SYLLABUS
For
MASTER PROGRAM (MSc.)
In
PHYSICS

(Batch 2025 Onwards)

Under

The National Education Policy, 2020 (NEP 2020)

DEPARTMENT OF PHYSICS

(A DST-FIST & UGC-SAP Assisted Department)

University of Kashmir

(NAAC Accredited A++)

Hazratbal, Srinagar, Kashmir, J&K-190006

(Approved in Borad of Post Graduate Studies (BOPGS) held on 05th May 2025)

MASTER PROGRAM (MSc.) In PHYSICS	
Program Learning Outcomes (PLOs)	**Postgraduate Degree in Physics**
After successfully earning the Postgraduate Degree in Physics, the awardee will be able to:	
PLO-01: Knowledge & Understanding	● Demonstrate advanced theoretical and applied knowledge of core and specialized areas in physics and apply this knowledge to analyze natural phenomena.
PLO-02: Experimental & Analytical Skills	● Acquire advanced computational, experimental, and analytical skills to investigate physical phenomena, interpret data, and solve complex problems, including those with interdisciplinary and real-world applications.
PLO-03: Application of Knowledge & Skills	● Integrate theoretical principles and practical methodologies to design experiments, develop models, and propose solutions to research and real-world challenges in physics.
PLO-04: Critical Thinking & Problem-Solving	● Critically evaluate scientific literature across diverse physics domains, analyze complex systems, and formulate evidence-based conclusions using logical and quantitative methods.
PLO-05: Lifelong Learning & Adaptability	● Engage in continuous self-directed learning to stay abreast of advancements in physics and related technologies, adapting to evolving scientific demands. Foster academic and scientific growth.
PLO-06: Digital Literacy & Computational Proficiency	● Utilize information and communication technologies (ICT) for scientific research, collaborative work, and lifelong learning. Conduct literature reviews using digital databases, process and visualize data with programming tools (e.g., Python, MATLAB, Origin. etc.) and develop computational models.
PLO-07: Research & Innovation Aptitude	● Formulate research problems and hypotheses, apply scientific methods, and conduct independent and collaborative research. Demonstrate competence in preparing, submitting, and presenting dissertations or internship reports. Work productively as part of research or project team.

Course Structure

The postgraduate program in Physics is a two-year degree meticulously designed with **Multiple Entry and Exit Points (MEES)**, in alignment with the National Education Policy (**NEP**) **2020**.

Program Structure:

S.No.	Award	Components	Credits Required
1.	PG Diploma	Coursework (CW)	46 Credits
2.	PG	(CW + CW)	90 Credits
3.	PG with Research	(CW + Research)	90 Credits

Multiple Entry and Exit System (MEES) Details

The program's MEES framework provides flexibility, as detailed below:

Entry Points:

1. **First Year Entry (M.Sc. Year 1): Eligibility:** Applicants must hold a 3-three-year Bachelor of Science (B.Sc.) degree or B.E./B. Tech degree with Physics Subject/discipline having at least 12 Credits.
2. **Second Year Direct Entry (M.Sc. Year 2): Eligibility:** Applicants with a 4-year undergraduate degree in Physics (Honors/Research) or B.E./B. Tech degree with having at least 20 Credits.

Exit Points:

1. **After First Year (PG Diploma):** Students who successfully complete two semesters (totaling 46 credits) are eligible to exit the program with a Postgraduate Diploma in Physics.
2. **After Second Year (PG):** Students who complete all four semesters (totaling 90 credits, exclusively coursework) will be awarded a Postgraduate Degree in Physics.
3. **After Second Year (PG with Research):** Students who complete all four semesters, which includes a dedicated 24-credit research internship (totaling 90 credits), will earn a Postgraduate Degree with Research in Physics.

Course Structure for PG Diploma in Physics (Programme Code: PDPH)/
Two Years PG. in Physics with Coursework Programme Code: MSPH)
1yr.PGD; 2/1 yr. lateral entry .PG(CW+CW)

