 of Book 2</td></tr>
<tr><td rowspan="5">IV</td><td colspan="2">Matplotlib module</td><td>8</td><td rowspan="5">15</td></tr>
<tr><td>19</td><td>Plotting, labelling, scale commands in matplotlib</td><td>2</td></tr>
<tr><td>20</td><td>subplot, axes, figure, commands in matplotlib</td><td>2</td></tr>
<tr><td>21</td><td>Plotting pie chart, histogram, line graph, scatter plot and bar graphs.</td><td>2</td></tr>
<tr><td>22</td><td>grid(), axhline(), axvline() commands.</td><td>2</td></tr>
<tr><td></td><td colspan="2">Chapter 14 of Book 2</td><td></td><td></td></tr>
</table>

V	**PRACTICALS**		**30**	
	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6th experiment may also be selected from the given list.			
	1	Developing Algorithms for Formatted Printing - Printing of triangle or inverted triangle (Pyramid form), Binomial coefficients in Pyramid form, fibonacci series.		
	2	Create and print a 3×3 matrix using nested loop.		
	3	Solution of simultaneous equations using Numpy.		
	4	Generate calendar using Calendar module.		
	5	Plot trigonometric functions - sin, cos, tan, x^2, exp(x).		
	6	Write a program for the ATM Pin verification process		
	7	Diagonalize a 3x3 matrix and verify that by evaluating the eigenvalues. Also evaluate the eigenvectors for the matrix.		
Relevant sections from Book 1 & Book 2				

Books and References:

1. Core Python Programming 2nd edition or higher, Dr. R. Nageswara Rao, Dreamtech press, 2020 (Book 1)
2. Machine Learning in Data Science using Python, Dr. R. Nageswara Rao, Dreamtech press, 2022 (Book 2)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	0	0	0	0	1	0	1	0	0	1	0	0	0
CO 2	0	0	0	0	1	0	1	0	0	1	0	0	0
CO 3	0	0	0	0	1	0	1	0	0	1	1	0	0
CO 4	0	0	0	0	1	0	1	0	0	2	1	0	0
CO 5	0	1	0	0	2	1	1	0	0	2	2	0	0
CO 6	0	1	0	0	2	1	1	0	0	2	1	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**DATA ANALYSIS IN PHYSICS USING PYTHON**				
Type of Course	**Vocational Minor (GROUP II: DATA ANALYSIS IN PHYSICS)**				
Semester	**II**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	PHY1VN102- Python Basics				
Course Summary	This paper continues from the previous paper for data analysis. More data analysis tools are introduced to be used in machine learning, as well as in physical data analysis. In addition, essential statistics required for data analysis is also introduced.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Become familiar with data format & programs used in data analysis	U	F	Practical Assignment / Observation of Practical Skills
CO2	Understand & apply Pandas module for data analysis	U, Ap	P	Instructor-created exams, Practical Assignment / Observation of Practical Skills

CO3	Understand & apply Seaborn module for data visualization	U, Ap	P	Instructor-created exams, Practical Assignment / Observation of Practical Skills
CO4	Understand the significance of statistical analyses as well as error analysis in physical measurements.	U	F	Instructor-created exams
CO5	Understand the significance of few distributions commonly found in physical measurements.	U	F	Instructor-created exams/ Home Assignments
CO6	Apply statistical methods to physical measurements	U, E	P	Home Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Data file formats**	**8**	**10**
	1	Introducing different data file formats: csv, xls, tab, dat formats.	2	
	2	Jupyter Notebooks using Anaconda and Google Colab: introduction.	2	
	3	Familiarization with Google Colab	1	
	4	Familiarization with Anaconda	2	
	5	Reading data files in Jupyter Notebooks.	1	
Basic overview to be given about data formats and software used.				
II		**Using Pandas for Data Analysis**	**12**	**20**
	6	Data Analysis Using Pandas: Series and dataframe, creating data frame from an excel spreadsheet - creating dataframe from .csv files.	3	

	7	Creating data frame from a python dictionary - creating dataframe from python list of tuples - viewing data frame using loc() and iloc().	3	
	8	Operations on data frames series object - creating series from a dataframe - creating dataframe from series - creating series from numpy array.	2	
	9	Converting series into numpy array - creating series from a dictionary - accessing elements of a series.	2	
	10	Joining data frames - how to join when there is no common column - concatenation of tables - where() method - groupby() method - aggregate functions on data frames.	2	
Chapters 12,13 (SQL & Regular expressions not required) of Book 1				
III		**Data Visualization using Seaborn**	**10**	**20**
	10	Loading datasets in Seaborn, Distribution plot	1	
	11	Count plot, box plot, scatter plot, joint plot.	2	
	12	Line Plot, displaying scatter plot with regression line	2	
	13	Creating subplots	1	
	14	Heat map - cat plot	2	
	15	Violin plot - pair plot.	2	
Chapter 15 of Book 1				
IV		**Basic Statistics & Error Analysis**	**15**	**20**
	16	Preliminaries of Error Analysis: errors as uncertainties, inevitability of uncertainty,	2	
	17	Importance of knowing the uncertainties.	2	
	18	Statistical analysis of random uncertainties: random and systematic errors, the mean and standard deviation.	2	
	19	Standard deviation as the uncertainty in a single measurement, the standard deviation of the mean, systematic errors.	2	
	20	The Normal Distribution: Histograms and distributions, limiting distributions, the normal distribution.	3	
	21	The Standard deviation as 68% confidence limit, justification of the mean as best estimate.	2	
	22	The Poisson Distribution: Definition of the Poisson Distribution, Properties of the Poisson Distribution.	2	

Sections 1.1-1.3; 4.1-4.6; 5.1-5.5; and 11.1-11.3 of Book 2			
V	**PRACTICALS**	**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list.		
	1. Familiarising Jupyter notebook using Colab/Anaconda and basic coding 2. Read data from different output format (csv, xls, tab, dat, txt) and save it in a specific format (csv, dat) 3. Heat map, Box plot, scatter plot 4. Violin plot, Pair plot 5. Basic statistics - plots including error bars 6. Grouping example using colab 7. Create series from a dataframe and dataframe from series using numpy array.		

Books and References:

1. Machine Learning in Data Science using Python, Dr. R. Nageswara Rao, Dreamtech press, 2022 (Book 1)
2. An Introduction to Error Analysis, John R. Taylor 2nd edition, University Science Books, 1996 (Book 2)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	0	0	0	0	1	0	1	0	0	2	1	0	0
CO 2	0	0	0	0	2	0	1	0	0	2	1	0	0
CO 3	0	0	0	0	2	0	1	0	0	2	1	0	0
CO 4	0	1	2	0	1	1	1	0	0	1	2	0	0
CO 5	0	1	1	0	1	1	1	0	0	1	2	0	0
CO 6	0	1	1	0	1	1	1	0	0	1	2	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignm ent	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">DATA ANALYSIS IN PHYSICS USING MACHINE LEARNING</td></tr>
<tr><td>Type of Course</td><td colspan="5">Vocational Minor (GROUP II: DATA ANALYSIS IN PHYSICS)</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 - 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. Fundamentals of Programming Concepts
2. PHY1VN102- Python Basics
3. PHY2VN102- Data Analysis in Physics Using Python</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course explores Machine Learning fundamentals: types, challenges, and model training techniques like Linear Regression, Gradient Descent, KNN, and clustering. Analyze data using Scikit-learn, handle classification problems with performance evaluation measures on real datasets.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Grasp the concepts and importance of Machine Learning, its types, and	U	C	Instructor-created exams / Quiz

	real-world problem-solving applications.			
CO2	Understand linear regression, model evaluation metrics, and various types of regression. They will apply this knowledge practically using examples.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Master in K-Nearest Neighbor classification, decision trees, entropy, Gini index, and K-means clustering, demonstrated through practical applications with sample datasets.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Apply classification algorithms to MNIST data, including binary classifiers and multilabel classification, and interpret performance measures like confusion matrix, precision, recall, and ROC curve	U	C	Instructor-created exams / Home Assignments
CO5	Learn to implement and construct a ML model for one of the problems mentioned.	Ap	P	One Minute Reflection Writing assignments/ Vice Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Foundations of Machine Learning**	11	15
	1	Introduction to Machine Learning - Need for Machine Learning - Machine Learning model	1	
	2	Challenges in ML - Applications of ML	1	
	3	Types of ML algorithms - Supervised ML Algorithms - Classification - Regression -	1	

	4	Exploring Unsupervised Learning, Reinforcement Learning -	2	
	5	Preparing Data - Steps involved in data cleaning - Data Standardization - Data Scaling, Binarization - Data Labeling,	3	
	6	Feature Selection Techniques - Detecting Outliers - Z score - Optimization Algorithm - Gradient Descent - SGD	3	
	Sections from 9.1 - 9.9 of Chapter 9 of Book 2			
II	**Regression Analysis: Techniques, Evaluation, and Practical Applications**		**11**	**18**
	7	Overview of how Regression works - Model evaluation metrics - Types of Regression	2	
	8	Understanding Linear Regression, Simple Linear regression - Variables - Linear Regression - Linear equation - The r-squared value	3	
	9	Practical use of Simple Linear regression - An example problem using sample data (home prices)	3	
	10	Make the data - identify the features - Training and Testing - another example problem for linear regression (Salary data)	1	
	11	Multiple linear regression - Example problem using sample data	2	
	1. Section 10.1 - 10.4 of Chapter 10 of Book 2 2. Chapter 19 page no. 382 - 400 of Book 3 3. Chapter 20 page no. 401 - 408 of Book 3			
III	**ML Classification & Clustering Essentials**		**14**	**25**
	12	Classification Algorithms - K-Nearest Neighbour classifier - How to select K value	2	
	13	Calculate the distance metric between two points - Example problem to construct the classifier - use breast cancer data set	3	
	14	Decision Trees - Entropy - How to calculate total entropy for a dataset	3	
	15	Gini Index	1	
	16	Comparison between Gini index and entropy- Example problem using a given data set	2	
	17	Clustering Algorithms - K- means clustering	1	
	18	Rules to generate clusters - Elbow method - Sample problem using a standard data set	2	
	1. Sections and references from Chapters 29 page no. 572 - 585 of Book 3			

	2. Sections and references from Chapters 30 page no. 591 - 607 of Book 3 3. Chapter 11 Section 11.3 - 11.4			
IV	**Classification: Metrics & Multilabel Analysis**		**9**	**12**
	19	Classification problem using MNIST data	2	
	20	Training a binary classifier	2	
	21	Performance Measures - Confusion Matrix - Precision and Recall - ROC curve	3	
	22	Multilabel Classification, multi output classification	2	
	1. Sections from Chapter 3 page no. 85 - 108 of Book 1			
V	**Hands-on Data Structures:** **Practical/Project Applications, Case Study and Course Project**		**30**	
	1	Implement the following: **1. Classification of iris data using KNN:** Data: Read from Scikit-learn **2. Classification of iris data using K-means Cluster:** Data: Read from Scikit-learn **3. Draw the confusion matrix of iris dat:** Data: Use the classification results from experiments 1 & 2 **4. Design ML Classifier:** To classify RR Lyrae stars using KNN.		
	1. https://scikit-learn.org/stable/auto_examples/neighbors/plot_classification.html#sphx-glr-auto-examples-neighbors-plot-classification-py 2. https://www.geeksforgeeks.org/analyzing-decision-tree-and-k-means-clustering-using-iris-dataset/ 3. https://www.kaggle.com/code/ankumagawa/knn-confusion-matrix-iris-flower-digits-data 4. https://sigmoidal.ai/en/k-nearest-neighbors-k-nn-for-classifying-rr-lyrae-stars/			

Books and References:

1. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Third Edition by Aurélien Géron. (Book 1)
2. Data Science and Machine Learning using Python by Reema Thereja (Book 2)
3. Machine Learning in Data Science using Python by R Nageswara Rao (Book 3)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	0	0	1	0	1	0	2	0	0	2	1	0	0
CO 2	0	1	2	0	1	0	2	0	0	2	1	0	0
CO 3	0	1	2	0	1	0	2	0	0	2	1	0	0
CO 4	0	1	2	0	1	0	2	0	0	2	2	0	0
CO 5	0	2	1	1	1	0	2	0	1	2	1	0	0
CO 6	0	0	1	0	1	0	2	0	0	2	1	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**APPLICATIONS OF ADVANCED MACHINE LEARNING & ARTIFICIAL INTELLIGENCE IN PHYSICS**				
Type of Course	**Vocational Minor (GROUP II: DATA ANALYSIS IN PHYSICS)**				
Semester	**VIII**				
Academic Level	**300 – 399**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. PHY1VN102- Python Basics 2. PHY2VN102- Data Analysis in Physics Using Python 3. PHY3VN202- Data Analysis in Physics Using Machine Learning				
Course Summary	This course explores the fundamentals of Artificial Intelligence: Basic idea about AI. It also explains the advanced concepts of Machine Learning Techniques. Deep Learning and CNNs are introduced.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Acquire expertise in DBSCAN for spatial clustering and neural networks for comprehensive data analysis and pattern recognition proficiency.	Ap	P	Practical Assignment / Observation of Practical Skills

CO2	Grasp the significance of SVM, apply it using Python, adjust parameters, evaluate pros/cons, and employ it across varied applications.	U	C	Instructor-created exams / Quiz
CO3	Understand the Deep Learning concepts, utilise the TensorFlow/Keras framework, grasp neural network variants, and understand various neural network architectures.	U	C	Seminar Presentation / Group Tutorial Work
CO4	Develop machine learning models for practical applications, enhancing skills in classification, feature selection, and model evaluation techniques.	Ap	P	Instructor-created exams / Home Assignments
CO5	Grasp the concepts and importance of Artificial Intelligence, historical context and how the brain processes information.	U	C	One Minute Reflection Writing assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**Neural Networks and Clustering Techniques in ML**	**13**	**18**
	1	Density Based Spatial Clustering of Applications with Noise (DBSCAN) - Understand how DBSCAN works	2	
	2	Algorithmic steps for DBSCAN clustering - parameter estimation	1	
	3	Python implementation of DBSCAN using Scikit-learn - example using random sample generation	3	
	4	Neural Network - Working of a neural network - model - Pros and Cons	3	

	5	Applications of neural networks - Activation Function - Steps involved in neural network methodology - Example using scikit-learn (not for examination)	4	
	Sections 11.5 - 11.5.5 and 11.7 - 11.7.6 of Chapter 11 of Book 1			
II	**Support Vector Machine**		**11**	**16**
	6	Support Vector Machine (SVM) - Need of SVM	2	
	7	Important terms in SVM - Hyperplane - Margin - Tuning Parameters	2	
	8	Working of SVM - Advantages and Disadvantages of SVM	2	
	9	Applications of SVM	2	
	10	Tuning hyperparameters - Python implementation of SVM - Example data using breast cancer (Not for examination)	3	
	Section 11.8 - 11.8.6 of Chapter 11 of Book 1			
III	**Advanced Machine Learning Techniques**		**13**	**20**
	11	Deep Learning - Working of DL Model - Comparison between ML and DL	2	
	12	Applications of Deep Learning - Libraries for implementing DL - TensorFlow and Keras	3	
	13	Types of Neural Networks - ANN - MLP - CNN - RNN	3	
	14	Architecture of Keras - Model - Layer	2	
	15	Loss - Optimizer - Metrics	1	
	16	Training the model - With ionosphere data to identify any structure is present in a radar data using Keras (Not for examination)	2	
	Section 12.1 - 12.4 of Chapter 12 of Book 1			
IV	**Foundations of Artificial Intelligence**		**11**	**16**
	17	What is Artificial Intelligence - Turing Test - Cognitive modeling approach	2	
	18	Foundations of AI - Philosophy	2	
	19	How do brain process information - How can we build an efficient computer	1	
	20	History of AI - The birth - Early Enthusiasm - Availability of large data sets	2	
	21	Knowledge-based systems - AI adopts the scientific method	2	

	22	Intelligent agents -The State of art	2	
	Section 1.1 - 1.4 of Chapter 1 of Book 2			
V	**OPEN ENDED MODULE**		**12**	
	Implement one of the following tasks or any other relevant project: **1. Photometric Redshift Estimation using the data:** Data: Read from Scikit-learn 2. **Develop a neural network for the detection of exoplanet:** Data: Repository given in the reference section 3. **Develop a SVM model for the detection of exoplanet:** Data:Repository given in the reference section			
	1. https://ogrisel.github.io/scikit-learn.org/sklearn-tutorial/tutorial/astronomy/regression.html 2. https://github.com/gabrielgarza/exoplanet-deep-learning/tree/master			

Books of Study:

1. Data Science and Machine Learning using Python by Reema Thereja
2. Artificial Intelligence – A Modern Approach Third Edition by Stuart Russel and Peter Norvig.

Reference:

1. Machine Learning in Data Science using Python by R Nageswara Rao

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	1	1	2	1	1	1	1	2	2	2	1	1
CO 2	1	2	2	1	1	1	1	1	2	2	2	1	1
CO 3	1	1	3	1	2	1	1	1	2	3	3	1	1
CO 4	1	2	3	3	1	1	1	1	3	3	3	1	1
CO 5	1	1	1	1	3	1	2	1	1	2	1	1	1
CO 6	2	1	1	2	1	1	1	1	2	2	2	1	1

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

GENERAL FOUNDATION COURSES

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**PHYSICS IN DAILY LIFE**				
Type of Course	**Multi-Disciplinary Course 1**				
Semester	**I**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	High school level science				
Course Summary	This course explores the use of physics in daily life. Working of the daily use devices, physical principles coming to play in the kitchen and in sports are explored.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply the principles of physics to several day-to-day phenomena in the kitchen.	Ap	F	Instructor-created exams / Quiz

CO2	Understand the working of common kitchen appliances, as well as the usage of several types of materials as kitchen utensils.	U	F	Instructor-created exams / Quiz
CO3	Apply the principles of physics to the sport of cricket.	Ap	F	Instructor-created exams / Quiz
CO4	Apply the principles of physics to the sport of football.	Ap	F	Instructor-created exams / Quiz
CO5	Understand the connection between resonance and sound phenomena.	U	F	Instructor-created exams / Quiz
CO6	Understand the working of common appliances like photostat machine, air conditioner etc.	U, Ap	F	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36+9)	Marks (50)
I		**Physics in the Kitchen (Thermodynamics)**	**10**	**15**
	1	Advantages and disadvantages of using LPG and electricity as energy sources in the kitchen – physics of induction cooktop physics of microwave oven	2	
	2	Smoke detectors – the fresh air fan: things to look out for. Purpose and use of different metals as kitchen utensils	2	

	3	Why do cold objects (plastic, metal) break easily – Working of refrigerator.	3	
	4	Noise in the kitchen, Dishwasher, Energy waste in the kitchen and solutions, Modern gas lighters, weighing scales	3	
Pages 154 - 159, 161-170, 179-186 of Chapter 5, 192-202 of Chapter 6, Book 1				
II	**The Physics of Sports: Cricket (Mechanics)**		**10**	**13**
	5	Physics of pace bowling – use of seam of the ball	3	
	6	Difference between hard & soft pitches on the pace bowling.	1	
	7	Spin bowling – reason for ball to spin during later the day.	2	
	8	Magnus effect and its importance.		
	9	The cricket bat: reasons for choosing willow wood, sweet spot of the bat.	2	
	10	Physics of *Hawkeye, Hotspot, Snicko* and *Super SloMo*, no need of Rutherford scattering, no need of elaborating equation of Planck's Law. Detailed discussion of equations of hawkeye not required; providing elementary ideas is sufficient.	2	
Pages 86-89 of Chapter 5, 187 - 200 of Chapter 10, 114 - 116, 123-125 of Chapter 7, 164-181 of Chapter 9, Book 2				
III	**The Physics of Sports: Football (Mechanics)**		**9**	**12**
	11	The kick	2	
	12	Forces on the foot, power, the curled kick.	2	
	13	The throw-in, goalkeeper's throw, heading, punching, catching, receiving, trapping the football.	1	
	14	Airflow around the ball – the boundary layer	1	

	15	The Bernoulli effect, separation of the flow, the turbulent wake, the critical speed, what happens at the critical speed, speed and range, effect of a wind, the banana kick.	2	
Pages 19 - 25 of Chapter 2, 33-41 of Chapter 3, 49 - 68 of Chapter 4, Book 3				
IV		**Physics Every day**	**7**	**10**
	16	Sound in air – natural resonances	1	
	17	Pendulums and harmonic oscillators, pendulum clock	2	
	18	Quartz/electronic clocks	2	
	19	Working of photocopier/ Xerograph	2	
Pages 232-237, 239-240 of Chapters 9, 276-280 of Chapter 10, Book 4				
V		**Open Ended Module (suggestions only)**	**9**	
	1	Bicycles: Stability, leaning, pedaling		
	2	Working of air conditioner: laws of thermodynamics & entropy.		
	3	Working of air conditioner: mechanism		
	4	Sound and music (basic ideas only, scale used in western music not needed)		
Pages 97-104 of Chapter 4, 209-219 of Chapter 8, 241-242 of Chapter 9, Book 4				

Books and References:

1. *Physics in the Kitchen*, George Vekinis, Springer Nature Switzerland, 2023. (Book 1)
2. *The Physics of Cricket*, Mark Kidger, Nottingham University Press, 2011. (Book 2)
3 *The Science of Soccer*, John Wesson, Institute of Physics Publishing, 2002. (Book 3)
4. *How Things Work* 6th Ed, Louis A Bloomfield, John Wiley & Sons, 2016. (Book 4)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO3	PO4	PO5	PO 6	PO 7
CO 1	1	1	1	1	0	0	0	0	0	0	0	0	0
CO 2	2	1	1	1	0	0	0	0	0	0	0	0	0
CO 3	2	1	1	1	0	0	0	0	0	0	0	0	0
CO 4	2	1	1	1	0	0	0	0	0	0	0	0	0
CO 5	2	1	1	1	0	0	0	0	0	0	0	0	0
CO 6	3	1	1	1	1	0	0	0	0	0	0	0	0

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ASTRONOMY AND STARGAZING**				
Type of Course	**Multi-Disciplinary Course 2**				
Semester	**II**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	High school level science				
Course Summary	This introductory course in amateur astronomy provides students with a foundational understanding of observational astronomy, celestial objects and basic techniques for amateur stargazing. Through a combination of lectures, classroom demonstrations and field observations, students will gain practical skills and theoretical knowledge to explore the wonders of the night sky.				

Course Outcomes (CO):

CO	**CO Statement**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Understand the development of astronomical knowledge from the ancient	U	C	Instructor-created

	models to the modern astronomical theories.			exams / Quiz
CO2	Understand the scientific principles underlying astronomical observations and the characteristics and properties of celestial objects	U	C	Instructor-created exams / Quiz
CO3	Apply observational techniques and methods to effectively navigate the night sky.	Ap	P	Observational Home Assignment / Viva Voce
CO4	Analyze astronomical phenomena such as phases of the moon, alignments of constellations and planets.	An	P	Demonstration Skills / Viva Voce
CO5	Foster an interest in citizen science and amateur contributions to astronomy.	An	P	Instructor-created Home Assignments
CO6	Develop a scientific temper, curiosity and a sense of wonder about the universe	Ap	P	Instructor-created Home Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (36+9)**	**Marks (50)**
I		**Astronomy- an overview**	**10**	**15**
	1	Ancient Astronomy- Astronomy around the World, Early Greek and Roman Cosmology, Ptolemy's Model of the Solar System, Astrology and	2	

		Astronomy- The Beginnings of Astrology, The Horoscope, Astrology Today		
	2	The Celestial Sphere, Celestial Poles and Celestial Equator, Rising and Setting of the Sun, Fixed and Wandering Stars, Constellations	2	
	3	The Birth of Modern Astronomy-Copernicus, The Heliocentric Model, Galileo and the Beginning of Modern Science, Galileo's Astronomical Observations, Kepler's Laws of Planetary Motion, Orbits in the Solar System	3	
	4	Telescopes, How Telescopes Work, Formation of an Image by a Lens or a Mirror	1	
	5	The Nature of Astronomy, The Nature of Science, The Laws of Nature, Numbers in Astronomy, A Tour of the Universe, The Universe on the Large Scale, The Universe of the Very Small, A Conclusion and a Beginning	2	
	Sections 1.1-1.4, 1.6-1.9, 2.1-2.4, 3.1,3.4, 6.1 of Book 1			
II	**Step into the Sky**		**6**	**10**
	6	Darkness and Light, Finding Your Way around the Sky, Cosmic Protractor, Special Effects, Night Vision, The Milky Way	2	
	7	Moon: Phases of Moon, Characteristics, Moonrise, Moonset, Moon Illusion	1	
	8	Sightseeing on the moon, Lunar topography, Formation	2	
	9	Lunar Eclipse	1	
	Chapter 1 & 2 of Book 2			
III	**Sun and Planets**		**10**	**12**
	10	Sun, How seasons happen, Sun paths, Telling time by the Sun	1	
	11	A visit to the sun, Power house, Storms on Sun, How the Sun formed, Our sun is born	2	

	12	Solar Eclipse, How Are Eclipse of the Sun and Moon the Same-and Different? Why Can't We Look at the Sun? What to take eclipse-watching?	1	
	13	Planets: Earth's siblings in the sky, Star or Planet? Sky Wanderer, Roaming around Solar system	2	
	14	Terrestrial & Jovian Planets, Small solar system Bodies, Meet the eight planets	2	
	15	How the Solar System Formed, Comets, Other suns and their Solar Systems	2	
	Chapter 3 & 4 of Book 2			
IV		**Stars, constellations & stellar evolution**	**10**	**13**
	16	Stars and Constellations: How stars move during the night, North star	2	
	17	North & South Using the Stars, The Zodiac and the Ecliptic, Rasis & Nakshatras	2	
	18	Seasonal Sky gazing Northern Hemisphere - November, December & January Stars. (Constellations Orion, Canis Major, Lepus, Taurus, Gemini, Auriga)	3	
	19	How Stars Are Born, Live, and Die, Meteor Shower. Deep Sky Objects.	3	
	Chapter 5 of Book 2 and Chapter 3 & 10 of Book 3			
V		**Open Ended Module: Hands-on Astronomy**	**9**	
	1	● Demonstrations using Stellarium or any other sky guide apps – constellations, eclipses, planetary alignment etc. https://va-iitk.vlabs.ac.in/?page=exp1 ● Citizen science projects like Galaxy-zoo ● Smartphone Astrophotography		
	References 4-7			

Books and References:

1. Astronomy 2e by Andrew Fraknoi, David Morrison, and Sidney C. Wolff, OpenStax CNX (Book 1) https://open.umn.edu/opentextbooks/textbooks/390
2. Sky Gazing- A Guide to the Moon, Sun, Planets, Stars, Eclipses, and Constellations by Meg Thacher, Storey Publishing. (Book 2)
3. The Joy of Skywatching by Biman Bose, National Book Trust , India. (Book 3)
4. https://stellarium.org/
5. https://va-iitk.vlabs.ac.in/?page=exp1
6. https://www.zooniverse.org/projects/zookeeper/galaxy-zoo/
7. A Guide to Smartphone Astrophotography by Dr. Sten Odenwald, a free e-book from NASA https://spacemath.gsfc.nasa.gov/SMBooks/AstrophotographyV1.pdf

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PS O3	PSO 4	PS O5	PS O6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	1	2	2	2	0	0	0	0	0	0	0	0	0
CO 2	2	2	2	2	0	0	0	0	0	0	0	0	0
CO 3	2	1	1	1	1	0	0	0	0	0	0	0	0
CO 4	1	1	1	2	1	0	0	0	0	0	0	0	0
CO 5	1	2	1	1	0	0	0	0	0	0	0	0	0
CO 6	1	2	1	1	0	0	0	0	0	0	0	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

IMPORTANT: This course is for the Double Major pathway only.

Programme	**B.Sc. Physics Honours**				
Course Title	**RENEWABLE ENERGY SOURCES**				
Type of Course	**Value-Added Course 1**				
Semester	**III**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	0	45
Pre-requisites	Basic knowledge of different forms of energy.				
Course Summary	This course provides a comprehensive introduction to various renewable energy resources with a focus on non-conventional sources. Students will explore the principles, technologies, advantages, disadvantages, and practical applications of solar, wind, geothermal, ocean, and biomass energy.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Develop a foundational understanding of energy resources, focusing on non-conventional sources such as solar energy, and grasp key terms and concepts including solar constant, radiation measurements, collectors, and practical applications of solar power.	U	C	Instructor-created exams / Quiz
CO2	Discover wind energy comprehensively, covering utilization, advantages, disadvantages, environmental impact, sources, conversion principles, components, pros and cons, wind-electric power plants, economics, and operational challenges of large generators.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Gain insight into geothermal energy, exploring Earth's interior structure, geothermal systems like hot springs and various resources, and understanding the advantages, disadvantages, and applications of geothermal energy in comparison to other forms.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Explore ocean energy, focusing on tidal and wave energy, understanding tidal power plant components, economic aspects, OTEC working principles, efficiency, types, and applications, considering advantages and disadvantages.	U	C	Instructor-created exams / Home Assignments

CO5	Understand biomass with its resources and conversion processes, explore biogas applications and plants	Ap	P	Writing assignments
CO6	Study fuel cells, hydrogen energy, government schemes, and subsidies, and conduct plant visits for performance analysis.	Ap	P	Seminar Presentation /Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs (36 +9)**	**Marks (50)**
I		**Solar Energy**	**12**	**18**
	1	Introduction to Energy Resources-NonConventional Energy Sources-Renewable and Non-Renewable energy sources.	2	
	2	Solar Energy Terms and Definitions: Solar radiation, Solar Constant	2	
	3	Measurement of Solar radiation, Solar energy collectors: Principle (Physical) of the conversion of solar energy into heat, Types of collectors,	3	
	4	Flat plate collector, Advantages, disadvantages and applications of flat plate collectors,Need of orientation in concentrating collectors, Advantages and disadvantages of concentrating collectors, Parabolic trough collector	3	
	5	Concentrating collectors (Performance analysis not needed) ,Solar air heaters and dryers,	1	

	6	solar cookers, Solar photovoltaic cells (no need of mathematical equations)	1	
	Sections 1.3, 1.4, 1.5, 2.2.1, 2.2.2, 2.3, 3.1.3, 3.2, 3.3.1 , 3.3.3, 3.4 - (excluding 3.4.11), 4.16, 4.17, 4.21.4 of Book 1			
II	**Wind Energy**		**7**	**10**
	7	Introduction, Utilisation aspects of wind energy, Advantages and Disadvantages of wind energy, Environmental impact of wind energy	1	
	8	Sources/Origins of wind, Principle of wind energy conversion and wind power, Pattern factor	2	
	9	Basic components of wind energy conversion system(WECS), Advantages and Disadvantages of WECS	2	
	10	Wind-Electric Generating Power Plant, Problems in operating large wind power generators.	2	
	Sections 5.1-5.6, 5.8- 5.10, 5.11, 5.20, 5.26 of Book 1			
III	**Geo Thermal Energy**		**8**	**12**
	11	Introduction to Geothermal energy, Important aspects of Geothermal Energy, Structure of Earth's interior, Geothermal system-Hot Spring structure.	2	
	12	Geothermal Resources -Hydrothermal, Geopressured	3	
	13	Geothermal Resources - Petro-thermal system, Magma Resources	2	
	14	Advantages and disadvantages of geothermal energy over other energy forms, application of geothermal energy	1	
	Sections 7.1, 7.2, 7.3, 7.5, 7.8.1, 7.8.2, 7.8.3, 7.8.4, 7.9, 7.10 of Book 1			
IV	**Energy from Ocean**		**9**	**10**
	15	Ocean Energy, Ocean Energy Sources, Tidal energy	2	

	16	Components of a Tidal Power Plant, Advantages and disadvantages of tidal power, Economic aspects of tidal energy conversion	2	
	17	Wave energy, Advantages and disadvantages, Factors affecting Wave energy	2	
	18	Ocean Thermal Energy Conversion (OTEC), Working principle of OTEC, Efficiency of OTEC	2	
	19	Types of OTEC Plants (Closed system, Thermoelectric OTEC system), Advantages and Disadvantages and Applications of OTEC	1	
		Sections 8.1, 8.2, 8.3.1, 8.3.8, 8.3.14, 8.4.1, 8.4.2, 8.4.3, 8.5.1, 8.5.3, 8.5.4, 8.5.5.1, 8.5.5.5, 8.5.6 of Book 1		
V	**Open Ended Module : Biomass and Chemical Energy**		**9**	
	1	Biomass resources, conversion process and applications		
	2	Biogas applications and biogas plants		
	3	Fuel cells and Hydrogen energy		
	4	Government schemes and subsidies for renewable energy projects		
	5	Any renewable energy plant visit and performance analysis		

Books and References:

1. Non- Conventional Energy Sources and Utilisation by R.K.Rajput, S.Chand Publishers, 1st Edition (Book 1)
2. Nonconventional energy resources by G. D. Rai, Khanna publishers-2008 (Book 2)
3. Solar Energy by S. B. Sukhatme-Tata McGraw-Hill Publishing Company Ltd - 1997 (Book 3)

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	2	2	2	1	0	0	0	0	0	0	0	0	0
CO 2	2	2	2	2	1	0	0	0	0	0	0	0	0
CO 3	2	2	2	2	1	0	0	0	0	0	0	0	0

CO 4	2	2	2	1	0	0	0	0	0	0	0	0	0
CO 5	2	2	2	1	0	0	0	0	0	0	0	0	0
CO 6	2	2	1	2	2	1	0	0	0	0	0	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignme nt /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

IMPORTANT: This course is for the Double Major pathway only.

Programme	**B.Sc. Physics Honours**				
Course Title	**SCIENCE COMMUNICATION**				
Type of Course	**Value-Added Course 2**				
Semester	**IV**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	Basic computer operating knowledge.				
Course Summary	This course introduces Latex programming for preparing scientific documents and presentations. This paper also introduces formal science communication, of which presentation and document writing forms a part.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Learn the basic structure of a LaTeX document, creating a new latex document	U	F	Instructor-created exams / Quiz / Practical Assignment
CO2	Understanding how to split a document into logical parts.	U	F	Instructor-created exams / Quiz / Practical Assignment
CO3	Understand text and paragraph formatting in Latex, including insertion of numbered and bulleted lists.	U	F	Instructor-created exams / Quiz / Practical Assignment
CO4	Understand how to insert tables, pictures, table of contents and equations in latex document.	U	F	Instructor-created exams / Quiz / Practical Assignment
CO5	Understand how to prepare a presentation using Latex.	U, Ap	F	Instructor-created exams / Quiz / Practical Assignment
CO6	Acquire the skillset required for formal science communication, including knowledge about journals, presentation skills and time management.	U	C	Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36 +9)	Marks (50)
I		**Document structure and basic commands**	**5**	**7**
	1	Structure of a latex document: preamble, body/document environment. Creating a document by declaring its type: article, report, book, presentation (beamer), letter.	1	
	2	Options for the \documentclass command. The \title, \author, and \date commands. Creating abstract for articles: the abstract environment.	2	
	3	Starting and ending the body of our document: the \begin{document} and \end{document} commands. Splitting our document into segments: \part, \section, \subsection, \subsubsection commands. Creating numbered and non-numbered segments.	1	
	4	Optimizing space between words and sentences - quote-marks, slash marks, text mode superscript and subscript - dashes and hyphens, ellipsis, ready-made strings. font styles: bold, italic and underline text commands.	1	
Sections 5.1 - 5.3.4, 6.1, 6.3, 6.5, 6.7, 6.10, 6.12, 6.13 of Book 1				
II		**Page, text & paragraph formatting**	**9**	**13**
	5	Using Latex packages, two-sided documents, page dimensions, page size, margins, page orientation, margins, page size and rotation of a specific page, page styles, page background, multi-column pages, manual page formatting. (Chapter 16, Book1)	2	
	6	Paragraph formatting: paragraph alignment, paragraph indent and break, line spacing, manual breaks, verbatim text. Changing size of text, input encoding, escape codes. (Chapter 7, Book 1)	3	

	7	Less than (<) and greater than (>) symbols, degree symbol for temperature and math, other symbols in special environments. (Chapter 7, Book 1)	1	
	8	List Structures: itemize, enumerate, description environments. Nested lists, creating horizontal list using tasks package. (Chapter 10, Book 1).	3	
Sections 7.1 - 7.7, 10.1-10.3, 16.1 -16.13 of Book 1				
III		**Inserting pictures and tables, mathematics**	**12**	**15**
	9	Inserting table of contents.	1	
	10	Inserting pictures: The graphicx package, \includegraphics command, options for \includegraphics command: the scale, angle, options, supported image formats for compiling with pdflatex. The figure environment, captions for figures.	2	
	11	Mathematics environments, Symbols, Greek letters, Operators, Powers and indices, Fractions and Binomials, Roots, Sums and integrals, Brackets, braces and delimiters, Matrices and arrays, Adding text to equations, Formatting mathematics symbols, Colour	2	
	12	Plus and minus signs, Controlling horizontal spacing, dots in formulas, Equation numbering, Vertically aligning displayed mathematics, Indented Equations, Page breaks in math environments, Boxed Equations, Advanced formatting, Text in aligned math display, Changing font size.	2	
	13	Tables: The tabular environment, row specification, spanning, controlling table size, colors, width and stretching, table across several pages, partial vertical lines, vertically centred images, footnotes in tables, professional tables, sideways tables.	2	
	14	Presentations in Latex using Beamer: frames, title page, using presentation themes, frame customization, piece-wise presentation of slides, table and figure in presentation (21.1, 21.3.1, 21.4, 21.4.1,	3	