NCrf Credit Level	Semes-ter	Core Papers (Core Course/Elective)		Cour-se Level	Credit	Total Credits		Max. Marks			Credit Distribution	Contact Hour
		Course Name	Course Code					Internal	End Sem	Total	L:T:P	
6	Sem-I	Mathematical Physics -I (Core)	MPHYCMP125	550	4	16	22	30	70	100	3:1:0	64
		Quantum Mechanics-I (Core)	MPHYCQM125	550	4			30	70	100	3:1:0	64
		Classical Mechanics (Core)	MPHYCCM125	550	4			30	70	100	3:1:0	64
		Lab-I/ MPHYLLB125 (Core)	MPHYLLB125	550	4			30	70	100	0:0:4	128
		Electronics-I (Elective)	MPHYDEC125	550	2	06		15	35	50	2:0:0	32
		Atmospheric Physics (Elective)	MPHYDAP125	550	2			15	35	50	2:0:0	32
		Communication Physics (Elective)	MPHYDCP125	550	2			15	35	50	2:0:0	32
		Physics of Nanomaterials (Elective)	MPHYDNM125	550	2			15	35	50	2:0:0	32
		Materials Science (Elective)	MPHYDMS125	550	2			15	35	50	2:0:0	32
		Online SWAYAM Course (Elective)	MPHYDSY125	550	2			15	35	50	2:0:0	32
	Sem-II	Quantum Mechanics-II (Core)	MPHYCQM225	600	4	16	24	30	70	100	4:0:0	64
		Classical Electrodynamics (Core)	MPHYCCE225	600	4			30	70	100	3:1:0	64
		Statistical Mechanics (Core)	MPHYCSM225	600	4			30	70	100	3:1:0	64
		Lab-II (Core)	MPHYLLB225	600	4			30	70	100	0:0:4	128
		Astrophysics-I (Elective)	MPHYDAA225	600	2	04		15	35	50	2:0:0	32
		Electronics-II (Elective)	MPHYDEC225	600	2			15	35	50	2:0:0	32
		Electronic Instrumentation and Measurements (Elective)	MPHYDEM225	600	2			15	35	50	2:0:0	32
		Mathematical Physics-II (Elective)	MPHYDMP225	600	2			15	35	50	2:0:0	32
		Quantum Information Theory (Elective)	MPHYDQI225	600	2			15	35	50	2:0:0	32
		Energy Studies (Elective)	MPHYDES225	600	2			15	35	50	2:0:0	32
		Online SWAYAM Course (Elective)	MPHYDSY225	600	2			15	35	50	2:0:0	32
		Research Methodology-I (Skill)	MPHYSRM225	600	2	04		15	35	50	2:0:0	32
		Seminar-I (Skill)	MPHYSSM225	600	2			15	35	50	0:0:2	64
Total Credit (First Year)							**46**					**864 hrs. (Min)**

Exit option with Post-Graduate Diploma in Physics on completion of courses equal to a minimum of 46 credits or Entry to One Year PG in Physics with coursework & Research

NCrf Credit Level	Semes-ter	Core Papers (Core Course/Elective)		Cour-se Level	Credit	Total Credits		Max. Marks			Credit Distribution	Contact Hour
		Course Name	Course Code					Internal	End Sem	Total		
6.5	Sem-III	Nuclear & Particle Physics (Core)	MPHYCNP325	650	4	10	24	30	70	100	3:1:0	64
		Condensed Matter Physics (Core)	MPHYCCM325	650	4			30	70	100	3:1:0	64
		Atomic and Molecular Physics (Core)	MPHYCAM325	650	2			15	35	50	2:0:0	32
		Laser Physics (Elective)	MPHYDLP325	650	2	10		15	35	50	2:0:0	32
		Microwave Electronics (Elective)	MPHYDME325	650	2			15	35	50	2:0:0	32
		High Energy Physics (Elective)	MPHYDHE325	650	2			15	35	50		32
		Astrophysics-II (Elective)	MPHYDAA325	650	2			15	35	50	2:0:0	32
		Superconductivity (Elective)	MPHYDSC325	650	2			15	35	50	2:0:0	32
		Quantum Field Theory (Elective)	MPHYDQF325	650	2			15	35	50	2:0:0	32
		Radiation Physics (Elective)	MPHYDRP325	650	2			15	35	50	2:0:0	32
		Introduction to Spintronics (Elective)	MPHYDIS325	650	2			15	35	50	2:0:0	32
		Online SWAYAM Course (Elective)	MPHYDSY325	650	2			15	35	50	2:0:0	32
		Research Methodology-II (Skill)	MPHYSRM325	650	2	04		15	35	50	2:0:0	32
		Seminar-II (Skill)	MPHYSSM325	650	2			15	35	50	0:0:2	64
	Sem-IV	Computational Methods with Python (Core)	MPHYCCM425	700	4	04	20	30	70	100	2:0:2	32+64
		Advanced Solid-State Physics (Elective)	MPHYCSS425	700	4	08		30	70	100	3:1:0	64
		Antenna and Wave Propagation (Elective)	MPHYDAW425	700	4			30	70	100	3:1:0	64
		Density Functional Theory of Materials (Elective)	MPHYDDF425	700	2			15	35	50	2:0:0	32
		Neutrino Physics (Elective)	MPHYDNP425	700	2			15	35	50	2:0:0	32
		General Theory of Relativity (Elective)	MPHYCTR425	700	2			15	35	50	2:0:0	32
		Radiation Physics(Elective)	MPHYCRP425	700	2			15	35	50	2:0:0	32
		Environmental Physics (Elective)	MPHYDEP425	700	2			15	35	50	2:0:0	32
		Online SWAYAM Course (Elective)	MPHYDSY425	700	4			30	70	100	3:1:0	64
		Project (Project)	MPHYPPJ425	700	8	08		50	150	200	0:0:8	240
		Total Credit (Aggregate)				**90**		**1712 hrs.(Min.)**				
		Post-Graduate Degree in Physics with Coursework on completion of courses equal to 90 credits with 1712 hrs.										