<table>
<tr><td></td><td></td><td>21.5-21.5.6 of chapter 21, 22.1-22.1.4, 22.3 of chapter 22, Book 2). Dividing a Frame Column-Wise, Repeating Slides in Presentation, Numbering slides, Navigation buttons in beamer</td><td></td><td></td></tr>
<tr><td colspan="4">Sections 16.1 - 16.1.4, 21.1, 21.3.1, 21.4, 21.4.1, 21.5 - 21.5.6, 22.1 - 22.1.4, 22.3 - 22.5 of Book 2

Sections 14.1 - 14.12, 17.1 - 17.10, 18.1 - 18.1.1, 27.1 - 27.22, 28.1 - 28.12, 41.1.5 , 41.1.10 of Book 1</td><td></td></tr>
<tr><td rowspan="6">IV</td><td colspan="2">Science communication</td><td>10</td><td rowspan="6">15</td></tr>
<tr><td>15</td><td>Types of Science Communications- Research Publications, Conference Proceedings, Patents, Different Types Journals, The Process of Peer Review.</td><td>1</td></tr>
<tr><td>16</td><td>Quality Factors of a Journal, Subscribed Journals Versus Open Access Journals, Predatory Journals, Open Access to Scientific Knowledge, Popular Science Communication</td><td>2</td></tr>
<tr><td>17</td><td>Parts of a Research Paper: Writing the Introduction Section, Material and Methods, Experimental Methods, Results and Discussion.</td><td>2</td></tr>
<tr><td>18</td><td>Tables, Graphs, Images, Analysis, Justification, Validation, Limitation and Scope, Conclusion, Conflicts of Interest, References, Abstract, Ethics of Scientific Communication, Plagiarism.</td><td>2</td></tr>
<tr><td>19</td><td>Presentation Skills: Effective Oral Presentation, Norms for Preparing Slides and Presenting the Same, Converting a research paper to a presentation, Time Management in a Presentation.</td><td>3</td></tr>
<tr><td colspan="4">Relevant sections from Book 3 and Book 4</td><td></td></tr>
<tr><td rowspan="2">V</td><td colspan="2">Open Ended Module</td><td>9</td><td rowspan="3"></td></tr>
<tr><td colspan="3">Advanced beamer features, Designing of book</td></tr>
<tr><td></td><td colspan="2">Sections from References: Relevant sections from Book 1 and Book 2</td><td></td></tr>
<tr><td colspan="5">Books and References:</td></tr>
</table>

1. Latex, wikibooks. Free download from: https://upload.wikimedia.org/wikipedia/commons/2/2d/LaTeX.pdf (Book 1)
2. LaTeX in 24 Hours: A Practical Guide for Scientific Writing, Dilip Datta, Springer 2017.(Book 2)
3. Effective Science Communication (Second Edition), Sam Illingworth and Grant Allen, IOP
4. Science Communication: A Practical Guide, MIT OpenCourseWare, John Durant and Bina Venkataraman

   https://ocw.mit.edu/courses/sts-034-science-communication-a-practical-guide-fall-2011/pages/lecture-notes/

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	0	1	0	0	0	0	3	3	2	0	3	3	1
CO 2	0	1	0	0	0	0	3	3	2	0	3	3	1
CO 3	0	1	0	0	0	0	3	3	2	0	3	3	1
CO 4	0	1	0	0	0	0	3	3	2	0	3	3	1
CO 5	0	1	0	0	0	0	3	3	2	0	3	3	1
CO 6	0	1	0	0	0	0	3	3	2	0	3	3	1

Correlation Levels:

Level	**Correlation**
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory/ Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

SEC2 consists of 2 hrs. of lecture / tutorial classes and 1 hr. of demonstration/ practical classes per week.

Evaluation: Considering the nature of the SEC2 course, the internal evaluation for the 25 marks, including the 5 marks in the open ended module, will be entirely based on the practical examination and viva.

Programme	**B.Sc. Physics Honours**				
Course Title	**PYTHON FOR DATA ANALYSIS**				
Type of Course	**Skill Enhancement Course 2**				
Semester	**VI**				
Academic Level	**100-199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	2	-	1	45
Pre-requisites	1. Fundamentals of Programming Concepts				
Course Summary	This course explores the fundamental concepts of algorithms, control statements, functions, Numpy arrays, Matplotlib, and Seaborn for data visualization and practical application.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate Python for data analysis, including numerical operations, file handling, control flow, functions, and NumPy arrays.	U	C	Instructor-created exams / Quiz
CO2	Understand and master Pandas functionalities for data manipulation, sorting, handling missing data, statistical analysis, time series operations, and data merging/concatenation techniques in Python.	Ap	P	Instructor-created exams / Home Assignments
CO3	Master the visualisation tools in Pandas and Seaborn libraries using physics data. Draw various plots, interpret findings, and utilise the Seaborn library for advanced visualisation techniques.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Understand the various data file formats and learn to read and handle data files in Jupyter Notebooks, including CSV, XLS, TAB, and DAT formats.	U	C	Instructor-created exams / Home Assignments
CO5	Demonstrate problem-solving skills to solve practical physics problems by creating programs for real data analysis and utilise the different functionalities available in Pandas and Seaborn Python Packages.	Ap	P	One Minute Reflection Writing assignments/Viva Voce
CO 6	Develop skills in data manipulation and analysis using the pandas library, including dataframe creation, data wrangling,	Ap	P	Practical Assignment / Observation of Practical Skills

	descriptive statistics, and visualization techniques using matplotlib and seaborn			
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36 +9)	Marks (50)
I	**Python Core programming**		9	12
	1	Python - variable, operators, data types - numerical - int, float, complex - list - list operations	2	
	2	Tuples - Set - Dictionary, input(), file operations - open() - close()	2	
	3	Conditional & control statements - break & continue	2	
	4	Functions:define functions - Passing Arguments - Return Values Demonstration/ Practical: Write a function that accepts a list of numbers and returns the largest and smallest numbers in the list.	1	
	5	Numpy - Arrays - creation, access, array operations Demonstration/ Practical: Create a 3x3 NumPy array with random integers between 1 and 10. Perform and print the results of basic arithmetic operations (addition, subtraction, multiplication, division) on this array with another 3x3 array.	2	
	Sections from References: 1. Sections of Chapter 3 pages 46 - 62, Chapter 4 pages 73 - 87, Chapter 6 pages 117 - 139, Chapter 7 pages 151 - 174, Chapter 17 pages 441 - 451 of Book 1 2. Sections of Chapter 8 pages 129 - 140 of Book 2 [Topic 4 from this book]			

II	**Pandas Dataframe**		**12**	**15**
	6	Python Dataframe - Create Dataframe	1	
	7	Dataframe attributes - Pivoting dataframe - Sort - Sort by labels	2	
	8	Missing Data - fill, drop and replace missing values - Combining Data Frame - Descriptive statistics - describe() - min and max index values	3	
	9	Statistical values - count and mode function - Covariance - Correlation - Quantles - pipe() - apply()	2	
	10	Aggregation() - Grouping columns - Data wrangling - merging data - concatenating dataframes - Time series data structures Demonstration/ Practical: Example problem showing the operations of pandas dataframe- Illustrate the operations of table read, merge and groupby() in pandas using the data generated by charging three different capacitors using ExpEYES or the raw data of phone sensors using Phyphox/Physics Toolbox Sensor Suite app.	4	
	Sections of Chapter 5.1 - 5.11 of Book 4 https://phyphox.org/sensors/ https://www.vieyrasoftware.net/			
III	**Visualisation Tools**		**10**	**15**
	11	Importance of data Visualisation - Bar chart Demonstration/ Practical: practice the generation of a bar chart using the data generated for three capacitors using ExpEYES or the raw data of phone sensors using Phyphox/Physics Toolbox Sensor Suite app	2	
	12	Histogram - frequency polygon - Box plot - Scatter Plot - markers - xlabel - ylabel - title - different arguments in scatterplot	2	

		Demonstration/ Practical: Illustrate the operations of box plot using the data generated by finding the refractive index of a convex lens by liquid lens arrangement.		
	13	Correlation Matrix Plot - Calculate the correlations - correlation matrix - correlation plot Demonstration/ Practical: Plot the values obtained from sonometer mass versus length*2. Find the correlation matrix for the graph	1	
	14	Seaborn library - features - color palette -univariate distribution plot	1	
	15	Seaborn - Histogram - density plot - Bivariate Distribution plots - hexbin plot - violin plots Demonstration/ Practical: Example plot using the standard data set, Iris (https://archive.ics.uci.edu/dataset/53/iris)	2	
	16	Statistical estimation - bar plot - Plotting categorical data - pair grid - Linear relationships - regplot() and implot() - Heatmap - cmap attribute - bubble chart - time series data plots	1	
	Sections 6.1 - 6.22 of Book 4			
IV	**Data File Formats**		**5**	**8**
	17	Series and Dataframes - Introducing different data file formats: csv, xls, tab, dat formats. Create Dataframe from the above mentioned format.	2	
	18	Viewing Data frame using loc and iloc - Operations on Dataframes	2	
	19	Jupyter Notebooks using Anaconda and Google Colab: introduction - Familiarization with Google Colab and Anaconda	1	
	Sections from References: Chapter 12 - Page 232 - 248 of Book 3 https://colab.google/ https://www.anaconda.com/			
V	**OPEN ENDED MODULE: Additional Training on Data Analysis**		**9**	
	Implement the following:			

	1. Data File Creation and File Operations: ***Example1:*** Write a python program to generate a CSV file using the data generated from Simple Pendulum Experiment as two separate columns as Length and Period using Pandas Dataframe. **2. File Read & Plot Data:** ***Example2***: Write a Python program to read the data generated using example 1 and calculate the mean period for each pendulum length. Use Seaborn to plot a regression line and analyze the relationship between period and length. **3. Pandas merge, group by:** ***Example3***: Use the data generated by verifying Hooke's Law by measuring the relationship between the force applied to a spring and its resulting extension. Also, use different materials to see how Spring Constant changes with material properties. **4. Learn different visualisation tools in Pandas:** Plot Histogram, Barchart, Scatter plot and their functionalities **5. Learn different visualisation tools in Seaborn:** ***Example4***: Using the data generated by example3, draw the linear relationship between the force applied and extension using regplot functions.		
	Sections from References: 1. Example plots can be seen in https://www.geeksforgeeks.org/pandas-built-in-data-visualization-ml/ 2. https://www.datacamp.com/tutorial/types-of-data-plots-and-how-to-create-them-in-python 3. https://www.datacamp.com/tutorial/seaborn-python-tutorial 4. https://www.geeksforgeeks.org/data-visualisation-in-python-using-matplotlib-and-seaborn/		

Books and References:

1. *Core Python Programming* 2nd edition or higher, Dr. R. Nageswara Rao, Dreamtech press, 2020 (Book 1)
2. Python Crash Course - 3rd Edition by Eric Matthes (Book 2)
3. Machine Learning in Data Science using Python by Dr R Nageswara Rao (Book 3)
4. Data Science and Machine Learning using Python by Dr Reema Thareja (Book 4)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	0	2	1	1	1	1	1	1	0
CO 2	2	1	1	0	2	1	1	1	1	1	1	0
CO 3	2	1	1	0	2	1	1	1	1	1	1	0
CO 4	1	1	1	0	2	1	1	1	1	1	1	0
CO 5	2	2	3	1	2	1	1	1	1	1	1	0
CO 6	2	2	1	1	2	1	1	1	1	1	1	0

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments/Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓		✓	

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ELECTRICAL AND PHOTOVOLTAIC DEVICES**				
Type of Course	**Skill Enhancement Course 3**				
Semester	**V**				
Academic Level	**100 – 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	Basics of electromagnetism and electronics.				
Course Summary	This course explores the working of various electrical, photovoltaic and storage devices.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and analyse the working of a DC motor.	U & An	P	Instructor-created exams / Home Assignments
CO2	Identify different electrical elements used in house wiring and demonstrate the working of these elements.	R & Ap	P	Instructor-created exams / Home Assignments

CO3	Explain various conventional and non-conventional power generation techniques and discuss the possibility of using these techniques in your state.	U	P	Instructor-created exams / Home Assignments
CO4	Analyse and determine the basic characteristics of Photovoltaic Cell. Design a model unit.	An & Ap	C	Instructor-created exams / Home Assignments
CO5	Explain the scope of different battery technologies and analyse the technical complexity to design the same.	Ap	P	Seminar Presentation / Group Tutorial Work
CO6	Generate skill to wind motors, wiring a home, develop storage devices.	Ap & C	P	Practical Assignment / Observation of Practical Skills / Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36 +9)	Marks (50)
I		**ELECTRICAL DEVICES**	**10**	**15**
	1	DC motor basics: motor principle, comparison of generator and motor action, significance of the back e.m.f., voltage equation of a motor, condition of maximum power, torque, Armature torque of a motor, shaft torque, Speed of a DC motor, speed regulation, torque and speed of a DC motor.	3	
	2	Working principle of a transformer, transformer construction, core-type transformers, shell type transformers.	1	
	3	Elementary theory of an ideal transformer, E.M.F. equation of a transformer, voltage transformation ratio, Transformer on load.	2	

	4	Magnetic leakage, total approximate and exact voltage drop in a transformer.	2	
	5	Classification of ac motors, induction motor: general principle, construction, squirrel-cage rotor, phase-wound rotor, production of rotating field, three phase supply, mathematical proof, to starting torque, why does the rotor rotate, slip, frequency of rotor current, relation between torque and rotor power factor, starting torque.	2	
	Sections 29.1 – 29.11, 32.1 – 32.7, 32.10, 32.13, 32.16, 32.17, 34.1 – 34.13 of Book 1			
II	**BASICS OF WIRING, CONTROL AND SECURITY SYSTEMS**		**7**	**8**
	6	Different types of wiring, Specifications of wires, types of cables. Basics of wiring-Star and delta connection. Simple wiring schemes.	3	
	7	Fuses, Circuit breakers, earthing.	2	
	8	Ground-fault circuit interrupters, Arc-fault circuit interrupters, Lightning and surge protection	2	
	Sections 11.1 – 11.3, 11.5 of Book 2, sections 5.2, 5.3, 6.7- 6.9, 6.11 – 6.14 of Book 3, Chapter 8, Chapter 9 and Chapter 14 of Book 4			
III	**POWER GENERATION AND PHOTOVOLTAIC TECHNOLOGY**		**10**	**15**
	9	Preference for electricity, comparison of sources of power, sources for generation of electricity, brief aspects of electrical energy systems, Conventional and non-conventional energy sources.	3	
	10	Photovoltaic materials: Introduction, Basic semiconductor physics	2	
	11	A generic photovoltaic cell, a more accurate equivalent circuit for a PV cell.	2	
	12	From cells to modules to arrays.	1	
	13	Crystalline silicon technologies	1	
	14	Thin film photovoltaic	1	

	Sections 24.1 – 24.6 of Book 1, sections 8.1 – 8.4, 8.8,8.9 of Book 5			
IV	**POWER STORAGE**		**9**	**12**
	15	Introduction to energy sources	1	
	16	Battery technology: Lead acid batteries, Nickel metal hydride batteries, Lithium batteries.	2	
	17	Nickel - zinc batteries, zinc-carbon batteries, zinc - air batteries, other battery types.	2	
	18	Voltage characteristics, standard and nomenclature, cell designs	1	
	19	Fuel cell types: types of fuel cells, complementary electrochemistry and thermodynamics of fuel cells, solid oxide fuel cells, intermediate solid oxide fuel cells, proton exchange membrane fuel cells, Aerospace applications.	3	
	Sections 1.1 – 1.8, 4.1 – 4.10 and 8.1 – 8.6 (results in section 8.2 can be used, derivations not needed) of Book 6.			
V	**OPEN ENDED MODULE**		**9**	
	1	Construction of a stepdown transformer a. 0-12 volt out b. 6-0-6 – 2 Amp out **c.** 800-Watt transformer for home ups		
	2	Rewind a household device motor (fan motor/mixer grinder motor/single phase water pump motor)		
	3	Create a miniature circuit including, isolator, rccb, mcb, single way switch and two-way switch.		
	4	Study the characteristics of photovoltaic cell		
	5	Construct a cylindrical capacitor by using aluminium foil and paper as dielectric.		

	6	Construct lead-acid cell.		
	7	Familiarise a battery management system (BMS) for a lithium-ion battery unit.		

Books and References:

1. A textbook of electrical technology by B. L. Thereja and A. K. Thereja, first multicolour edition (Book1)
2. Basic electrical engineering by C. L. Wadhwa, Fourth edition (Book 2)
3. Basic electrical engineering by Dr. K. Uma Rao and Dr. A. Jayalakshmi, revised edition 2014 (Book 3)
4. Wiring a house by Rex Cauldwell, , 4th edition, Publisher: The Taunton Press (Book 4)
5. Renewable and efficient electric power systems by Gilbert M Masters (Book 5)
6. Hydrogen, Batteries and Fuel Cells by Bengt Sunden Chapter1, 4, 8 (Book 6)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	2	2	1	0	0	0	0	0	0	0	0
CO 2	2	1	2	2	1	0	0	0	0	0	0	0	0
CO 3	1	2	2	2	1	0	0	0	0	0	0	0	0
CO 4	2	1	1	2	2	1	0	0	0	0	0	0	0
CO 5	2	2	2	1	1	0	0	0	0	0	0	0	0
CO 6	2	1	2	2	1	0	0	0	0	0	0	0	0

Correlation Levels:

Level	Correlation
0	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

MODEL QUESTION PAPERS

MAJOR CORE COURSES

Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY1CJ101: Fundamentals of Physics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. If the two ends of a rope in equilibrium are pulled with forces of equal magnitude and opposite directions, why isn't the total tension in the rope zero?

2. When a car is hit from behind, the occupants may experience whiplash. Use Newton's laws of motion to explain what causes this result.

3. You drive a car up a steep hill at constant speed. Discuss all of the forces that act on the car. What pushes it up the hill?

4. A block rests on an inclined plane with enough friction to prevent it from sliding down. To start the block moving, is it easier to push it up the plane or down the plane? Why?

5. A rope tied to a body is pulled, causing the body to accelerate. But according to Newton's third law, the body pulls back on the rope with a force of equal magnitude and opposite direction. Is the total work done then zero? If so, how can the body's kinetic energy change? Explain.

6. Can the *total* work done on an object during a displacement be negative? Explain. If the total work is negative, can its magnitude be larger than the initial kinetic energy of the object?

7. If work W is required to stretch a spring a distance x from its unstretched length, what work (in terms of W) is required to stretch the spring an ***additional*** distance x?

8. A projectile has the same initial kinetic energy no matter what the angle of projection. Why doesn't it rise to the same maximum height in each case?

9. Is it possible for a friction force to increase the mechanical energy of a system? If so, give examples.

10. A particle is in neutral equilibrium if the net force on it is zero and remains zero if the particle is displaced slightly in any direction. Sketch the potential energy function near a point of neutral equilibrium for the case of one dimensional motion.

Section B

[Answer All. Each question carries 6 marks] *(Ceiling: 36 Marks)*

11. After an annual checkup, you leave your physician's office, where you weighed 683 N. You then get into an elevator that, conveniently, has a scale. Find the magnitude and direction of the elevator's acceleration if the scale reads (a) 725 N and (b) 595 N.

12. A mysterious rocket-propelled object of mass 45.0 kg is initially at rest in the middle of the horizontal, frictionless surface of an ice-covered lake. Then a force directed east and with magnitude $F(t) = (16.8\ \text{N/s})t$ is applied. How far does the object travel in the first 5.00 s after the force is applied?

13. 75.0-kg wrecking ball hangs from a uniform, heavy-duty chain of mass 26.0 kg. (a) Find the maximum and minimum tensions in the chain. (b) What is the tension at a point three-fourths of the way up from the bottom of the chain?

14. A 5.00-kg crate is suspended from the end of a short vertical rope of negligible mass. An upward force $F(t)$ is applied to the end of the rope, and the height of the crate above its initial position is given by $y(t) = (2.80\ \text{m/s}\ t\,) + (0.610\ \text{m/s}^3)t^3$

What is the magnitude of F when $t = 4.00$ s?

15. Using a cable with a tension of 1350 N, a tow truck pulls a car 5.00 km along a horizontal roadway. (a) How much work does the cable do on the car if it pulls horizontally? If it pulls at 35^0 above the horizontal? (b) How much work does the cable do on the tow truck in both cases of part (a)? (c) How much work does gravity do on the car in part (a)?

16. A physics student spends part of her day walking between classes or for recreation, during which time she expends energy at an average rate of 280 W. The remainder of the day she is sitting in class, studying, or resting; during these activities, she expends energy at an average rate of 100 W. If she expends a total of $1.1 * 10^7$ J of energy in a 24-hour day, how much of the day did she spend walking?

17. In one day, a 75kg mountain climber ascends from the 1500m level on a vertical cliff to the top at 2400 m. The next day, she descends from the top to the base of the cliff, which is at an elevation of 1350 m. What is her change in gravitational potential energy (a) on the first day and (b) on the second day?

18. An ideal spring of negligible mass is 12.00 cm long when nothing is attached to it. When you hang a 3.15-kg weight from it, you measure its length to be 13.40 cm. If you wanted to store 10.0 J of potential energy in this spring, what would be its total length?

Section C

(Answer any one. Each question carries 10 marks]   (1x10=10 marks)

19. Explain the derivation and implications of the Work – Energy theorem in mechanics, and analyze its concept, mathematical formulation and practical utility in solving mechanical problems.

20. Discuss the relationship between elastic potential energy and gravitational potential energy in systems involving springs and vertical motion. Provide examples to illustrate how these two forms of potential energy interplay in real-world scenarios. Additionally, analyze how changes in the displacement or height affect the total potential energy stored in such systems and the subsequent impact on the motion of objects.

II Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY2CJ101: Electronics I

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Give the mechanism of hole current flow in a semiconductor

2. Discuss the effect of temperature on semiconductors.

3. How does LED differ from an ordinary diode ?

4. How does photo-diode work ?

5 Discuss the importance of peak inverse voltage in rectifier service

6. What is a zener diode ? Draw the equivalent circuit of an ideal zener in the breakdown region.

7. Describe a half-wave rectifier using a crystal diode.

8. Describe the transistor action in detail

9. Write a short note on analog and digital signals.

10. How will you make decimal to binary conversion ?

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. Write short notes on the following:

(i) Breakdown voltage

(ii) Knee voltage

(iii) Limitations in the operating conditions of pn junction

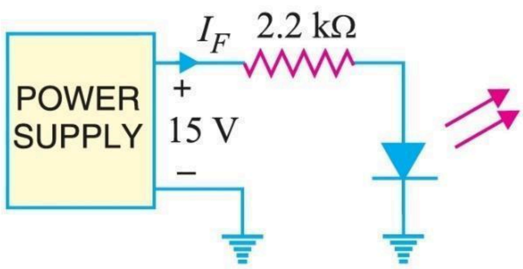
12. Describe the action of the following filter circuits : (i) capacitor filter (ii) choke input filter (iii) capacitor input filter

13. In a transistor, I_B = 68 μA, I_E = 30 mA and β = 440. Find the value of α. Hence determine the value of I_C.

14. A full-wave rectifier uses two diodes, the internal resistance of each diode may be assumed constant at 20 Ω. The transformer r.m.s. secondary voltage from centre tap to each end of secondary is 50 V and load resistance is 980 Ω. Find :

(i) the mean load current (ii) the r.m.s. value of load current

15. What is current through the LED in the circuit shown in Fig. ? Assume that voltage drop across the LED is 2 V



16. A half-wave rectifier is used to supply 50V d.c. to a resistive load of 800 Ω. The diode has a resistance of 25 Ω. Calculate a.c. voltage required.

17. Convert the following decimal numbers in to binary i) 17.85 2) 0.984

18. What is the decimal number for 10000111000 BCD ?

Section C

[Answer any one. Each question carries 10 marks] **(1x10=10 marks)**

19. Describe the principle and working of a full wave rectifier and derive the expressions for its efficiency and ripple factor .

20. Describe voltage divider biasing in detail. Explain how stability is achieved in this method.

III Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY3CJ201: Mechanics I

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Suppose you catch a baseball and then someone invites you to catch a bowling ball with either the same momentum or the same kinetic energy as the baseball. Which would you choose? Explain.

2. At the highest point in its parabolic trajectory, a shell explodes into two fragments. Is it possible for both fragments to fall straight down after the explosion? Why or why not?

3. What is the difference between tangential and radial acceleration for a point on a rotating body?

4. To maximize the moment of inertia of a flywheel while minimizing its weight, what shape and distribution of mass should it have? Explain.

5. When calculating the moment of inertia of an object, can we treat all its mass as if it were concentrated at the centre of mass of the object? Justify your answer.

6. The work done is the product of force and distance. The torque due to a force is the product of force and distance. Does this mean that torque and work are equivalent? Explain.

7. A student is sitting on a frictionless rotating stool with her arms outstretched as she holds equal heavy weights in each hand. If she suddenly lets go of the weights, will her angular speed increase, stay the same, or decrease? Explain

8. State Newton's law of universal gravitation

9.Explain why objects experience weightlessness in free fall.

10. Write the equations of Poisson and Laplace of gravitation.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. a) What is the magnitude of the momentum of a 10,000-kg truck whose speed is 12.0 m/s? (b) What speed would a 2000-kg SUV have to attain in order to have (i) the same momentum? (ii) the same kinetic energy?

12. A 68.5-kg astronaut is doing a repair in space on the orbiting space station. She throws a 2.25-kg tool away from her at 3.20 m/s relative to the space station. With what speed and in

what direction will she begin to move?

13. An airplane propeller is rotating at 1900 rev/min. (a) Compute the propeller's angular velocity in rad/s. (b) How many seconds does it take for the propeller to turn through 35^0?

14. Small blocks, each with mass *m*, are clamped at the ends and at the center of a rod of length *L* and negligible mass. Compute the moment of inertia of the system about an axis perpendicular to the rod and passing through (a) the centre of the rod and (b) a point one-fourth of the length from one end.

15. A 2kg textbook rests on a horizontal surface. A cord attached to the book passes over a pulley whose diameter is 0.150 m, to a hanging book with mass 3 kg. The system is released from rest, and the books are observed to move 1.20 m in 0.8s. (a) What is the tension in each part of the cord? (b) What is the moment of inertia of the pulley about its rotation axis?

16. An engine delivers 175 hp to an aircraft propeller at 2400 rev/min. (a) How much torque does the aircraft engine provide? (b) How much work does the engine do in one revolution

of the propeller?

17. determine the gravitational potential at a point outside a spherical shell of mass M and radius a.

18. A neutron star has mass of 10^{30} Kg and a radius of 5 km. A body dropped from a height of 20 cm above the surface. Determine the speed of the body when it hits the surface.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10marks)

19. Discuss the principle of momentum conservation and how does it apply in collisions.

20.Discuss the concept of torque and its significance in rotational motion. Provide examples of how torque affects the motion of the object and how change in torque impact rotational dynamics.

III Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY3CJ202: Computational Physics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A *[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)*

1. Write an algorithm to check whether the given number is prime or not.

2. Develop an algorithm for verifying the PIN number in the ATM counter.

3. Give the python code for plotting sin(x) and cos(x) as two subplots.

4. Define a list a= [4,8,2] and then using list operations modify the list as [9,8,4,2,1]

5. 1. Write the output of the following code

```
s = 0
for i in range(3,11,2):
        s = s+i
        if i= =7: continue
        print (s)
```

6. What is the difference between the operations a.append(x) and a.insert(i,x)?

7. What is the advantage of Numerov's method?

8. What are the different types of errors involved while implementing numerical methods in computers?

9. Why is Simpson's rule not accurate for an odd number of subintervals?

10. Why is the Runge-Kutta method more accurate than the Euler method?

Section B

[Answer All. Each question carries 6 marks] ***(Ceiling: 36 Marks)***

11. Develop an algorithm for generating the Fibonacci series.

12. Discuss the different ways to create Numpy arrays.

13. Using Newton Raphson method find $\sqrt{7}$. Take the initial guess as 1 and do it for 4 iterations.

14. Estimate Cos(50) using Taylor series with 4 terms.

15. Solve dy/dx=$3x^2$+1 using Euler method with initial condition y(x=1) =2. Solve it for x=2 with step size of 0.25

16. From the following table estimate the area bounded by the curve and x-axis from x=0 to x=1

x	0	0.2	0.4	0.6	0.8	1.0
y	2.00	2.04	2.16	2.36	2.64	3.00

17. Discuss the Monte-Carlo method of finding the value of Pi. Develop a python code for it.

18. Obtain the equations for the 2nd order Runge-Kutta method of solving differential equations.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

19. Starting from the general formula, obtain Simpsons 1/3 rule for numerical integration. Write a python code for the numerical integration of a known function.

20. Discuss different flow controls in Python with syntaxes and examples.

IV Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY4CJ203: Electrodynamics I

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Explain the difference between conductors and insulators in terms of their behavior in an electric field.

2. Discuss the concept of electric flux and its significance in Gauss's law.

3. Describe the magnetic field pattern around a straight current-carrying conductor according to Ampère's law.

4. Describe the magnetic field produced by a current-carrying loop of wire at its center.

5. Describe the process of finding the Thevenin equivalent voltage of a circuit.

6. Explain the practical applications of Norton's theorems in simplifying complex circuits.

7. Describe the use of a potentiometer in measuring emf of a cell. Explain how potentiometers are used in calibration and adjustment of electronic circuits.

8. Define a tabletop galvanometer and explain its principle of operation.

9. State Biot-Savart law in vector form and explain the meaning of each term.

10. Define magnetic vector potential and explain its physical significance.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Describe the vector calculus operations commonly used in electromagnetism, such as the gradient, divergence, and curl. Explain their physical significance and how they are applied in describing electric and magnetic fields.

12. Discuss the significance of line, surface, and volume integrals in Gauss's law, Ampère's law, and Faraday's law, respectively. Provide an example illustrating the calculation of a line integral for a given vector field.

13. Explain Gauss's law and its application in finding the electric field due to a uniformly charged sphere. A solid conducting sphere of radius 10 cm10cm carries a charge of +2 μC+2μC. Calculate the electric field at a point 5 cm5cm away from the center of the sphere.

14. Define electric potential energy and derive the expression for the electric potential energy of a system of two point charges. If two charges +2 μC+2μC and −3 μC−3μC are placed 10 cm apart in a vacuum, calculate the electric potential energy of the system.

15. Describe the Biot-Savart law and its significance in magnetostatics. Use the law to derive an expression for the magnetic field produced by an infinitely long straight current-carrying wire at a distance r from the wire.

16. Explain Ampère's circuital law and its application in calculating magnetic fields around current-carrying conductors. Use Ampère's law to determine the magnetic field inside and outside a solenoid carrying a steady current I per unit length.

17. Define a moving coil ballistic galvanometer (MCBG) and explain its principle of operation. How does a MCBG differ from a regular moving coil galvanometer in terms of design and functionality?

18. Discuss the advantages of star and delta connections in three-phase systems. b. Provide examples of practical applications where each type of connection is preferred.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10marks)

19. Derive the expression for potential at a point due to uniformly charged spherical shell.

20. Calculate the magnetic field (**B**) at a point Q located on the z-axis at a distance d above the current-carrying wire segment.. Determine the magnetic flux (ΦB) passing through a circular loop of radius r centered at the origin and lying in the xy-plane.

IV Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY4CJ204: Mechanics II

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Describe Kepler's equation and its role in determining the position of a planet along its elliptical orbit.

2. Describe Kepler's second law and its significance in understanding the equal area law of planetary motion.

3. Define the concepts of springs and pendulums in the context of oscillatory motion and briefly discuss their applications in physics.

4. Differentiate between underdamped, overdamped, and critically damped harmonic oscillators, discussing their respective behaviors.

5. Define the quality factor (Q factor) of a harmonic oscillator and discuss its significance in characterizing the sharpness of resonance and damping in the system.

6. Define the concept of a wave in a stretched string and discuss the factors that determine the speed of propagation of such waves..

7. Differentiate between standing waves and traveling waves, discussing their respective characteristics and behaviors in a medium such as a stretched string.

8. Define a linearly accelerating reference frame and discuss how objects behave within such a frame relative to an inertial frame.

9. Define fictitious forces and discuss their appearance in non-inertial reference frames, contrasting them with real forces.

10. Describe the Coriolis force and its effect on a falling body or a projectile in a rotating reference frame.

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. a) Given an eccentricity e of 0.2 for a planet's orbit, determine whether the orbit is elliptical, parabolic, or hyperbolic.

b) Given the orbital period of a planet as 1.88 years, determine the semi-major axis of its orbit in astronomical units (AU).

12. Consider a mass-spring system with a mass m=0.2kg attached to a spring with spring constant k=100N/m. The system is set into simple harmonic motion with an amplitude of A=0.1m.a) Determine the Period of Oscillation b) Find the Maximum Velocity and Acceleration

13. Define Fourier series and explain its significance in representing periodic functions as infinite sums of sine and cosine functions.

14 Explain the concept of energy in the context of waves traveling along a stretched string and discuss how energy is transferred and conserved in such systems..

15. A 2kg textbook rests on a horizontal surface. A cord attached to the book passes over a pulley whose diameter is 0.150 m, to a hanging book with mass 3 kg. The system is released from rest, and the books are observed to move 1.20 m in 0.8s. (a) What is the tension in each part of the cord? (b) What is the moment of inertia of the pulley about its rotation axis?

16. Consider an observer in a rocket accelerating at 9.8m/s in deep space. Calculate the apparent weight of an object with a mass of 2kg when placed on a scale inside the rocket. Discuss how this apparent weight differs from the object's actual weight and its implications for the observer.

17. A cannon is fired due north from the equator with a velocity of 200m/s. Calculate the deflection in the projectile's path due to the Coriolis force. Discuss how this deflection changes with the latitude of the firing location.

18. Discuss the Foucault pendulum experiment and explain how it demonstrates the rotation of the Earth.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10marks)

19. Derive Kepler's First Law of Planetary Motion, showcasing the mathematical formulation that describes the elliptical orbits of planets around the Sun.

20.Discuss the motion of a damped harmonic oscillator, including the damping term, and discuss the implications of damping on the solution of the equation.

IV Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY4CJ205: Modern Physics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. What do Galilean Transformation and Galilean invariance principle mean?

2. Explain the phenomenon of time dilation

3. State the postulates of special theory of relativity.

4. Explain the term Ultraviolet catastrophe

5. Give Einstein's explanation of photoelectric effect.

6. State and explain Heisenberg uncertainty principle

7. Distinguish between phase velocity and group velocity

8. List the assumptions made in deriving the Bohr theory

9. Explain with example the term correspondence principle

10. Explain the statistical interpretation of uncertainty principle .

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. A rod has length 100 cm when the rod is in a satellite moving with velocity 0.8 C relative to the laboratory. What

is the length of the rod as determined by an observer in the laboratory?

12. The stopping potential for photoelectrons emitted from a surface illuminated by light of wavelength 5000Å is 0.70 volt. When the incident wavelength is changed, the stopping potential is found to be 1.50 volt . What is the new wavelength?

13. A 300 keV photon undergoes a Compton scattering. The kinetic energy of recoil electron is 250 keV. Calculate the wavelength of the scattered photon.

14. Describe Davisson-Germer experiment and interpret its results.

15. Find the de Broglie wavelength of (i) electron moving with velocity 1000 m/s (ii) an object of mass 100 gram moving with the same velocity.

16. The position and momentum of 1 keV electrons are measured simultaneously. If its position is located within 1Å, what is the percentage uncertainty in its momentum? Is this consistent with the binding energy of electrons in atoms?

17. How Frank Hertz experiment showed a electron must have a certain minimum energy

18. Find the shortest and longest wavelength of |Lyman series of singly ionised helium atom.

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. Derive Lorentz transformation equations.

20. What is Compton's effect? Derive an expression for Compton's shift. Discuss the dependence of Compton's shift on the angle of scattering. Explain the existence of unmodified radiation in the scattered radiation.

V Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY5CJ301: Electrodynamics II

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Discuss the difference between electric fields in vacuum and electric fields in matter.

2. Define permittivity (ε) and conductivity (σ) of materials. Discuss the relationship between permittivity, conductivity, and the behavior of electric fields in matter.

3. Describe the concept of energy storage in electric fields within dielectric materials.

4. Discuss the factors that influence the amount of energy stored in magnetic fields in matter.

5. State and explain Faraday's law in electromagnetic induction

6. Discuss how the behavior of magnetic fields differs from that of electric fields within materials.

7. Write down the importance of displacement current in Maxwell's equation

8. Define Poynting vector and give an expression for it.

9. Give an expression for the instantaneous current in series CR circuit.

10. Draw the basic circuit of an AC bridge and write down the balancing condition for it.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. A 200 turn coil with a cross.sectional area of 9 cm^2 is removed in perpendicular direction frorn a field of 4 T magnetic field in 0.125 s. What is the emf induced in the coil ?

12. The time averaged magnitude of the Poy:nting vector of sun's electromagnetic radiation received at the upper surface of the earth's atmosphere, (s) = 1.35 x 10^3 W/m^2. Assuming that the waves are plane sinusoidal, what are the magnitudes of the electric and magnetic fields

13. If the charge on a capacitor of capacitance 2 microfarad in leaking through a high resistance of 100 mega ohms is reduced to half its maximum value, calculate the time of leakage.

14. Describe the boundary conditions for electric and magnetic fields at material interfaces. Explain how to apply boundary conditions in practice using the continuity of electric and magnetic fields.

15. A fully charged condenser of capacity 1 pF is discharged through a resistance of 2 megaohm 1) calculate the time taken by charge to fall 36.87 percentage of its initial value ; and (2) How long will it take for the charge to fall to half of its initial value.

16. Discuss the magnetization of materials and its effect on magnetic fields.

17. Write down the expression for energy density and momentum density of an electromagnetic wave .

18. State and prove Poynting's theorem.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10marks)

19. Obtain the expression for resultant emf, impedance and power factor of an LCR series circuit . Explain resonance in series LCR circuit.