Course Structure for One Year PG Diploma in (Physics; Prog. Code: PDPH)/
Two Years PG. in (Physics) with Coursework & Research (Programme Code: MSPH)
1yr.PGD; 2 /1 yr. lateral entry PG (CW+R)

NCrf Credit Level	Semes -ter	Core Papers (Core Course/Elective)		Course Level	Credit	Total Credits		Max. Marks			Credit Distribution	Contact Hour
		Course Name	Course Code					Internal	End Sem	Total	L:T:P	
6	Sem-I	Mathematical Physics -I (Core)	MPHYCMP125	550	4	16	22	30	70	100	3:1:0	64
		Quantum Mechanics-I (Core)	MPHYCQM125	550	4			30	70	100	3:1:0	64
		Classical Mechanics (Core)	MPHYCCM125	550	4			30	70	100	3:1:0	64
		Lab-I (Laboratory)	MPHYLLB125	550	4			30	70	100	0:0:4	128
		Electronics-I (Elective)	MPHYDEC125	550	2	06		15	35	50	2:0:0	32
		Atmospheric Physics (Elective)	MPHYDAP125	550	2			15	35	50	2:0:0	32
		Communication Physics (Elective)	MPHYDCP125	550	2			15	35	50	2:0:0	32
		Physics of Nanomaterials (Elective)	MPHYDNM125	550	2			15	35	50	2:0:0	32
		Materials Science (Elective)	MPHYDMS125	550	2			15	35	50	2:0:0	32
		Online SWAYAM Course (Elective)	MPHYDSY125	550	2			15	35	50	2:0:0	32
	Sem-II	Quantum Mechanics-II (Core)	MPHYCQM225	600	4	16	24	30	70	100	4:0:0	64
		Classical Electrodynamics (Core)	MPHYCCE225	600	4			30	70	100	3:1:0	64
		Statistical Mechanics (Core)	MPHYCSM225	600	4			30	70	100	3:1:0	64
		Lab-II (Laboratory)	MPHYLLB225	600	4			30	70	100	0:0:4	128
		Astrophysics-I (Elective)	MPHYDAA225	600	2	04		15	35	50	2:0:0	32
		Electronics-II (Elective)	MPHYDEC225	600	2			15	35	50	2:0:0	32
		Electronic Instrumentation and Measurements (Elective)	MPHYDEM225	600	2			15	35	50	2:0:0	32
		Mathematical Physics-II (Elective)	MPHYDMP225	600	2			15	35	50	2:0:0	32
		Quantum Information Theory (Elective)	MPHYDQI225	600	2			15	35	50	2:0:0	32
		Energy Studies (Elective)	MPHYDES225	600	2			15	35	50	2:0:0	32
		Online SWAYAM Course (Elective)	MPHYDSY225	600	2			15	35	50	2:0:0	32
		Research Methodology-I (Skill)	MPHYSRM225	600	2	04		15	35	50	2:0:0	32
		Seminar-I (Skill)	MPHYSSM225	600	2			15	35	50	0:0:2	64
Total Credit (First Year)							**46**					**864 hrs. (Min)**

Exit option with Post-Graduate Diploma in Physics on completion of courses equal to a minimum of 46 credits or Entry to One Year PG in Physics with coursework & Research

NCrf Credit Level	Semes-ter	Core Papers (Core Course/Elective)		Course Level	Credit	Total Credits		Max. Marks			Credit Distribution	Contact Hour
		Course Name	Course Code					Internal	End Sem	Total		
6.5	Sem-III	Nuclear & Particle Physics (Core)	MPHYCNP325	650	4	10	**24**	30	70	100	3:1:0	64
		Condensed Matter Physics (Core)	MPHYCCM325	650	4			30	70	100	3:1:0	64
		Atomic and Molecular Physics (Core)	MPHYCAM325	650	2			15	35	50	2:0:0	32
		Laser Physics (Elective)	MPHYDLP325	650	2	10		15	35	50	2:0:0	32
		Microwave Electronics (Elective)	MPHYDME325	650	2			15	35	50	2:0:0	32
		High Energy Physics (Elective)	MPHYDHE325	650	2			15	35	50		32
		Astrophysics-II (Elective)	MPHYDAA325	650	2			15	35	50	2:0:0	32
		Superconductivity (Elective)	MPHYDSC325	650	2			15	35	50	2:0:0	32
		Quantum Field Theory (Elective)	MPHYDQF325	650	2			15	35	50	2:0:0	32
		Radiation Physics (Elective)	MPHYDRP325	650	2			15	35	50	2:0:0	32
		Introduction to Spintronics (Elective)	MPHYDIS325	650	2			15	35	50	2:0:0	32
		Online SWAYAM Course (Elective)	MPHYDSY325	650	2			15	35	50	2:0:0	32
		Research Methodology-II (Skill)	MPHYSRM325	650	2	04		15	35	50	2:0:0	32
		Seminar-II (Skill)	MPHYSSM325	650	2			15	35	50	0:0:2	64
	Sem-IV	Dissertation/Internship (Internship)	MPHYIDI425	700	20		**20**	150	350	500	0:0:24	720
	Total Credit (Aggregate)						**90**					**1880 hrs. (Min.)**
	Post-Graduate Degree in Physics with Research on completion of courses equal to 90 credits with 1880 hrs.											