20. Derive Maxwell's equations inside a polarized matter.

V Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY5CJ302: Optics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Monochromatic coherent light passing through two thin slits is viewed on a distant screen. Are the bright fringes equally spaced on the screen? If so, why? If not, which ones are closest to being equally spaced?

2. A glass windowpane with a thin film of water on it reflects less than when it is perfectly dry. Why?

3. Discuss the principle of Lloyd's mirror experiment and how it demonstrates interference.

4. Describe Michelson's interferometer and explain how it can be used to measure small displacements.

5. Explain how the colors are produced in soap bubbles using the concept of interference.

6. Discuss the concept of the Fraunhofer diffraction pattern and its dependence on slit width.

7. Discuss the concept of the Fresnel zones and their significance in Fresnel diffraction.

8. Describe Brewster's law and discuss its significance in understanding polarization by reflection.

9. Explain the phenomenon of double refraction in birefringent materials.

10. Explain the concept of circular polarization. How can circularly polarized light be produced?

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. An experiment is conducted in which a monochromatic light source of wavelength 500 nm is used to illuminate a double-slit setup. The distance between the slits is 0.1 mm, and the screen is placed 1 m away from the slits. Calculate the distance between adjacent bright fringes on the screen.

12. A single slit of width 0.1 mm is illuminated by monochromatic light of wavelength 600 nm. If the screen is placed 2 m away from the slit, calculate the angular width of the central maximum on the screen.

13. Determine the focal length of a Fresnel zone plate designed to focus light with a wavelength of 550 nm. The zone plate has 15 zones and a diameter of 8 cm, and it is placed at 1.5 meters from the light source.

14. A wave plate with a thickness of 1 mm is placed in the path of light traveling in air. If the refractive index of the wave plate material is 1.5, calculate the optical path difference introduced by the wave plate for light with a wavelength of 600 nm.

15. In a drift tube portion of a linear accelerator, protons are accelerated from 0.75 MeV to 100 MeV. AC voltage applied has a frequency of 200 MHz. Find the length of the first and last drift tubes.

16. Unpolarized light of intensity 10 W/m^2 is incident on a Polaroid sheet. If the intensity of the transmitted light is reduced to 5 W/m^2, calculate the angle between the transmission axis of the Polaroid and the initial direction of polarization of light.

17. The diameter of the 5th bright ring in Newton's rings is measured to be 2.0 mm. If the radius of the plano-convex lens is known to be 1.5 meters, determine the radius of curvature of the lens surface.

18. What are the different methods for the production of plane polarized light. Explain ?

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

19. Discuss the interference by a plane parallel film when illuminated by a plane wave and obtain the conditions for maxima and minima

20. Derive the expression for the intensity distribution in Fraunhofer diffraction due to a single slit.

V Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY5CJ303: Quantum Mechanics I

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Explain the significance of the Schrödinger equation in quantum mechanics and briefly outline its mathematical form.

2. What does it mean for a wavefunction to be normalized? Explain the normalization condition mathematically and its significance in quantum mechanics

3. Discuss the relationship between momentum and wavelength in quantum mechanics, highlighting any fundamental differences from classical mechanics.

4. Define the concept of a stationary state in quantum mechanics and explain its significance in terms of the time-independent Schrödinger equation.

5. Define probability amplitudes in the context of quantum mechanics and explain their significance in determining the probability of finding a particle in a particular state..

6. Define what constitutes a linear vector space in the context of quantum mechanics and provide an example.

7. Define the dimension of a vector space and explain the role of basis vectors in representing arbitrary vectors within the space.

8. Define square-integrable functions and explain their importance as wave functions representing physical states of quantum systems.

9. State the expression for the energy eigenvalues of a one-dimensional harmonic oscillator and briefly explain their quantization.

10. Calculate the expectation value of the momentum operator for the ground state of the harmonic oscillator.

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. If quantum mechanics replaces the language of Newtonian mechanics, why don't we have to use wave functions to describe the motion of macroscopic bodies such as baseballs and cars?

12. For the particle in a box, we chose k = nπ/L with n = 1, 2, 3, … to fit the boundary condition that φ = 0 at x = L. However, n = 0, -1, -2, -3, c also satisfies that boundary condition. Why didn't we also choose those values of n?

13. An electron is moving as a free particle in the -x- direction with momentum that has magnitude 4.50 * 10-24 kg m/s. What is the one-dimensional time dependent wave function of the electron?

14. Consider a wave function given by φ(x) = A sin kx, where k = 2π/λ and A is a real constant. (a) For what values of x is there the highest probability of finding the particle described by this wave function? Explain. (b) For which values of x is the probability zero? Explain.

15. Find the width L of a one- dimensional box for which the ground state energy of an electron in the box equals the absolute value of the ground state of a hydrogen atom.

16. An electron in a one -dimensional box has ground state energy 2.00 eV. What is the wavelength of the photon absorbed when the electron makes a transition to the second excited state?

17. A wooden block with mass 0.250 kg is oscillating on the end of a spring that has force constant 110 N/m. Calculate the ground level energy and the energy separation between adjacent levels. Express your results in joules and in electron volts. Are quantum effects important?

18. The ground state energy of a harmonic oscillator is 5.60 eV. If the oscillator undergoes a transition from its n = 3 to n = 2 level by emitting a photon, what is the wavelength of the photon?

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. Explain how a particle encounters and interacts with a potential barrier, leading to tunneling behavior.

20. Discuss the significance of the quantum harmonic oscillator as a fundamental model in quantum mechanics.

VI Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY6CJ304:Thermodynamics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Discuss the relationship between heat, work, and internal energy in the First Law of Thermodynamics.

2. In an adiabatic process for an ideal gas, the pressure decreases. In this process does the internal energy of the gas increase or decrease? Explain

3. Explain the Kelvin-Planck statement of the Second Law of Thermodynamics.

4. Discuss the concept of reversible and irreversible processes.

5. Is it a violation of the second law of thermodynamics to convert mechanical energy completely into heat? To convert heat completely into work? Explain your answers.

6. Define entropy and its significance in thermodynamics.

7. Define thermodynamic potentials and their role in describing the equilibrium state of a thermodynamic system.

8. Describe the enthalpy as a thermodynamic potential and its application in constant pressure processes.

9. A piece of aluminum foil used to wrap a potato for baking in a hot oven can usually be handled safely within a few seconds after the potato is removed from the oven. The same is not true of the potato, however! Give two reasons for this difference.

10. Define magnetic vector potential and explain its physical significance.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. One mole of ideal monatomic gas is confined in a cylinder by a piston and is maintained at a constant temperature T0 by thermal contact with a heat reservoir. The

gas slowly expands from V1 to V2 while being held at the same temperature 0. Why does the internal energy of the gas not change? Calculate the work done by the gas and the heat flow into the gas..

12. Assuming $U = C_V T$ for an ideal gas, find (i) the internal energy per unit mass and (ii) the internal energy per unit volume.

13. State and prove Carnot's theorem

14. What is the maximum possible efficiency of an engine operating between two thermal reservoirs, one at 100°C and the other at 0°C?

15. A 10Ω resistor is held at a temperature of 300 K. A current of 5A is passed through the resistor for 2 minutes. Ignoring changes in the source of the current, what is the change of entropy in (a) the resistor and (b) the Universe?

16. Show that another expression for the entropy per mole of an ideal gas is

$S = Cp \ln T - R \ln p + \text{constant}.$

17. A camper pours 0.300 kg of coffee, initially in a pot at 70.^{0}C, into a 0.120-kg aluminum cup initially at 20.^{0}C. What is the equilibrium temperature? Assume that coffee has the same specific heat as water and that no heat is exchanged with the surroundings.

18. An ideal Carnot engine operates between 500-C and 100-C with a heat input of 250 J per cycle. (a) How much heat is delivered to the cold reservoir in each cycle? (b) What minimum number of cycles is necessary for the engine to lift a 500-kg rock through a height of 100 m?

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

19. Describe the Carnot cycle and its importance in understanding the maximum efficiency of heat engines. Discuss the factors that limit the efficiency of real-world heat engines compared to the ideal Carnot engine.

20. Explain the concept of thermodynamic potentials and derive Maxwell's thermodynamic relations.

VI Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY6CJ305: Electronics II

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. What do you understand by d.c. and a.c. load lines ?

2. Show that the output voltage of a single stage common emitter transistor amplifier is 180º out of phase with the input voltage.

3. Explain the following terms : (i) Frequency response (ii) Decibel gain (iii) Bandwidth

4. What do you understand by feedback ? Why is negative feedback applied in high gain amplifiers ?

5. What is an oscillator? What is its need? Discuss the advantages of oscillators

6. Explain the construction and working of a JFET

7. Write short notes on the difference between MOSFET and JFET

8. What do you mean by CMRR?

9. Discuss the operation of OP-amp differentiator.

10. What is the importance of De Morgan's theorems in Boolean Algebra ?

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. Draw the circuit of a practical single stage transistor amplifier. Explain the function of each component.

12 A standard CE amplifier has the following values: VCC = 30V, R1 = 51 kΩ, R2 = 5.1 kΩ, RC = 5.1 kΩ, RE = 910Ω and β = 250. Determine the voltage gain of the amplifier.

13. The overall gain of a multistage amplifier is 140. When negative voltage feedback is applied, the gain is reduced to 17.5. Find the fraction of the output that is feedback to the

input.

14. A 1 mH inductor is available. Choose the capacitor values in a Colpitts oscillator so that f = 1 MHz and mv = 0.25.

15. A JFET has a drain current of 5 mA. If IDSS = 10 mA and VGS(off) is − 6 V, find the value of (i) V_{GS} and (ii) V_P.

16. Two voltages of + 0.6V and – 1.4 V are applied to the two input resistors of

a summing amplifier. The respective input resistors are 400 kΩ and 100 kΩ and feedback resistor is 200 kΩ. Determine the output voltage

17. How will you obtain Basic gates from NAND gate ?

18. Explain R S and J K flip flops.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

19. Explain transistor RC coupled amplifier with special reference to frequency response, advantages, disadvantages and applications.

20. Explain with neat diagrams the working of i) Inverting amplifier ii) non invering amplifier iii) Opamp Integrator

VI Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY6CJ306: Nuclear and Particle Physics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. What are the main features of nuclear forces?

2. Explain the terms: mass defect, binding energy and amu. Discuss how binding energy varies with A.

3. State assumptions of liquid drop model.

4. What are magic numbers? What is their significance?

5How are atomic number and mass number changes during Alpha, Beta and

Gama decays?

6. What is Geiger–Nuttal law?

7. Define half-life of a radioactive material. Find the relation between half-life and disintegration constant.

8. Why are particle accelerators required?

9. Why cannot electrons be accelerated in cyclotron

10. Explain the phenomenon of quenching in GM counter.

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. The binding energy of ${}_{10}Ne^{20}$ is 160.64 MeV. Find its atomic mass. Given m_p = 1.007825 amu and m_n = 1.008665 amu.

12. Derive the Coulomb energy term of semiempirical mass formula.

13. Find the kinetic energy required by a proton to penetrate Coulomb barrier of a hydrogen nucleus.

14. A sample of carbon from an ancient wooden boat piece gives 5 count/min/g of carbon due to ^{14}C present in it. If freshly cut wooden piece gives 16 count/min, what is the age of the boat? Half-life of ^{14}C = 5760 years.

15. In a drift tube portion of a linear accelerator, protons are accelerated from 0.75 MeV to 100 MeV. AC voltage applied has a frequency of 200 MHz. Find the length of the first and last drift tubes.

16. A cyclotron in which flux density of 1.4 tesla is used to accelerate protons, what should be the frequency of alternating field applied to dees?

17. Discuss the construction, theory and working of a linear accelerator.

18. Calculate the electric field at the surface of the wire of a GM counter. The radius of the wire is 0.1 mm and the inner radius of the outer cylinder is 2 cm. The potential applied between the two electrodes is 2000 volts.

Section C

[Answer any one. Each question carries 10 marks]
(1x10=10 marks)

19. What are gas-filled, ionization-based nuclear detectors? Discuss the curve between pulse height and applied voltage for a gas-filled counter serving as (i) an ionization chamber. (ii) a proportional counter.

20. Discuss the principle, construction, working and theory of a cyclotron. Derive an expression for the maximum kinetic energy achieved by a particle of mass m in terms of applied magnetic field and dee radius. Discuss its limitations.

VII Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY7CJ401: Mathematical Physics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Explain the concept of linear dependence among vectors in a vector space.

2. What is meant by a singular point of a differential equation..

3. Explain the concept of the metric tensor and its role in measuring distances in curved spaces.

4. Show that the matrix $Cos\theta\ Sin\theta\ \ -\ Sin\theta\ Cos\theta$. Is an orthogonal matrix.

5. Write down the expression for gradient and divergence in spherical polar coordinates .

6. Define what constitutes a linear vector space in the context of quantum mechanics and provide an example.

7. What are Hermitian and Unitary matrices .

8. Evaluate $\int_{-\propto}^{+\propto} e^{-x^2} x\, dx$

9. Find the Laplace transform of f(t) = t.

10. Define Dirac delta function . State one situation where its find application

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. In spherical coordinates, compute the components of the metric tensor g_{ij} for the sphere of radius r. Calculate the line element ds^2 in cylindrical coordinates.

12. Perform the tensor product of a non-Cartesian tensor $\mathbf{A_{ij}}$ and a Cartesian tensor $\mathbf{B_{kl}}$

13. Explain Gram-Schmitz orthogonalization process.

14. Solve simple harmonic problem by applying Laplace transform.

15. Show that $P'_n(1) = \frac{n(n+1)}{2}$

16. Derive the recurrence relation of Gamma function

17. Show that $L_{n+1}(x) = 2L_n(x) - L_{n-1}(x)$

18. Find the Fourier series of the function $f(x) = x^2, \quad -\pi \leq x \leq \pi$

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. Diagonalize the matrix A by a similarity transformation

$A = 1\ 1\ 0\ 1\ 0\ 1\ 0\ 1\ 1$.

20. Establish the orthogonality of Legendre polynomial.

VII Semester B.Sc. (FYUGP) Degree Examinations October 2028

PHY7CJ402: Classical Mechanics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Explain the significance of Euler's equations. Discuss one physical interpretation of each term in the equation.

2. Define Hamilton's Principle and explain its significance in classical mechanics. Describe the mathematical statement of Hamilton's Principle and discuss how it can be used to derive the equations of motion for a mechanical system.

3. Define generalized coordinates and explain their role in Lagrangian mechanics. Provide an example of a mechanical system and explain how generalized coordinates can be chosen to describe the system's configuration space..

4. Explain the concept of canonical equations of motion in classical mechanics.

5. Discuss the implications of Liouville's theorem for the conservation of phase space volume and the behavior of dynamical systems.

6. Define what constitutes a linear vector space in the context of quantum mechanics and provide an example.

7. Describe phase space and its significance in classical mechanics.

8. Define two coupled harmonic oscillators and explain how they interact with each other

9. Discuss how normal coordinates simplify the analysis of systems with multiple degrees of freedom and provide an example demonstrating the use of normal coordinates in solving coupled oscillator problems.

10. Describe the behavior of a loaded spring system. Discuss how the presence of additional masses or springs affects the dynamics of the system

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. Discuss the conservation theorems associated with Lagrangian dynamics. Explain how each conservation theorem (e.g., conservation of energy, momentum, or angular momentum) arises from the symmetries of the Lagrangian function. Provide a brief mathematical justification for one of the conservation theorems.

12. Consider the motion of a particle of mass m moving in space. Selecting the cylindrical co-ordinates (p, ¢, z) as the generalized co-ordinates, calculate the generalized force components if a force F acts on it.

13. A simple pendulum has a bob of mass m with a mass m1 at the moving support (pendulum with moving support) which moves on a horizontal line in the vertical plane in which the pendulum oscillates. Find the Lagrangian and Lagrange's equation of motion.

14. A mass m is suspended by a massless spring of spring constant k. The suspension point is pulled upwards with constant acceleration ao' Find the Hamiltonian of the system, Hamilton's equations of motion and the equation of motion.

15. Obtain the Hamiltonian of a charged particle in an electromagnetic field.

16. Solve the problem of simple harmonic oscillator in one dimension by effecting a canonical transformation.

17. Consider a diatomic molecule consisting of masses m 1 and m2 connected by a spring of spring constant k vibrating along the line joining the two masses. Obtain its normal frequencies and normal modes of vibration.

18. The masses of the bobs of two pendulums are m1 and m2. The bobs are coupled by a spring of force constant k. If their lengths are equal to i, obtain the normal frequencies of the system.

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. Consider a mechanical system described by the Lagrangian Lwith generalized coordinates q.

a) State Hamilton's principle and explain its significance in classical mechanics.

b) Derive the Euler-Lagrange equations of motion from Hamilton's principle.

c) Discuss the relationship between Hamilton's principle and the principle of least action, and how they lead to the same equations of motion.

20. Discuss the free vibrations of a linear triatomic molecule in terms of normal coordinates. Explain the normal modes of vibration.

VII Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY7CJ403: Quantum Mechanics II

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Explain the significance of the angular equation and spherical harmonics in the solution of the Schrödinger equation for a particle in spherical coordinates..

2. How does the spectrum of hydrogen arise from the solutions of the radial equation, and what are the implications of the spectrum for the energy levels of the hydrogen atom?

3. Define orbital angular momentum in quantum mechanics and explain its significance in describing the rotational motion of particles in three-dimensional space.

4. State the commutation relations between the angular momentum operators Lx ,Ly , and Lz and discuss their implications for the measurement of angular momentum components.

5. Explain the significance of Clebsch–Gordan coefficients in the addition of angular momenta.

6. Define what constitutes a linear vector space in the context of quantum mechanics and provide an example.

7. Discuss the Stark effect in the ground state of hydrogen.

8. Compare and contrast the fine structure and the anomalous Zeeman effect in hydrogen..

9. Discuss the concept of cross-section in classical scattering theory.

10. Describe the formalism of partial wave analysis in quantum scattering theory.

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. A particle of spin 1 and a particle of spin 2 are at rest in a configuration such that the total spin is 3, and its z-component is 1 (that is, the eigenvalue of Sz is h). If you measured the z-component of the angular momentum of the spin-2 particle, what values might you get, and what is the probability of each one?

12. Consider the three-dimensional harmonic oscillator, for which the potential is

$V(r) = ½ m\omega^2 r^2$

(a) Show that separation of variables in Cartesian coordinates turns this into three one-dimensional oscillators, and exploit your knowledge of the latter to determine the allowed energies.

13. Consider a charged particle in the one-dimensional harmonic oscillator potential. Suppose we turn on a weak electric field (E) so that the potential energy is shifted by an amount $H' = —qEx$. Show that there is no first-order change in the energy levels, and calculate the second-order correction.

14.a) Use the variational principle to prove that first-order nondegenerate perturbation theory always overestimates (or at any rate never underestimates) the ground-state energy.

(b) In view of (a), you would expect that the second-order correction to the ground state is always negative.

15. Find the lowest bound on the ground state of hydrogen you can get

$$\varphi(r) = Ae^{-br3}$$

using a gaussian trial wave function where A is determined by normalization and b is an adjustable parameter.

16. Use the WKB approximation to find the allowed energies of the harmonic oscillator.

17. Consider the case of low-energy scattering from a spherical delta- function shell:

$$V(r) = \alpha\, \delta(r-a),$$

where α and a are constants. Calculate the scattering amplitude, the differential cross-section, and the total cross-section

18. Find the scattering amplitude for low-energy soft-sphere scattering in the second Born approximation.

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. Discuss the WKB approximation in quantum mechanics, its theoretical foundation, applications, and limitations.

20. a) Explain the integral form of the Schrödinger equation used in the Born approximation.

b) Discuss the concept of the first Born approximation and its limitations.

c) Describe the Born series and its application in quantum scattering theory.

VII Semester B.Sc. (FYUGP) Degree Examinations October 2028

PHY7CJ404: Statistical Mechanics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Describe the concept of two-state systems and explain how it relates to the two-state paramagnet model.

2. Compare and contrast the multiplicity function of a monatomic ideal gas with that of interacting ideal gases.

3. Describe the relationship between the change in entropy and heat capacity of a system.

4. Explain diffusive equilibrium and the concept of chemical potential

5. Describe the partition function and discuss how it is used to calculate average values of physical quantities in a system.

6. State the equipartition theorem and explain its implications for the distribution of energy among degrees of freedom in a system. Discuss the conditions under which the equipartition theorem is valid and any limitations it may have.

7. Describe the Maxwell speed distribution and its significance in describing the distribution of speeds of particles in a gas at thermal equilibrium. Discuss the factors that influence the shape of the Maxwell speed distribution.

8. Explain how the total partition function of a composite system is related to the partition functions of its individual components.

9. Define the Gibbs factor and explain its significance in statistical mechanics. Discuss how the Gibbs factor is related to the probability of finding a system in a particular microstate.

10. Differentiate between bosons and fermions in terms of their quantum statistics. Describe the distribution functions (Bose-Einstein and Fermi-Dirac distributions) associated with bosons and fermions and discuss their key characteristics.

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. Calculate the multiplicity of an Einstein solid with 30 oscillators and 30 units of energy.

12. Use Stirling's approximation to find an approximate formula for the multiplicity of a two-state paramagnet.

13. Consider an ideal monatomic gas that lives in a two-dimensional universe ("flatland"), occupying an area A instead of a volume V. By following the same logic as above, find a formula for the multiplicity of this gas

14. Use the Sackur-Tetrode equation to calculate the entropy of a mole of argon gas at room temperature and atmospheric pressure. Why is the entropy greater than that of a mole of helium under the same conditions?

15. Estimate the probability that a hydrogen atom at room temperature is in one of its first excited states (relative to the probability of being in the ground state). Don't forget to take degeneracy into account..

16. Calculate the most probable speed, average speed, and rms speed for oxygen (02) molecules at room temperature.

17. Assuming that the conduction electrons behave like an ordinary ideal gas (with two spin states per particle), write their chemical potential in terms of the number of conduction electrons per unit volume.

18. Each atom in a chunk of copper contributes one conduction electron. Look up the density and atomic mass of copper, and calculate the Fermi energy, the Fermi temperature, the degeneracy pressure, and the contribution of the degeneracy pressure to the bulk modulus. Is room temperature sufficiently low to treat this system as a degenerate electron gas?

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. Explain the Gibbs Paradox and its resolution

20 Discuss the thermodynamics of phonons and hence derive Debye equation for specific heat capacity of solids.

VII Semester B.Sc. (FYUGP) Degree Examinations October 2028

PHY7CJ405: Electronics III

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Define Bode plots and explain their significance in the analysis of amplifier circuits.
2. Describe the Miller effect capacitance and its impact on the high-frequency response of amplifier circuits.
3. Discuss the multistage frequency effects in amplifier circuits and their role in square wave testing.
4. Explain the concept of operational amplifier frequency responses and the relevance of Bode plot analysis.
5. Define and discuss the characteristics of active low pass, high pass, and band pass Butterworth filters.
6. Describe the construction and working principles of the Wien bridge oscillator.
7. Discuss the applications of operational amplifiers as inverters, scale changers, summers, and V to I converters.
8. Explain the operation of integrators and differentiators using operational amplifiers.
9. Describe the minimization of Boolean functions using Karnaugh maps and representation using logic gates.
10. Discuss the operation of JK and MS JK flip-flops, and the use of shift registers in digital systems.

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. Using Bode plots, analyze the low-frequency response of a BJT amplifier circuit. Discuss the implications of your analysis.
12. Calculate the Miller effect capacitance for a given amplifier circuit with relevant parameters provided. Discuss strategies to minimize its impact.
13. Explain how multistage frequency effects affect the performance of amplifier circuits. Describe the process of square wave testing.

14. Design an active band pass filter with multiple feedback. Present the circuit diagram and discuss its performance.
15. Discuss the operation of the Wien bridge oscillator and its advantages over other types of oscillators.
16. Illustrate the use of operational amplifiers as scale changers and summers. Provide practical examples for each application.
17. Design an integrator circuit using an operational amplifier. Calculate the output voltage for a given input signal.
18. Explain the operation of R-2R ladder D/A converter and its advantages over other types of digital-to-analog converters.

Section C

[Answer any one. Each question carries 10 marks]

(1x10=10 marks)

19. Describe the internal architecture of the Intel 8085 microprocessor, focusing on its register organization and operational modes.

20. Explain the architecture of AVR microcontrollers, with a focus on general-purpose registers and data memory. Discuss the importance of microcontrollers in embedded systems.

VIII Semester B.Sc. (FYUGP) Degree Examinations October 2028

PHY8CJ406: Solid State Physics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Discuss the relationship between crystal structures and lattice parameters.

2. Define Brillouin zones and their significance in characterizing the allowed wave vectors in reciprocal space.

3. Explain how the nature of bonding influences the physical properties of crystals, such as their mechanical strength, conductivity, and optical properties.

4. Discuss the behavior of the electronic heat capacity at low and high temperatures and how it contributes to the overall heat capacity of a material.

5. Analyze the role of electron scattering mechanisms in determining the electrical conductivity of a material.

6. Analyze the factors that influence the thermal conductivity of metals and how they vary with temperature and material properties.

7. Define the concept of the band gap in semiconductors and insulators and explain its significance in determining their electronic properties.

8. Discuss the factors that influence the intrinsic carrier concentration, including temperature and band gap energy.

9. Discuss the classification of magnetic materials based on their magnetic properties and temperature dependence.

10. Analyze the assumptions and limitations of Langevin's theories and their relevance to experimental observations.

Section B [Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. The potential energy of a system of two atoms is given by

$$U = -\propto \frac{1}{r4} + \beta \frac{1}{r^{12}}$$

Calculate the amount of energy released when the atoms form a stable bond. Determine the bond length.

12. The visible light of wavelength 5000 A^0 undergoes scattering from a crystal of refractive index 1.5. Calculate the maximum frequency of the phonon generated and the fractional change in frequency of the incident radiation, given the velocity of sound in the crystal as 5000 m/s.

13. Show that the zero-point energy of a solid according to Debye model is $\frac{9}{8} R\, \theta_D$

14. What is the Fermi energy? Calculate its value for the free electron gas at 0K and mention its significance

15. What are Bloch functions? Explain the origin of allowed and forbidden bands for electrons in solids.

16. The resistivity of intrinsic semiconductor is 4.5 ohm-m at 20°C and 2.0 ohm-m at 32°C. What is the energy band gap ?

17. Explain the concepts of drift current and diffusion current. How are they different?

18. Give an account of the Weiss theory of ferromagnetism. Discuss the temperature variation of saturation magnetisation.

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. a)Describe the Kronig-Penney model and its importance in solid-state physics.

b. Discuss the assumptions made in the Kronig-Penney model and their implications on the behavior of electrons in a periodic potential.

c. Explain how the Kronig-Penney model predicts the band structure of a crystalline material and the formation of energy bands and bandgaps.

20. Explain the quantum theory of paramagnetism, detailing its historical evolution, theoretical principles grounded in quantum mechanics, and experimental verifications.

VIII Semester B.Sc. (FYUGP) Degree Examinations October 2028

PHY8CJ407: Spectroscopy

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. The observed rotational spectrum of HF shows decrease in the line separation on the high frequency side. Why?

2. What is isomer shift? Explain with examples.

3. The IR spectrum of a symmetric XY_2 molecule gives 3 prominent lines. Check whether the molecule is bent or linear.

4. In the vibration rotation spectrum of HBr, the rotational lines at the high frequency end of the R-branch are closely spaced and those at the low frequency end of the P branch are widely spaced. Why?.

5. In the rotational fine structure of electronic vibration spectra, in certain molecules the band head appears on the high wavenumber side, in certain others it is on the low wavenumber side and in some others there is no band head. Why?.

6. What is a Fortrat parabola?

7. What is Fermi contact interaction? Why Fermi contact interaction is possible only when the free electron occupies an s-orbital?

8. How many hyperfine components will there be in the ESR spectrum of a system having an unpaired electron interacting with (i) two equivalent protons (ii) two non equivalent protons?.

9. Distinguish between spin lattice and spin-spin relaxations..

10. Explain the effect of dipolar term in the NMR spectra of solids..

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. Rotational and centrifugal distortion constants of HCl molecule are 10.593 cm-1 and 5.3 x 10-4cm-1 respectively. Estimate the vibrational frequency and force constant of the molecule.

12. Estimate the minimum kinetic energy at which a neutron, in a collision with a molecule

of gaseous oxygen, can lose energy by exciting molecular rotation. The bond length of the oxygen molecule is 1.2 A^0.

13. The fundamental band for HCl is centred at 2,886 em-I. Assuming that the internuclear distance is 1.276 A, calculate the wave number of the first two lines of each of the P and R branches of HCl.

14. Stretching vibrations of CH in organic compounds occur around 2,920 em-1. At what wave number would C-D stretching vibrations occur?

15. The first-three rotational Raman lines of a linear triatomic molecule are at 4.86, 8.14 and 11.36 cm-I from the exciting Raman line. Estimate the rotational constant Band the moment of inertia of the molecule.

16. Calculate the ESR frequency of a free -electron in a magnetic field of 2.5 T. Given that g = 2.0023, $\mu_B = 9.274 \times 10^{-24}$J /T

17. The onset of the absorption continuum in the electronic vibration spectrum of I_2 occurs at 4,995 A^0. The I_2 molecule is known to dissociate into one ground state atom and one excited atom. The energy of the excited atom is 21.70 kcal /mol. Calculate the dissociation energy of I_2 in its ground electronic state.

18. Calculate the magnetic field strength required to get a transition frequency of 60 MHz for fluorine (g_N = 5.255) .

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. Describe with theory a) Rotational Raman spectra of symmetric top molecules
b) Vibrational Raman spectra.

20. How does nuclear magnetic resonance (NMR) spectroscopy work, and what are the fundamental principles behind it? Discuss the interactions between nuclear spins and magnetic fields, the concept of chemical shift, and the role of relaxation processes in NMR signal generation.,.

VIII Semester B.Sc. (FYUGP) Degree Examinations March 2029

PHY8CJ408: Electrodynamics III

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks](Ceiling: 24 Marks)

1. Define Poynting's theorem and explain how it relates to the flow of energy in electromagnetic fields.

2. State the continuity equation in the context of electromagnetism and explain its significance.

3. Explain why the magnetic force does no work on a charged particle moving through a magnetic field.

4. Explain how scalar and vector potentials are related to the electric and magnetic fields. Discuss the advantages of using scalar and vector potentials in solving electromagnetic problems..

5. Explain the Lorenz force law in potential form and its relationship to the scalar and vector potentials.

6. Define electric dipole radiation and explain its physical origin..

7. Describe the approaches used to address the self-force problem and their limitations.

8. Explain how magnetism arises as a relativistic phenomenon from the perspective of special relativity.

9. Discuss the components of the field tensor and their physical interpretations..

10Describe how the scalar and vector potentials are combined to form the four-potential in special relativity.

Section B

[Answer All. Each question carries 6 marks](Ceiling: 36 Marks)

11. Calculate the force of magnetic attraction between the northern and southern

hemispheres of a uniformly charged spinning spherical shell, with radius R, angular velocity

ω, and surface charge density σ.

12. magnetic dipole moment = mˆz is at rest at the origin; an electric charge q is at

rest at r. Find the angular momentum in their fields.

13. Suppose V = 0 and A=A0 sin(kx − ωt)ˆy, where A0, ω, and k are constants. Find E and B, and check that they satisfy Maxwell's equations in vacuum. What condition must you impose on ω and k?

14. Find the potentials of a point charge moving with constant velocity.

15 A particle of charge q moves in a circle of radius a at constant angular velocity ω. (Assume that the circle lies in the xy plane, centered at the origin, and at time t = 0 the charge is at (a, 0), on the positive x-axis.) Find the Liénard–Wiechert potentials for points on the z-axis.

16. Find the (Lorenz gauge) potentials and fields of a time-dependent ideal electric dipole p(t) at the origin.

17. A positive charge q is fired head-on at a distant positive charge Q (which is

held stationary), with an initial velocity v0. It comes in, decelerates to v = 0, and returns out

to infinity. What fraction of its initial energy is radiated away?

18. Find the magnetic field of a point charge q moving at constant velocity v.

Section C

[Answer any one. Each question carries 10 marks](1x10=10marks)

19. Discuss the behavior of electromagnetic plane waves when incident normal to a boundary between two mediums. Explain how Fresnel's equations describe the reflection and transmission coefficients in terms of the refractive indices of the mediums.

20. Discuss how Maxwell's equations are reformulated in the framework of special relativity. Explore the covariance of Maxwell's equations under Lorentz transformations and the implications for relativistic electromagnetism.

MODEL QUESTION PAPERS

MAJOR ELECTIVE COURSES

V Semester B.Sc. (FYUGP) Degree Examinations

PHY5EJ305(3): Physics of the Human Body

(Credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer all questions. Each question carries 3 marks] (Ceiling: 24 Marks)

1. List the conditions that a body should satisfy to remain in static equilibrium.
2. Which are the forces acting on one leg when someone is walking slowly?
3. What is the criterion for overall stability during standing?
4. What are the forces on the feet of a person weighing 70kg while standing (assume g=10m/s2)?
5. Which are the three different phases during walking? Mention the time for each phase also.
6. Define coefficient of restitution.
7. How are components of the human body classified as passive or active?
8. In terms of osteoblasts, osteoclasts and osteocytes, what leads to osteoporosis?
9. Which are the three types of muscles in the body?
10. Differentiate between agonist, synergist and antagonist muscles.

Section B

[Answer all questions. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Draw figures showing the forces involved in first-, second- and third-class levers. Give examples of each class levers in the body. Explain the torque balancing action of each class levers.
12. Explain overall stability of the human body during standing.
13. *In the case of walking, internal friction is usually troublesome, but external friction can be necessary*. Justify this statement.
14. Obtain the equation for stress on a body during an inelastic collision.
15. Explain the structure of a long bone like the femur.
16. Explain different types of bone fractures due to difference in load application to the bone.
17. Describe the various contractions of muscles.
18. Explain type I, type IIA, type IIB muscle fibres.

Section C

[Answer any one question. 10 marks] *(1×10=10 marks)*

19. Explain the equilibrium of the leg when in slow walk.
20. Explain the elastic properties of bones. hence or otherwise, taking the femur as an example, explain bone shortening under stress.

V Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY5EJ309: ASTROPHYSICS

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Define the one parsec.

2. Cepheid stars are the ideal standard candle to measure the distance of clusters and external galaxies. Why?

3. Explain the spectroscopic parallax method of stellar distance estimation.

4. Discuss the active and adaptive optics wavefront error correction techniques used in telescopes.

5. What are Fraunhofer lines in the solar spectrum and what information do they provide?

6. What is Algol paradox?

7. What are pulsars, and what do they tell us about the universe?

8. Distinguish between open and globular star clusters.

9. Define cosmological redshift, z.

10. How does the inflation model address the problem with the standard Big Bang model?

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. A star has an apparent magnitude of 17 and a measured parallax of 0.2 arcsec. Calculate its absolute magnitude.

12. A Newtonian telescope has a mirror diameter of 300 mm and a focal length of 1500 mm.

(a) Calculate the magnification while using an eyepiece having focal length 2.5mm

(b) What is the theoretical resolution, in arcseconds, of the telescope at the wavelength of green light, 5.1 X 10^7 m?

13. Discuss the active and adaptive optics wavefront error correction techniques in telescopes.

14. Neatly sketch H-R diagram and describe main regions.

15. Write a short note on black holes and their detection.

16. How did the observation of Hubble proved the expansion of the universe? Discuss the problem of age of the universe, determined from Hubble's constant.

17. Observations of the central region of the Galaxy M87 indicate that stars which are 60 light years from the center are orbiting the central supermassive black hole at a speed of 550 km/s. Estimate the mass of the black hole in solar masses. (The Earth orbits the Sun with an orbital speed of 30 km/s. 1 light year is 63240 AU.)

18. Explain how the discovery of CMB radiation supports the Big Bang theory.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10marks)

19. Discuss about the energy production mechanism and magnetic activities in the sun.

20. Describe the various stages and processes involved in the evolution of mid mass stars.

VI Semester B.Sc. (FYUGP) Degree Examinations

PHY6EJ310: Atmospheric Physics

(Credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer all questions. Each question carries 3 marks] (Ceiling: 24 Marks)

1. What is the difference between homosphere and heterosphere?
2. Which are the variable and non-variable constituents of the atmosphere?
3. What is atmospheric window?
4. What is potential temperature of an air parcel? Write its equation.
5. What is level of free convection (LFC)?
6. Write equation for Planck's law. How can we obtain Stefan-Boltzmann law from Planck's law?
7. Obtain an indirect estimate of solar irradiance at the top of the atmosphere.
8. Define quantum yield for a process involving an excited species (e.g., molecule)
9. Draw a schematic diagram showing the distribution of electric charges in a typical and relatively simple thunderstorm.
10. Sketch typical graphs showing variation of atmospheric electric field and space charge with height.

Section B

[Answer all questions. Each question carries 6 marks] (Ceiling: 36 Marks)

11. How can we classify the atmosphere on basis of temperature?
12. Explain the concept of an air parcel.
13. Briefly explain Earth's heat energy budget.
14. When is dry air said to be statically stable?
15. Starting from molecular dissociation, explain the production of ozone.
16. Explain the absorption of CO_2 in the atmosphere.
17. Write a note on the fundamental problem of atmospheric electricity.
18. Starting with the stepped leader, explain a lightning strike.

Section C

[Answer any one question. 10 marks] (1x10=10marks)

19. Explain the three types of thunderstorms.
20. Write an essay on the greenhouse effect, explaining with the aid of graphs how energy is transported vertically and horizontally. What are the consequences of the greenhouse effect?