Course Selection Guidelines:

- **SWAYAM Courses:** Students need to talk with the Head of the Physics Department (HOD Physics) before choosing any online SWAYAM courses.
- **Mandatory Courses:** All **Core Courses (C)**, **Laboratory Courses (L)**, **Skill Enhancement Courses (S)**, **Internship (I)**, and **Project (P)** are required. You don't have a choice for these.
- **Elective Courses:** You can choose your **Discipline-Centric Elective courses (D)** from a provided list. The total credits for these chosen electives must be:
  - **06 credits** for Semester I
  - **10 credits** for Semester III
  - **04 credits** for Semester II
  - **08 credits** for Semester IV (CW+CW)

Semester-I

Course Type	Course Code	Course Name	Credits
Core Course (C) /Laboratory (L)	MPHYCMP125	Mathematical Physics -I	4
	MPHYCQM125	Quantum Mechanics-I	4
	MPHYCCM125	Classical Mechanics	4
	MPHYLLB125	Lab-I	4
		Total Core/Laboratory Credits	**16**
Discipline Centric Elective Course (D)	MPHYDEC125	Electronics-I	2
	MPHYDAP125	Atmospheric Physics	2
	MPHYDCP125	Communication Physics	2
	MPHYDNM125	Physics of Nanomaterials	2
	MPHYDMS125	Materials Science	2
	MPHYDSY125	Online SWAYAM Course (No overlap with running courses)	2
		Total Discipline Centric Elective Credits	**6**
Total Credits Semester-I			**22**

Note: Students will choose online SWAYAM courses in consultation with HOD Physics

- No. of Core Course (C) /Laboratory (L) to be opted = 04 (12 Credits Theory + 04 Credits Lab) = **16** credits
- No. of Discipline Centric Elective Papers to be opted = 03 (02 Credits each) = **06** Credits
- Total No. of Credits = **22** Credits

Semester-II

Course Type	Course Code	Course Name	Credits
Core Course (C) /Laboratory (L)	MPHYCQM225	Quantum Mechanics-II	4
	MPHYCCE225	Classical Electrodynamics	4
	MPHYCSM225	Statistical Mechanics	4
	MPHYLLB225	Lab-II	4
		Total Core/Laboratory Credits	**16**
Discipline Centric Elective Course (D)	MPHYDAA225	Astrophysics-I	2
	MPHYDEC225	Electronics-II	2
	MPHYDEM225	Electronic Instrumentation and Measurements	2
	MPHYDMP225	Mathematical Physics-II	2
	MPHYDQI225	Quantum Information Theory	2
	MPHYDES225	Energy Studies	2
	MPHYDXX225	Online SWAYAM Course (No overlap with running courses)	2
		Total Discipline Centric Elective Credits	**4**
Skill Enhancement Course (S)	MPHYSRM225	Research Methodology-I	2
	MPHYSSM225	Seminar-I	2
		Total Skill Enhancement course (S) Credits	**4**
Total Credits Semester-II			**24**

Note: Students will choose online SWAYAM courses in consultation with HOD Physics

- No. of Core Course (C) /Laboratory (L) to be opted = 04 (12 Credits Theory + 04 Credits Lab) = **16** credits
- No. of Discipline Centric Elective Papers to be opted = 02 (02 Credits each) = **04** Credits
- No. of Skill Enhancement course (S) to be opted = 02 (04 Credits each) = **04** Credits
- Total No. of Credits = **24** Credits

Semester-III

Course Type	Course Code	Course Name	Credits
Core Course (C)	MPHYCNP325	Nuclear & Particle Physics	4
	MPHYCCM325	Condensed Matter Physics	4
	MPHYCAM325	Atomic and Molecular Physics	2
		Total Major Core Credits	**10**
Discipline Centric Elective Course (D)	MPHYDLP325	Laser Physics	2
	MPHYDME325	Microwave Electronics	2
	MPHYDHE325	High Energy Physics	2
	MPHYDAA325	Astrophysics-II	2
	MPHYDSC325	Superconductivity	2
	MPHYDQF325	Quantum Field Theory	2
	MPHYDRP325	Radiation Physics	2
	MPHYDIS325	Introduction to Spintronics	2
	MPHYDXX325	Online SWAYAM Course (No overlap with running courses)	2
		Total Discipline Centric Elective Credits	**10**
	MPHYSRM325	Research Methodology-II	2
Skill Enhancement course (S)	MPHYSSM325	Seminar-II	2
		Total Skill Enhancement course (S) Credits	**4**
Total Credits Semester-III			24

Note: Students will choose online SWAYAM courses in consultation with HOD Physics

- No. of Core Course (C) = 03 (10 Credits Theory) = **10** credits
- No. of Discipline Centric Elective Papers to be opted = 05 (02 Credits each) = **10** Credits
- No. of Skill Enhancement course (S) to be opted = 02 (02 Credits each) = **04** Credits
- Total No. of Credits = **24** Credits

Semester-IV (CW)