VIII Semester B.Sc. (FYUGP) Degree Examinations

PHY8EJ408: Introductory General Relativity

(Credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer all questions. Each question carries 3 marks] (Ceiling: 24 Marks)

1. What is Riemannian space?
2. Show that for a covariant vector x_μ and contravariant vector y^ν, $x_\mu y^\nu$ is invariant.
3. What is Einstein tensor?
4. Show that in a Cartesian system, there is no distinction between the contravariant and covariant components of a vector.
5. Write equation for Christoffel symbol $\Gamma^\sigma{}_{\mu\nu}$ in terms of metric tensor and its derivatives.
6. Define a geodesic.
7. State one symmetry property and one symmetry property of the Riemann-Christoffel curvature tensor.
8. State the three forms of Equivalence Principle.
9. Which are the three tests of the general theory of relativity?
10. Find the Schwarzschild radius of (i) Sun (ii) Earth. Mass of Sun is 2×10^{30} kg. Mass of Earth is 6×10^{24} kg.

Section B

[Answer all questions. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Prove that Kronecker delta is a rank 2 mixed tensor.
12. Explain the concept of the metric. Show that it is a 2^{nd} rank covariant tensor.
13. Find Christoffel indices of the second kind for a cylindrical surface.
14. Explain how, we can take the derivative of a tensor and still obtain a tensor.
15. Obtain the condition for a space-time to be flat.
16. Give an account of the fundamental hypotheses and postulates of general relativity.
17. Write the Schwarzschild line-element. Which are the singularities of the Schwarzschild line-element?
18. Show that using tortoise transformation, one singularity of the Schwarzschild line-element can be removed.

Section C

[Answer any one question. 10 marks] (1x10=10 marks)

19. Obtain the Riemann-Christoffel curvature tensor in mixed form as well as completely covariant form.
20. Obtain the equations of a geodesic. Hence or otherwise, show that geodesics in three-dimensional Euclidean space are straight lines.

MODEL QUESTION PAPERS

MINOR COURSES

I Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY1MN101: Mechanics and Optics

(credits: 4)

Maximum Time: 2 hours Maximum Marks: 70

Section A

Answer All. Each question carries 3 marks (Ceiling: 24 Marks)

1. How the concept of inertial frame is important in explaining Newtons first law.
2. An object with mass ***m*** attached to a string has uniform circular motion with radius ***R*** in a gravity free region**.** Discuss about the force acting on the object, its direction, magnitude, relation to velocity etc.
3. Discuss different types of friction.
4. Discuss the concept of apparent weight and actual weight in the context of a man standing in an elevator which is accelerating up and down.
5. How work done by a force is calculated? What are the different contexts in which work done being positive, zero and negative?
6. What are the two types of diffraction phenomena?
7. Stationary Interference pattern is observed in limited conditions, comment.
8. Discuss about the basic nature of light.
9. How rainbow is formed? Briefly discuss.
10. How work done by a varying force is calculated for straight line motion?

Section B

Answer All. Each question carries 6 marks (Ceiling: 36 Marks)

11. An iceboat with a rider on it is at rest on a frictionless horizontal surface. Due to the blowing wind, 4.0 s after the iceboat is released, it is moving to the right at 6.0 m/s. What constant horizontal force $\boldsymbol{F}_W$ does the wind exert on the iceboat? The combined mass of iceboat and rider is 200 kg.
12. State and explain work energy theorem. A constant force acting on an object of mass 200kg at an angle of 30˚relative to the direction of motion accelerates it from rest to 30m/s over a distance of 30m. Calculate the magnitude of the force (neglect friction and gravity.)
13. Define gravitational potential energy. How mechanical energy conservation is explained in a purely gravitational field.
14. A 2000kg elevator with broken cables in a test rig is falling at 4.00 m/s when it contacts a cushioning spring at the bottom of the shaft. The spring is intended to stop the elevator, compressing 2.00 m as it does so. During the motion a safety clamp applies a constant 17,000-N friction force to the elevator. What is the necessary force constant ***k*** for the spring?
15. Explain single slit diffraction phenomena.
16. Explain total internal reflection. A beam of light is traveling inside a solid glass cube that has index of refraction 1.62. It strikes the surface of the cube from the inside. (a) If the cube is in air, at what minimum angle with the normal inside the glass will this light not enter the air at this surface?

17. Derive object-image relationship for spherical refracting surface. Also obtain the equation for lateral magnification.
18. Write down lens maker's equation. A lens forms an image of an object. The object is 16.0 cm from the lens. The image is 12.0 cm from the lens on the same side as the object. (a) What is the focal length of the lens? Is the lens converging or diverging? (b) If the object is 8.50 mm tall, how tall is the image? Is it erect or inverted?

Section C

Answer any one. Each question carries 10 marks (1x10=10marks)

19. Discuss about fluid resistance to motion. Analyse the problem in which an object moves vertically down through air under gravity, obtain the general expression for velocity and terminal velocity.
20. Discuss the interference phenomenon related to two source interference. Analyse the intensity variation on the screen.

II Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY2MN101: Electromagnetism and Network Theorems

(credits: 4)

Maximum Time: 2 hours Maximum Marks: 70

Section A

Answer All. Each question carries 3 marks (Ceiling: 24 Marks)

1. State and explain Coulombs law in electrostatics.
2. What are the significance of electric field lines? Draw an electric field line map of two slightly separated positive charges.
3. Define electric flux. How can electric flux through an area **A** in a nonuniform electric field is calculated.
4. What is an electric dipole? Calculate the potential energy of an electric dipole.
5. Give an analysis on force experienced by charged particles moving in a uniform magnetic field.
6. Discuss on magnetic field due to a current carrying conductor.
7. What is an ideal voltage source and current source? Explain.
8. Explain maximum power transfer theorem.
9. Discuss the variation of voltage, current and power across a capacitor which is connected to **ac** source**.**
10. Discuss different characteristics such as voltage, current and impedance of a circuit consisting a resistor and a capacitor connected in series to an ac source.

Section B

Answer All. Each question carries 6 marks (Ceiling: 36 Marks)

11. Define electric field at a point. Two equal and opposite charges of magnitude 12nC each are placed on x-axis at +5cm and -5cm about the origin. Find out the direction and magnitude of electric field at +5cm on y-axis.
12. Define magnetic flux? A flat surface with area $4cm^2$ is in a uniform magnetic field $\vec{B}$. Magnetic flux through this surface is +0.90mWb. Find the magnitude of the magnetic field and the direction of the area vector $\vec{A}$.(Given: $\vec{B}$ points in the +ve x-direction, plane of the area makes 150° with +ve x-direction).
13. What is Ampere's law? A cylindrical conductor with radius ***R*** carries a current ***I***. The current is uniformly distributed over the cross-sectional area of the conductor. Find the magnetic field as a function of the distance ***r*** from the conductor axis for points both inside ($r<R$) and outside ($r > R$) of the conductor.
14. Obtain the expression for torque acting on a current carrying loop. What is the potential energy of a dipole placed in a magnetic field.
15. Determine the currents in the unbalanced bridge circuit of Fig. 1 below. Also, determine the p.d. across BD and the resistance from B to D.
16. State Thevenin theorem. Using Thevenin theorem, calculate the current flowing through the 4 Ω resistor in Fig. 2.
17. State Norton's theorem. Using Norton's theorem, calculate the current flowing through the 15 Ω load resistor in the circuit of Fig. 3. All resistance values are in ohm.

18. In a given R-L circuit, R = 3.5 Ω and L = 0.1 H. Find (i) the current through the circuit and (ii) power factor if a 50-Hz voltage $V = 220 \angle 30°$ is applied across the circuit.

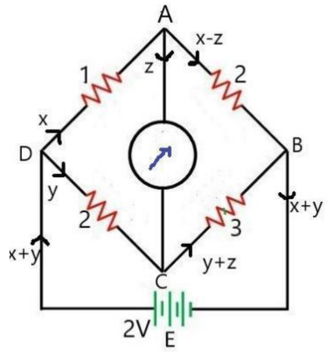


Fig. 1

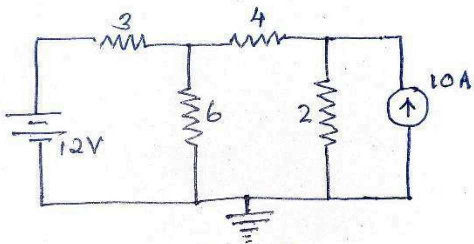


Fig. 2

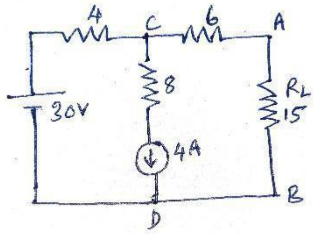


Fig. 3

Section C

Answer any one. Each question carries 10 marks (1x10=10marks)

19. State and explain Gauss's law. Use Gauss's law to calculate the electric field due to
    a. A thin, flat, infinite sheet with uniform positive surface charge density σ
    b. Infinitely long thin wire with charge per unit length λ
20. Discuss different characteristics of an LCR series ac circuit including resonance frequency, resonance curve, half power bandwidth, q-factor etc.

I Semester B.Sc.(FYUGP) Degree Examinations October 2024

PHY1MN102: Properties of matter and Thermodynamics

(Credits: 4)

MaximumTime:2 hours **Maximum Marks:70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling:24Marks)

1. Define the concept of center of gravity and discuss its significance in determining the stability of objects.
2. Define stress and strain in the context of elasticity.
3. Differentiate between elastic and plastic deformation
4. State and explain Pascal's law.
5. Explain Archimedes' principle and how it relates to the buoyant force experienced by an object submerged in a fluid.
6. Define thermal equilibrium and explain its significance in thermodynamics
7. Define internal energy and state the first law of thermodynamics.
8. State and explain the second law of thermodynamics.
9. Explain why the Kelvin temperature scale is truly absolute.
10. Define entropy and explain how it relates to the disorder or randomness of a system

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. In a material testing laboratory, a metal wire made from a new alloy is found to break when a tensile force of 87.8 N is applied perpendicular to each end. If the diameter of the wire is 1.19mm, what is the breaking stress of the alloy?

12. Describe the steps involved in solving rigid body equilibrium problems using the conditions of equilibrium. Include a detailed explanation of how to apply the concepts of force analysis and torque analysis in determining the equilibrium of a rigid body.

13. Define viscosity and explain its role in fluid flow. Mention the factors influencing viscosity and how it affects the behavior of fluids, including laminar and turbulent flow.

14. Explore the phenomenon of turbulence in fluid flow. Discuss the characteristics of turbulent flow and the parameters that govern its onset and intensity.

15. Show that the total entropy change during any reversible cyclic process is zero.

16. Discuss the mathematical relationship between pressure, volume, and temperature during an adiabatic expansion or compression.

17.Draw the schematic energy flow-diagram of a refrigerator and obtain an expression for the coefficient of performance

18. Describe the Carnot cycle and explain why it is considered an idealized model for heat engines.

Section C

[Answer anyone. Each question carries 10 marks] (1x10=10marks)

19. Derive Bernoulli's equation and explain its significance in fluid mechanics. Discuss the limitations of Bernoulli's equation and situations where it may not accurately predict fluid behavior.

20. Discuss the significance of work done during volume changes in thermodynamic processes. Provide a detailed explanation of how work is calculated for different types of volume changes, including isobaric, isochoric, and adiabatic processes.

II Semester B.Sc.(FYUGP) Degree Examinations October 2024

PHY2MN102: MODERN PHYSICS AND NUCLEAR PHYSICS

(Credits: 4)

MaximumTime:2 hours **Maximum Marks:70 Section A**

[Answer All. Each question carries 3 marks] (Ceiling:24 Marks)

1. Define the term "photoelectric effect" and explain its significance in the context of modern physics.
2. Describe the phenomenon of Compton effect and explain how it provides evidence for the particle nature of light.
3. What is pair production? Discuss its implications for particle physics.
4. Explain the concept of De Broglie waves and their significance in understanding the wave-particle duality.
5. Define black body radiation and explain its characteristics according to modern physics theories.
6. Discuss the relationship between wavelength and frequency in electromagnetic waves.
7. Explain the significance of the Bohr atom model in the development of atomic theory.
8. Describe the energy levels and spectra of atoms according to the Bohr model.
9. Discuss the concept of nuclear composition and its relevance in nuclear physics.
10. Explain the concept of stable nuclei and discuss the factors influencing nuclear stability.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36Marks)

11. Discuss the experimental evidence supporting the wave-particle duality of electromagnetic radiation.
12. Explain the process of nuclear fission and discuss its applications in energy production.
13. Describe the principles of radiometric dating and explain how it is used to determine the age of geological samples.
14. Discuss the significance of magic numbers in nuclear physics and their role in determining nuclear stability.
15. Explain the concept of binding energy and its importance in understanding nuclear reactions.
16. Describe the characteristics of alpha, beta, and gamma decay processes in radioactive nuclei.
17. Discuss the liquid drop model and shell model of nuclear structure and compare their predictions.
18. Explain the process of nuclear fusion in stars and discuss its role in stellar evolution.

Section C

[Answer anyone. Each question carries 10 marks] (1x10=10marks)

19. Investigate and analyze the experimental setup and results of the photoelectric effect, highlighting its implications for the understanding of quantum mechanics.
20. Compare and contrast the characteristics and behaviors of electromagnetic waves and matter waves, emphasizing their significance in modern physics theories.

I Semester B.Sc. (FYUGP) Degree Examinations October

PHY1MN103: Semiconductor Physics and Electronics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Discuss the concept of breakdown voltage in a diode.
2. How are solids classified based on energy bandgap?
3. Differentiate rectification and filtering.
4. For an input sine wave sketch the output in the case of inverting and non-inverting opamp . Also mention the general expression for voltage gain.
5. How can we identify the terminals of a pnp transistor using multimeter?
6. What is the significance of operating point of a transistor?
7. Draw an opamp summing circuit to add 3 voltages.
8. Which are the universal gates and why are they called so?
9. Differentiate half adder and full adder
10. Solve the Boolean expressions
    A.1= A+1= A.0 =

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. How does the voltage-current characteristic of a PN junction diode appear in forward and reverse bias? Explain.
12. Compare the voltage and current gain in Common Base (CB), Common Collector (CC), and Common Emitter (CE) transistor configurations.
13. What is the purpose of transistor biasing?
14. Based on the voltage-current characteristics, mention the peculiarity of a Tunnel diode.
15. How is a Zener diode utilized for voltage regulation?
16. Explain the working of full-adder.
17. State De Morgan's theorem and illustrate it with a 2-input truth table.
18. Compose a note on basic logic gates.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10marks)

19. Describe the operation of a full-wave bridge rectifier and derive the expression for rectification efficiency
20. Explain a practical CE amplifier having potential divider biasing with the help of a circuit diagram

II Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY2MN103: Fundamentals of Optics

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. What us meant by refraction? Sate and explain law of refraction.
2. Explain the sign convention used for spherical mirrors.
3. In Young's double-slit experiment, what is observed on the screen?
4. Write the conditions for observing interference?
5. Distinguish between Fresnel and Fraunhoffer types of diffraction?
6. Describe the different types of optical fibers based on propagation modes
7. What is a polarizer?
8. Discuss the use of optical fibers.
9. Explain the concept of optical activity.
10. What is population inversion? Mention a method to achieve population inversion.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. A concave mirror has a focal length of 15 cm. An object 10 cm tall is placed 20 cm away from the mirror. What is the nature, size, and position of the image formed?
12. A polarizer transmits only light waves with their electric field vectors vibrating in a specific plane. Unpolarized light with an intensity of 10 W/m^2 is incident on a polarizer. If the transmitted light has an intensity of 5 W/m^2, calculate the angle between the axis of the polarizer and the initial plane of polarization of the unpolarized light.
13. Explain the principle of total internal reflection (TIR). How does TIR enable light transmission through optical fibers?

14. A double-slit experiment is performed with a separation of 0.1 mm and monochromatic light of wavelength 600 nm. The screen is placed 1 meter away from the slits. Determine the distance between the central maximum and the first-order bright fringe on the screen.
15. How does diffraction differ from interference?
16. Describe the basic principle behind the operation of a laser. Explain the roles of stimulated emission and population inversion in laser action.
17. Describe different types of losses that occur in optical fibers and how they can be minimized.
18. What is Brewster's Law? Explain how it can be used to produce plane-polarized light.

Section C

[Answer any one. Each question carries 10 marks] (1x10 = 10 marks)

19. How the wavelength of sodium light is is measured using Newton’s Rings method?
20. With neat diagram explain the working of a) Ruby Laser, b) He-Neon laser.

I Semester B.Sc.(FYUGP) Degree Examinations October 2024

PHY1MN104: Electricity and Magnetism

(Credits: 4)

MaximumTime:2 hours **Maximum Marks:70**

Section A [Answer All. Each question carries 3 marks] (Ceiling:24 Marks)

1. Define electric charge and explain its properties briefly.
2. State Coulomb's law and express it mathematically.
3. Calculate the electric field intensity at a point due to a point charge of $+2\,\mu C$+2μC located at (2,3,4) m(2,3,4)m in free space.
4. Explain the concept of electric field lines and their properties.
5. Derive an expression for the electric potential energy of a system of two point charges.
6. Define electric flux and explain its significance.
7. Calculate the electric flux through a closed surface enclosing a point charge of $+3\,nC$+3nC.
8. State Gauss's law and its significance in electrostatics.
9. Describe an application of Gauss's law to find the electric field due to an infinite uniformly charged line.
10. Explain the method to determine the charges on a conductor using Gauss's law experimentally.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36Marks)

11. Derive an expression for the electric field intensity due to an electric dipole at a point on its axial line.
12. Discuss the behavior of electric potential around a charged conducting sphere.
13. Define current, resistance, and resistivity. Explain their interrelations.
14. Describe the working principle of a simple electric circuit and explain how EMF is related to it.
15. Calculate the power dissipated in a circuit with a resistance of $10\,\Omega$10Ω and a current of $5\,A$5A.
16. Discuss the theory of metallic conduction and the factors affecting the resistance of a conductor.
17. Solve a circuit consisting of resistors in series and parallel and calculate the equivalent resistance.
18. Apply Kirchhoff's laws to analyze a complex circuit and determine the currents in different branches.

Section C

[Answer anyone. Each question carries 10 marks] (1x10=10marks)

19. Explain the concept of magnetic field lines and their properties. Discuss the similarities and differences between electric field lines and magnetic field lines.
20. Explain the motion of a charged particle in a magnetic field. Provide relevant mathematical expressions and examples.

II Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY2MN104: Optics and Lasers

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. State the law of reflection and law of refraction.
2. Explain the sign convention used for spherical mirrors.
3. Write the lens equation for a thin lens. Explain the terms involved in the lens equation.
4. Write the conditions for observing interference?
5. Distinguish between diffraction and interference of light.
6. What are the different types of polarization?
7. Define optical activity and specific rotation.
8. Distinguish between spontaneous emission and stimulated emission in lasers.
9. What are the essential components of a laser?
10. What is population inversion? Mention a method to achieve population inversion.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Define refractive index and explain its physical significance. Briefly explain how the frequency of light affects its color.
12. A concave mirror has a focal length of 15 cm. An object 10 cm tall is placed 20 cm away from the mirror. What is the nature, size, and position of the image formed?
13. Define coherence and state two conditions required for sustained interference. Give an example of a practical application that relies on the phenomenon of interference.
14. Briefly explain the principle behind Newton's rings experiment.
15. Explain the difference between Fresnel and Fraunhofer diffraction. Sketch the diffraction pattern observed when light diffracts through a single slit.
16. A soap bubble with a thickness of 1 μm appears red when illuminated with white light. Assuming the refractive index of the soap film is 1.33, calculate the approximate wavelength of the red light reflected most strongly.
17. Describe the basic principle behind the operation of a laser. Explain the roles of stimulated emission and population inversion in laser action.
18. What is Brewster's Law? Explain how it can be used to produce plane-polarized light.

Section C

[Answer any one. Each question carries 10 marks] (1x10 = 10 marks)

19. Discuss the refraction at a spherical surface. Also obtain lens maker's formula.
20. With neat diagram explain the working of a) Ruby Laser, b) He-Neon laser.

I Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY1MN105 :Non- conventional Energy Sources

(credits:4)

Maximum Time:2 hours **Maximum Marks:70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24Marks)

1. List any three advantages of non- conventional energy sources.
2. Write a short note on solar green houses.
3. What are the two sources of wind?
4. Comment on the utilisation aspects of wind energy.
5. Mention the main problems in operating large wind power generators?
6. What are the advantages of hydrogen as a fuel?
7. What are the applications of geothermal energy?
8. Explain the working principle of Ocean Thermal Energy Conversion (OTEC).
9. What are the advantages and disadvantages of wave energy?
10. List the components of a biogas plant.

Section B

[Answer All. Each question carries 6 marks] (Ceiling:36 Marks)

11. Explain the construction and working of a pyranometer
12. What is a solar cell? Discuss the working theory of a solar photovoltaic cell.
13. What are the advantages and disadvantages of wind Energy?
14. With the help of a suitable block diagram, discuss the basic components of a wind energy conversion system.
15. Briefly explain the components and working theory of a fuel cell.
16. How can ocean energy sources be categorised? Explain briefly.
17. Explain the various components of a tidal power plant.
18. Discuss the different biomass conversion processes.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

19. What is a solar cooker? What are different designs of solar cookers? Using a suitable figure, discuss the working of a box type solar cooker.

20.Briefly explain the different categories of the geothermal sources of energy. List any four advantages and disadvantages of geothermal energy.

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II Semester B.Sc. (FYUGP) Degree Examinations October2024

PHY2MN105: Fluid Mechanics and Thermodynamics

(Credits: 4)

MaximumTime:2 hours **Maximum Marks:70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24Marks)

1. What is buoyant force, and how does it affect the behavior of objects immersed in a fluid?
2. Discuss the different types of fluid flow, including laminar and turbulent flow.
3. State and explain the Zeroth law of thermodynamics.
4. Write a short note on thermal expansion of water.
5. Discuss the differences between reversible and irreversible processes.
6. Define internal energy in thermodynamics and explain how it relates to the first law of thermodynamics.
7. Define the first law of thermodynamics and explain its significance in the context of energy conservation within thermodynamic systems.
8. State Kelvin-Planck statement of the second law of thermodynamics.
9. Define entropy and discuss how it is related to randomness.
10. What is Coefficient of performance of a refrigerator?

Section B

[Answer All. Each question carries 6 marks] (Ceiling:36 Marks)

11. Define density and explain how hydrometer is used to calculate the density of liquids.
12. Describe how the continuity equation for a fluid in motion is derived and discuss its significance.
13. Explain thermal stress. Derive an expression for the thermal stress of a clamped rod.
14. Derive an expression for the amount of work done during isothermal expansion of an ideal gas.
15. Discuss heat capacities of an ideal gas and derive the relationship between them.
16. Describe the concept of work done during volume changes in a thermodynamic system. Explain how work is calculated.
17. A room contains about 2500 moles of air. Find the change in internal energy of this much air when it is cooled from 35.0^0C to 26.0^0C at a constant pressure of 1 atm. Treat the air as an ideal gas with $\gamma = 1.40$
18. In one cycle a Carnot engine takes in 8.0×10^4 J of heat and does .1.68×10^4 J of work. The temperature of the cold reservoir is 25.0^0C. a) What is the efficiency of this engine? b) What is the temperature of the hot reservoir?

Section C

[Answer anyone. Each question carries 10 marks] (1x10=10marks)

19. Explain the concept of linear and volume expansion and how they are influenced by temperature changes. Discuss the practical applications of thermal expansion phenomena in engineering and everyday life, and provide examples where thermal expansion is both beneficial and problematic.
20. a)Draw the energy flow diagram of a heat engine and obtain a mathematical expression for the thermal efficiency of the engine.
    b) Prove that ‘no engine can be more efficient than a Carnot engine operating between the same two temperatures’

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MODEL QUESTION PAPERS

VOCATIONAL MINOR COURSES

I Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY1VN102: Python Basics

(Credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer all questions. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Draw a flowchart to find the sum of first n natural numbers, where n is to be obtained from user prompt.
2. List the different Identity operators in python with examples.
3. Consider the following statement: *a=1,2,3*. How will you identify the data type of the variable a? Which data type is a?
4. Write the syntax of *for* loop.
5. How can elements of a list be accessed using *while* loop?
6. Write the output of the program:

```
for i in range(1,11):
        if (i==5):
                continue
        print(I, end=' ')
print('\n End')
```

7. What is the use of *with* statement in Python?
8. Create a one-dimensional array using Numpy.
9. Give the syntax of any three functions used to create an array in Numpy. How can the array be converted to a matrix?
10. What is the use of legends in matplotlib?

Section B

[Answer all questions. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Explain the different arithmetic operators used in Python with examples.
12. Differentiate between global and local variables. Which type of variables is better to be used? Why?
13. Enumerate and explain different types of formatted print statements in Python.
14. Write Python code to solve the quadratic equation ax2 + bx + c = 0 by getting the input coefficient from the user.
15. Write a Python program to print the calendar for the month of August, 1947.
16. Explain nested function with an example.
17. Write a python program to accept a matrix from the user and print its transpose.
18. Write a python program to create a pie chart from the following data about the solar radiation reaching earth.:

Type of radiation	Energy percentage
Infrared	51
Visible	43
Ultraviolet	5
Others	1

Section C

[Answer any one question.10 marks] (1×10=10 marks)

19. Explain the data types used in Python with examples of each. Which among these are mutable data types?
20. Explain the different types of arguments used in functions. Write a program showing each of the arguments.

II Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY2VN102: Data Analysis in Physics Using Python

(Credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer all questions. Each question carries 3 marks] (Ceiling: 24 Marks)

1. How can we open (i) a new Python notebook (ii) an existing Python notebook in Google Colab?
2. What is the advantage of using a Jupyter notebook instead of a pure python file created in the IDLE editor?
3. In which all programs can files with the following extension opened: .csv, .xlsx
4. What is the difference between series and dataframe in pandas?
5. We have a dataframe stored in the variable dtf. How will we know the number of (i) rows and columns in the data frame (ii) Columns only?
6. How can we create a series from a dictionary? Write an example.
7. What is a heat map?
8. What is the difference between systematic errors and random errors?
9. Write equations of population standard deveation and sample standard deveation.
10. Why is the mean called as the best estimate of a measured value X?

Section B

[Answer all questions. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Write a Python program to create a dataframe by converting a nested list that stores names and marks five students scored in 50. Suitable names can be given to columns.
12. Write a Python program to create a dataframe from an .xlsx file that stores roll numbers, names, marks and grades of five students in an examination of 50 marks. How can we modify the program so that a user can view the names and marks of first 3 students only?
13. How can we create a series from a dataframe and a dataframe from series in Pandas? Write brief examples.
14. A data frame is created from an .xlsx file showing the distance in kms vehicles have traveled and their count. Write python code to create a count plot with legend representing this data.
15. What is a box plot? Explain the various components of a box plot.
16. The values of head scale reading (HSR) for measuring diameter of a wire taken using a screw gauge is given. Find the standard deviation of the HSR values.

Trial	HSR
1	65
2	63

3	59
4	67
5	70
6	69

17. Write a note on Normal distribution.
18. Why is the Standard deviation known as 68% confidence limit of a measurement?

Section C

[Answer any one question. 10 marks] (1x10=10marks)

19. Explain how different data frames can be joined with the aid of examples.
20. Using radioactive decay of an element as an example, explain Poisson distribution. What is the significance of μ in Poisson distribution? Compare normal and Poisson distribution.

III Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY3VN202: Data Analysis in Physics using Machine Learning

(credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Define Machine Learning. Explain the need for machine learning.
2. What are the different feature selection techniques used in machine learning?
3. Explain how regression works in machine learning.
4. What are the different model evaluation metrics used in regression analysis?
5. What is the Gini index, and how is it used in decision tree algorithms?
6. Explain the concept of classification algorithms in machine learning.
7. Explain the concept of the decision tree algorithm.
8. What are the main challenges in machine learning? Discuss at least three challenges.
9. Describe multilabel classification and multi-output classification.
10. Define precision and recall in the context of classification models.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Describe various feature selection techniques and methods for detecting outliers.
12. Differentiate between supervised, unsupervised, and reinforcement learning.
13. Explain the importance of feature selection techniques in machine learning. Discuss at least three feature selection techniques.
14. Explain the K-Nearest Neighbour (KNN) classifier. Discuss how the value of K is selected in the KNN algorithm.
15. Discuss the K-means clustering algorithm. Explain the rules to generate clusters and the elbow method for determining the optimal number of clusters.
16. Explain the Receiver Operating Characteristic (ROC) curve. What is its significance in evaluating the performance of a classification model?
17. What do you mean by the term overfitting? How can it be resolved in a decision tree?
18. Discuss the challenges faced in machine learning and provide examples of real-world applications of machine learning algorithms.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

19. Describe the importance of machine learning in today's world. Discuss the process of preparing data for machine learning and the steps involved in data cleaning, standardization, scaling, binarisation, and labeling.
20. Explain the concept of regression analysis in machine learning. Describe the different types of regression algorithms and their applications.

MODEL QUESTION PAPERS

GENERAL FOUNDATION COURSES

I Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY1FM105: Physics in Daily Life

(Credits: 3)

Maximum Time: 1.5 hours **Maximum Marks: 50**

Section A

[Answer all questions. Each question carries 2 marks] (Ceiling 16 marks)

1. 'Using wood-burning stoves does not affect the climate'. Comment on this statement.
2. Which are the two types of smoke detectors? Which one is better?
3. Which vessel is better to freeze food: steel or ceramic?
4. How does the seam of the ball help the bowler in cricket?
5. What is 'sweet spot' of a cricket bat?
6. What is Magnus effect?
7. How are the following shots made in football: (i) slow, but accurate pass, (ii) Hard shots, (iii) shot that gives a sidespin to the ball?
8. How and when will a football knock the player unconscious?
9. When pushing a child on a playground swing, what happens if you push him/her forward each time s/he moves toward you?
10. What is an octave in music?

Section B

[Answer all questions. Each question carries 6 marks] (Ceiling 24 marks)

11. How do Cooking gas bottles (LPG/cooking cylinders) work?
12. Explain the behavior of a cricket ball on (i) a hard pitch and (ii) a soft pitch.
13. Explain trapping of football with the aid of diagrams.
14. What led to the collapse of the Tacoma Narrows Bridge?
15. How does a quartz clock work?

Section C

[Answer any one question. 10 marks] (1×10=10 marks)

16. Explain the working of a refrigerator.
17. Explain how Hawkeye, Hotspot, Snicko and Super SloMo works.

II Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY2FM106: ASTRONOMY AND STARGAZING

(credits: 3)

Maximum Time: 1.5 hours **Maximum Marks: 50**

Section A

[Answer All. Each question carries 2 marks] (Ceiling 16 marks)

1. Define the terms zenith and meridian.
2. Lunar eclipse happens when the Moon is in a full moon phase, why?
3. Distinguish between refracting and reflecting telescopes.
4. Explain the terms equinoxes and solstices.
5. List out the naked eye planets in the solar system.
6. What is Zodiac?
7. How did Hipparchus classify the stars based on the brightness?
8. How did meteor showers form?
9. Why do we always see the same face of the Moon?
10. What is the Kuiper Belt and what is its significance?

Section B

[Answer All. Each question carries 6 marks] (Ceiling 24 marks)

11. Write a note on the Milky way galaxy.
12. Explain the Giant Impact Model of the formation of the Moon.
13. How stars are born, live, and die? 4
14. Write a short note on the winter constellation, Orion, Taurus and Canis Major.
15. Discuss the large-scale structural hierarchy of the Universe.

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

16. Discuss about the (a) structure, power production, formation of Sun (b) organization and formation of Solar system.

17. In what ways did the work of Copernicus and Galileo differ from the views of the ancient Greeks and of their contemporaries and how Kepler's three laws strengthened their ideas?

III Semester B.Sc. (FYUGP) Degree Examinations October 2024

PHY4FV110: Science Communication

(Credits: 3)

Maximum Time: 1.5 hours **Maximum Marks: 50**

Section A

[Answer all questions. Each question carries 2 marks] (Ceiling: 16 Marks)

1. What all elements are included in the preamble of a latex document? Illustrate with an article document type.
2. How can a Latex document split into different parts? Illustrate with a book document type.
3. Which all environments can be used to type in equations in Latex? Give brief examples.
4. Which are the font sizes available In Latex?
5. Write latex code to obtain the following output:

   The value of x is given by:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

6. How will you obtain the following output in Latex *without* using any math environments? Measured 1st temperature: 30^0 C, H_2O level: 40%
7. How can we include a logo in our presentation using beamer? Illustrate with an example.
8. What do you mean by peer review and why is it important in scientific publishing?
9. Write a note on different types of science communication?
10. What is plagiarism in the context of scientific communication?

Section B

[Answer all questions. Each question carries 6 marks] (Ceiling: 24 Marks)

11. In a beamer presentation, how can we display bulleted points one by one?
12. Write Latex code to obtain the following table in Latex:

Day	Min Temp	Max Temp	Summary
Monday	11C	22C	A clear day with lots of sunshine. However, the strong breeze will bring down the temperatures.
Tuesday	9C	19C	Cloudy with rain, across many northern regions. Clear spells across most of Scotland and Northern Ireland, but rain reaching the far northwest.
Wednesday	10C	21C	Rain will still linger for the morning. Conditions will improve by early afternoon and continue throughout the evening.

13. Write Latex code to obtain the following output. Take note of alignment, equations etc. Do not use more than one math environment.

$$\lambda = \frac{h}{p}$$

$$p = \frac{h}{\lambda} = \frac{6.626 \times 10^{-34}}{9.16 \times 10^{-15}} = 7.23 \times 10^{-20}\, kgms^{-1}$$

Using $p = \dfrac{mv}{\sqrt{1 - \dfrac{v^2}{c^2}}}$

$$p = \frac{mv}{\sqrt{1 - \dfrac{v^2}{c^2}}}$$

$$p^2 \left(1 - \frac{v^2}{c^2}\right) = m^2 v^2$$

Solving for v,

$$v = \frac{p}{\sqrt{m^2 + \dfrac{p^2}{c^2}}}$$

$$= \frac{7.23 \times 10^{-20}}{\sqrt{(1.673 \times 10^{-27})^2 + \dfrac{(7.23 \times 10^{-20})^2}{(3 \times 10^8)^2}}} = 4.28 \times 10^7\, m/s$$

14. Explore the significance of open access to scientific knowledge. What are the potential benefits and challenges associated with this?
15. What are the main parts of a research paper? Briefly explain the purpose of each part.

Section C

[Answer any one question. 10 marks] (1×10=10 marks)

16. Design a Beamer presentation about a P-N junction diode with 6-7 slides: Title slide, slides explaining, P type material, N type material, doping, what a P-N junction diode is, how it is created and the depletion layer. Slides need a title, preferably a theme, display bulleted points should appear one by one. Include a picture with .jpg extension with a filename 'diode.jpg' in the side describing what a diode is.

17. Discuss the importance of effective oral presentation skills in science communication. Explain the norms for preparing slides and delivering presentations to engage and inform audiences effectively.

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EQUIVALENT ONLINE COURSES

LIST OF EQUIVALENT ONLINE COURSES

Sl. No.	CU-FYUGP Course	Equivalent Online Course	Equivalent Credit	Duration	Repository	Weblink	Remarks
	MAJOR CORE (Level 300-399)						
1	PHY6CJ304 Thermodynamics	Engineering Thermodynamics	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc23_me141/preview	
2		Thermodynamics	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_me98/preview	
3	PHY6CJ305 Electronics – II	Analog Electronic Circuits	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ee106/preview	
4		Fundamental of Electronic Engineering	4	12 weeks	Swayam-NPTEL	https://onlinecourses.swayam2.ac.in/nou24_ec08/preview	
5	PHY6CJ306 Nuclear and Particle Physics	Nuclear and Particle Physics	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ph41/preview	
		Nuclear and Particle Physics	4	12 weeks	Swayam-CEC	https://onlinecourses.swayam2.ac.in/cec24_ma13/preview	
	MAJOR ELECTIVE (Level 300-399)						
6	PHY6EJ301(1) Nano Science and Nano Technology	Nanomaterials and their Properties	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_mm38/preview	Elective for specialization
7	PHY6EJ 302(1)/PHY6EJ304(2) Optoelectronic and Solid State Devices	Physics of Biological Systems	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc20_ph02/preview	Elective for specialization
8	PHY6EJ303(2)Biophotonics	Nanomaterials and their Properties	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_mm38/preview	Elective for specialization
9	PHY6EJ305(3) Introductory Biophysics	Bio Photonics	3	12 Weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc21_ge13/preview	Elective for specialization
10	PHY6EJ307(4) Foundations of Artificial Intelligence	Fundamentals of Artificial intelligence	3	12 Weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ge47/preview	Elective for specialization
11	PHY6EJ308(4) Machine Learning using Python	Introduction to Machine Learning	3	12 Weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_cs101/preview	Elective for specialization
12	PHY6EJ310 Atmospheric Physics	Introduction to Atmospheric and Space Sciences	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc20_ph11/preview	

	Other Elective Courses (Level 300-399)						
13		Nanophotonics, Plasmonics, and Metamaterials	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ee142/preview	
14		Introduction to LASER	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ph45/preview	
15		Applied Optics	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ph39/preview	
16		Physics of Functional Materials & Devices	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ph32/preview	
17		Physics of Renewable Energy Systems	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ph29/preview	
18		Particle Physics	4	12 weeks	Swayam-NPTEL	https://onlinecourses.swayam2.ac.in/ini24_ph01/preview	
19		Statistical Physics of Non-Interacting and Interacting Systems	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ph46/preview	
20		Scientific Computing using Python	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ph36/preview	
21		An Introduction to Climate Dynamics, Variability and Monitoring	3	12 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ce100/preview	
	SEC3 (Level 300-399)						
22	PHY6FS113 - SEC 3 Electrical And Photovoltaic Devices	Solar Photovoltaics Fundamentals, Technology and Applications	2	8 weeks	Swayam-NPTEL	https://onlinecourses.nptel.ac.in/noc24_ph26/preview	