Course Type	Course Code	Course Name	Credits
Core Course (C)	MPHYCCP425	**Computational Methods in Physics (Programing)**	4
	Total Major Core Credits		**4**
Discipline Centric Elective Course (D)	MPHYCSS425	Advanced Solid-State Physics	4
	MPHYDAW425	Antenna and Wave Propagation	4
	MPHYDDF425	Density Functional Theory of Materials	2
	MPHYDNP425	Neutrino Physics	2
	MPHYCTR425	General Theory of Relativity	2
	MPHYCRP425	Radiation Physics	2
	MPHYDEP425	Environmental Physics	2
	MPHYDXX425	Online SWAYAM Course/Courses (No overlap with running courses)	4
	Total Discipline (Centric Elective Credits)		**8**
Project	MPHYPPJ425	Project	8
	Total Discipline (Centric Elective Credits)		**8**
Total Credits Semester-IV			**20**

Note: Students will choose online SWAYAM courses in consultation with HOD Physics

- No. of Core Course (C) = 01 (12 Credits Theory) = **04** credits
- No. of Discipline Centric Elective Papers to be opted = 02 to 04 (02/04 Credits each) = **8** Credits
- Project (P) = 01 (08 Credits Theory) = **08** credits
- Total No. of Credits = **20** Credits

Semester-IV (Research)

Course Type	Course Code	Course Name	Credits
Dissertation (DI)	MPHYIDI425	Dissertation/Internship	20
Total Credits Semester-IV			**20**

- Dissertation/Internship (I) = **20** credits
- Total No. of Credits = **20** Credits

Total credit distribution for the Four semesters

CW+R					
	C/L	D	S	I	Total credits (semester wise)
Semester-I	16	6	0	0	22
Semester-II	16	6	2	0	24
Semester-III	10	12	2	0	24
Semester-IV	0	0	0	20	20
Total credits (Courses type)	42	24	4	20	90

CW+CW					
	C/L	D	S	P	Total credits (semester wise)
Semester-I	16	6	0	0	22
Semester-II	16	6	2	0	24
Semester-III	10	12	2	0	24
Semester-IV	4	8	0	8	20
Total credits (Courses type)	46	32	4	8	90

Types of Courses:

- C - Core Course (C)
- L - Laboratory (L)
- D - Discipline Centric Elective Course (D)
- S - Skill Enhancement course (S)
- I – Internship/Dissertation (I)

Semester I

Course Code		Course Title			Type of Course
MPHYCMP125		**Mathematical Physics I**			**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**64 (48L+16T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Understand the theory of complex functions and master the mathematical tools of complex analysis so as to efficiently solve problems in Physics
- **CLO 2:** Understand the utility of Gamma and Beta functions, Dirac Delta function and their applications. Create ad manipulate infinite series along with the convergence tests
- **CLO 3:** Formulate problems in Physics in terms of differential equations and solve the frequently used differential equations in Physics
- **CLO 4:** Develop an understanding of the widely used special mathematical functions in Physics, particularly the Bessel functions, Legendre/associated Legendre, Laguerree/ associate Laguerree, hermite functions and the likes. Also, derivation and discussion of their properties including orthonormality, recurrence relations, generating functions etc.

Unit-I

Review of Complex variable Theory; Laurent Series, Singularities; Calculus of residues, Evaluation of Definite Integrals, Evaluation of Sums.

Schwarz Reflection Principle; Conformal Mapping; Rodrigue's Formula; Generating Functions for the commonly used polynomials in Physics.

Unit-II

The Gamma Function; Definitions, Simple Properties, Factorial and Double factorial, Digamma and Polygamma Functions, Stirlings Series. The Beta Function, Legendre duplication formula. Infinite series; Convergence tests, Riemann Zeta Functions. Dirac Delta function and its properties.

Unit-III

Partial differential equations (PDEs) and their reduction to ordinary differential equations (ODEs), First and Second order ODEs, Series Solution and its limitations, Other (Wronskian double integral) Solution. Inhomogeneous ODEs, Nonlinear Differential Equations

Unit-IV

Bessel functions of integral order; Recurrence Relations, Integral representation, Orthonormality, non-integer order, Bessel Series. Definitions of the Bessel functions of Second and Third kind; Recurrence relations. Modified Bessel functions. Spherical Bessel functions.

Legendre functions; Properties and Recurrence relations, Upper and Lower bound, Orthonormality. Associated Legendre functions. Spherical Harmonics. Angular Momentum.

Hermite functions; Recurrence relations, Orthonormality, Simple Harmonic Oscillator. Laguerre and Associated Laguerre Polynomials; Properties, Radial Schrodinger equation.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCMP125. 1	3	2	3	3	2	2	2	2.43
MPHYCMP125. 2	3	2	3	3	2	2	2	2.43
MPHYCMP125. 3	3	2	3	3	2	2	2	2.43
MPHYCMP125. 4	3	2	3	3	2	2	2	2.43
Average PLO	3	2	3	3	2	2	2	**2.43**

Text Books:

1) Mathematical Methods for Physicists (7th Ed. by G. B. Arfken and H. J. Weber and F. E. Harris (Academic Press)

References:

1) Mathematical Methods For Students of Physics and Related Fields by Sadri Hassani (Springer)
2) Mathematics for Physicists by Philippe Dennery (Dover)
3) Advanced Engineering Mathematics by Michel Greenberg (Prentice Hall)
4) Mathematical Methods for Physics and Engineering by Riley, Hobson and Bence (Cambridge)
5) Advanced Engineering Mathematics by E Kreyzig (Wiley)

<table>
<tr><td colspan="2">Course Code</td><td colspan="3">Course Title</td><td>Type of Course</td></tr>
<tr><td colspan="2">MPHYCQM125</td><td colspan="3">Quantum Mechanics-I</td><td>C</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Total Credits</td><td>Max. Marks</td><td>Total Contact Hrs.</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>100</td><td>64 (48L+16T)</td></tr>
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Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO1 (Unit I)**: Develop a foundational understanding of quantum mechanics through key experiments, mathematical representations, and operator formalism.
- **CLO2 (Unit II):** Analyze the solutions of the Schrödinger equation for model systems (potential wells, barriers, harmonic oscillator), and interpret physical phenomena like tunneling and classical limits.
- **CLO3 (Unit III):** Apply angular momentum algebra including spin, orbital contributions, and SU(2)/O(3) symmetry; compute eigenvalues, Clebsch-Gordon coefficients, and use symmetry arguments in quantum systems.
- **CLO4 (Unit IV):** Solve problems involving motion in central potentials, including the hydrogen atom, and analyze spherical wave functions and associated boundary conditions.

UNIT-I

The Double-Slit Experiment and Stern-Gerlach Experiment. Kets, Bras, and Operators. Matrix Representations. Measurements, Observables, and Uncertainty Relations. Change of Basis: Unitary operators. Position, Momentum, and Translation. Wave Functions in Position and Momentum. Quantum Dynamics: Time-Evolution and the Schrodinger Equation. The Schrodinger Versus the Heisenberg Picture.

UNIT-II

Schrodinger's Wave Equation: Fundamental properties, Current density, General Properties of motion in one dimension. Classical Limit of Schrodinger equation. Potential well, Harmonic oscillator. Transmission and Reflection coefficients: Delta function potential. Tunnelling through a Barrier.

UNIT-III

Angular momentum, Rotation as Group. O(3) and SU(2). Eigenvalues and eigenfunctions of angular momentum. Symmetries and their Consequences. Parity and time reversal invariance. Addition of angular momentum, Clebsch-Gordon Coefficients, Symmetry Relations of CG coefficients, Evaluation of CG coefficients. Matrix representation of the rotation operators.

UNIT-IV

Motion in a centrally symmetric field, Spherical waves, Infinite Spherical Well, Resolution of a plane wave. Fall of a particle to the Centre, Motion in a coulomb field: Hydrogen atom.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCQM125.1	3	2	2	2	2	1	2	2
MPHYCQM125.2	3	3	3	3	2	2	2	2.57
MPHYCQM125.3	3	3	3	3	2	3	3	2.86
MPHYCQM125.4	3	3	3	3	2	2	3	2.7
Average PLO	3	2.75	2.75	2.75	2	2	2.5	**2.54**

TEXTBOOK:

1) J. J. Sakurai, Modern Quantum Mechanics, Third Edition(Cambridge University Press).

REFERENCE BOOKS:

1) Non-Relativistic Quantum Mechanics: L. D. Landau and E. M. Lifshitz, Permagon Press.
2) Principles of Quantum Mechanics: R. Shankar, Springer-Verlag.

<table>
<tr><td colspan="2">Course Code</td><td colspan="3">Course Title</td><td>Type of Course</td></tr>
<tr><td colspan="2">MPHYCCM125</td><td colspan="3">Classical Mechanics</td><td>C</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Total Credits</td><td>Max. Marks</td><td>Total Contact Hrs.</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>100</td><td>64 (48L+16T)</td></tr>
<tr><td colspan="6">Course Learning Objectives (CLOs) : By the end of this course, students will be able to:
• CLO 1 (Unit I): Apply Lagrangian mechanics to derive equations of motion for various physical systems, including constrained systems and those in electromagnetic fields.
• CLO 2 (Unit II): Utilize the principles of variational calculus and Hamiltonian dynamics to solve problems in classical mechanics, understanding concepts like conservation laws, phase space, and Liouville's theorem.
• CLO 3 (Unit III): Analyze advanced theoretical mechanics concepts such as canonical transformations, Poisson Brackets, action-angle variables, and the Hamilton-Jacobi equation, applying them to specific problems like central force motion.
• CLO 4 (Unit IV): Solve problems related to different types of oscillations, including damped and coupled systems, and extend Lagrangian and Hamiltonian formulations to continuous systems.</td></tr>
</table>

Unit - I

The Lagrangian Approach to Mechanics: degrees of freedom, constraints and generalized coordinates, virtual displacement, virtual work and generalized force, d'Alembert's principle and the generalized equation of motion, the Lagrangian and the Euler Lagrange equation of motion, the Hamiltonian, cyclic coordinates and canonical momenta, applications; double pendulum, spherical pendulum, particle in electromagnetic field.

Unit - II

Variational calculus and Hamiltonian dynamics: the variational calculus and the Euler equation, the principle of least action and the Euler Lagrange equation, constraints in variational dynamics. Hamiltonian dynamics: Legendre transformations, Hamilton's equations, conservation laws, phase space and Liouville's theorem.

Unit - III

Theoretical Mechanics: canonical transformations and generating functions, symplectic notation, Poisson Brackets (PB); the angular momentum PB relations, invariance of PBs under canonical transformations, action-angle variables and adiabatic invariance, the Hamilton Jacobi (HJ) Equation; HJ equation for Hamilton's characteristic function, separation of variables, particle motion under central force

Unit - IV

Oscillations: the simple harmonic oscillator; the damped harmonic oscillator, the damped simple and damped harmonic oscillator, coupled simple harmonic oscillators; couple pendulum, general method of solution.

Lagrangian and Hamiltonian of continuous systems: transition from discrete to continuous systems, the Hamiltonian formulation.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCCM125. 1	3	2	3	2	3	1	1	2.14
MPHYCCM125. 2	3	2	3	2	3	1	1	2.14
MPHYCCM125. 3	3	2	3	3	3	1	1	2.29
MPHYCCM125. 4	3	2	3	3	3	2	1	2.43
Average PLO	3	2	3	2.5	3	1.25	1	2.25

Text Books:

1) Classical Mechanics by Goldstein, Poole and Safko (Pearson Education)
2) Mechanics by Landau and Lifshitz

Reference Books:

1) Analytical Mechanics by L. N. Hand and J. D. Finch (Cambridge University Press)

Course Code		Course Title			Type of Course
MPHYCLB125		**Lab-I**			**Laboratory**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
0	**0**	**4**	**4**	**100**	**128**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1:** Apply fundamental experimental techniques and principles to measure physical constants and properties in areas such as quantum mechanics (ESR, e/m), optics (laser diffraction), and acoustics (speed of sound).
- **CLO 2:** Design, construct, and characterize the performance of various analog electronic circuits, including operational amplifiers, rectifiers, Zener diode regulators, and function generators.
- **CLO 3:** Conduct experiments to investigate the characteristics and applications of semiconductor devices (LDR, Zener diode) and advanced materials (BaTiO3), interpreting their behavior under varying conditions.
- **CLO 4:** Develop proficient laboratory skills, including systematic data acquisition, accurate error analysis, and clear scientific report writing, while adhering to safety protocols.

List of Experiments:

S.No	Expt-No.	Aim/Objective	CREDIT	LAB
1	Expt-01:	(ESR)To measure the Landé g factor for the free electron in DPPH as predicted by quantum mechanics.	2	I
2	Expt-02:	Design and realize to analyze the frequency response of an op – amplifier under inverting and non - inverting configuration for a given gain.	2	I
3	Expt-03:	To study the variation in current flowing in circuit containing a LDR due to variation in intensity of light source and the distance from LDR also to Study LDR as an dark sensor.	2	I
4	Expt-04 :	To study the characteristics of half wave, full wave and bridge rectifier with and without filter and calculate the ripple factor, rectification efficiency and % regulation.	3	I
5	Expt-05:	To measure the relative permittivity (εr) of BaTiO3 at a series of temperatures and use these data obtain the Curie temperature Tc of barium Titanate.	3	I
6	Expt-06:	To determine Speed of Sound in air Using Phase change/ Lissajous Figures and show that the speed increases when the temperature is increased.	3	I

7	Expt-07:	To determine the plateau and optimal operating voltage of a Geiger-Müller counter. To determine the resolving time (dead time) of a GM counter and verify the Inverse square relationship between the distance and intensity of radiation:	3	I
8	Expt-08:	Obtain IV Characteristics of Zener diode & also observe zener as a voltage regulator. Calculate its load & line regulation.	2	I
9	Expt-09:	To Determine the wavelength of a laser light using diffraction grating and narrow slit (or thin wire) and determining the grating radial spacing of the CD.	2	I
10	Expt-10:	To measure the ratio of charge/mass (e/m) by Helical method, for electrons and to learn about phenomena of electric and magnetic deflection and application of vector product.	2	I
11	Expt-11:	To perform No load and Load characteristics of Solar Panel and study charging of batteries with and without Solar Panel.	3	I
12	Expt-12:	Implementation of the given Boolean function using logic gates in both sop and pos forms. Design and realization of logic gates using universal gates.	3	I
13	Ept-13	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency.	3	I
14	Ept-14	To measure the load requirements of the solar panel with the power resistor measured over time and evaluate its parameters. To study the charging and discharging characteristics of a solar battery with solar panel and with inverter.	4	I

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCLB125. 1	3	3	3	2	3	1	1	2.29
MPHYCLB125. 2	3	3	3	3	3	1	2	2.57
MPHYCLB125. 3	3	3	3	2	3	1	2	2.43
MPHYCLB125. 4	1	3	2	3	3	2	2	2.29
Average PLO	2.5	3	2.75	2.5	3	1.25	1.75	**2.39**

Course Code		Course Title			Type of Course
MPHYDEC125		**Electronics-I**			**D**
L	T	P	Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** To gain a deeper understanding of diodes in linear electronic circuits. To be able to Conceptualize, implement, and actualize in electronics circuits.
- **CLO 2 (Unit II): The** unit will enable students to have a deep understanding of electronic devices and applications. To gain a deeper understanding of filters in linear electronic circuits, to be able to Conceptualize, implement, and actualize in electronics circuits.

Unit-I:

Junction Diodes: Diode structure, Diode equation, Diode Specifications, Peak Inverse Voltage (PIV) and bias circuits, Diode Models: The Ideal Diode Mode, The Practical Diode Model, Complete Diode model, Bridge Rectifier with filter, Metal semiconductor junctions- Schottky barriers; Rectifying contacts; Ohmic contacts; Typical Schottky barriers Schottky Diode, Switching diodes, Varactor Diodes, Photodiodes

Unit-II:

Electronic filters: Filters in Electronics Circuits, Passive Filters: low pass and high pass filters; RC bandpass filter; Band reject Filter. Disadvantages of passive filters. Introduction to operational Amplifiers, Filter Design and Analysis with an Operational Amplifiers, First and Second-order Low Pass Active Filter, First and Second-order high Pass Active Filter.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDEC125. 1	3	2	2	2	3	2	1	2.14
MPHYDEC125. 2	3	2	3	2	3	2	2	2.43
Average PLO	3	2	2.5	2	3	2	1.5	**2.29**

Text Books:

1) R. Boylestad and L. Nashelski: Electronic Devices and Circuit Theory
2) J. Millman and C. Halkias: Integrated Electronics
3) B.G. Streetman, S. Banerjee: Solid State Electronic Devices
4) H. Taub and D. Schilling: Digital Integrated Electronics

5) P. Bhattacharyya: Semiconductor Optoelectronic Devices
6) S.M. Sze: Physics of Semiconductor Devices
7) A. P. Malvino and A. Brown, *Digital Computer Electronics*.

Course Code		Course Title			Type of Course
MPHYDAP125		**Atmospheric Physics**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Understand atmospheric structure and apply radiation laws to analyze energy balance and radiative processes in the Earth-atmosphere system
- **CLO 2 (Unit II):** Understand the physical, chemical, and optical properties of atmospheric aerosols and evaluate their role in radiation interactions and climate impact

Unit I:

Atmospheric Structure and Radiation: Origin, Composition, and Mean Structure of the Atmosphere, Vertical Profiles of Pressure and Density, Variable Constituents and Vertical Temperature Structure Fundamental Physics of Radiation:, Solar and Terrestrial Radiation, Radiation Laws (Planck's Law, Stefan-Boltzmann Law, Wien's Law), Absorption, Emission, and Scattering in the Atmosphere, Schwarzschild's Equation, Radiation in the Earth-Atmosphere System: Geographical and Seasonal Distribution, Radiative Heating and Cooling of the Atmosphere, Surface Energy Budget, Mean Annual Heat Balance

Unit II:

Atmospheric Aerosols and Optical Properties: Introduction to Atmospheric Aerosols, Characterization of Aerosols, Physical and Optical Properties of Aerosols: Size Distribution, Refractive Indices, Absorption and Scattering of Radiation by Aerosols. Key Optical Properties of Aerosols: Single Scattering Albedo, Aerosol Optical Depth, Aerosol Phase Function, Hygroscopic Growth and Mixing State of Aerosols, Vertical Distribution in the Atmosphere, Chemical Composition of Aerosols and their Role in Climate.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDAP125. 1	3	2	3	2	2	2	2	2.28
MPHYDAP125. 2	3	2	3	2	2	2	2	2.28
Average PLO	3	2	3	2	2	2	2	**2.28**

Text Books:

1) Wallace, J. M., & Hobbs, P. V. (2006). *Atmospheric Science: An Introductory Survey*. Academic Press.
2) Salby, M. L. (2012). *Physics of the Atmosphere and Climate*. Cambridge University Press.
3) Houghton, J. (2009). *The Physics of Atmospheres*. Cambridge University Press.

Reference Books:

1) Ramanathan, V., & Crutzen, P. J. (2003). *Atmospheric Aerosols and Climate*. Science.
2) Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. Wiley.
3) Satheesh, S. K., Moorthy, K. K., & Babu, S. S. (2017). *Atmospheric Aerosols: Properties and Climate Impacts*. Springer.

<table>
<tr><td colspan="2">Course Code</td><td colspan="4">Course Title</td><td>Type of Course</td></tr>
<tr><td colspan="2">MPHYDCP125</td><td colspan="4">Communication Physics</td><td>D</td></tr>
<tr><td>L</td><td colspan="2">T</td><td>P</td><td>Total Credits</td><td>Max. Marks</td><td>Total Contact Hrs.</td></tr>
<tr><td>2</td><td colspan="2">0</td><td>0</td><td>2</td><td>50</td><td>32</td></tr>
<tr><td colspan="7">Course Learning Objectives (CLOs) : By the end of this course, students will be able to:
1. CLO 1 (Unit I): Describe the fundamental principles and characteristics of digital communication systems, including bandwidth, SNR, and various digital codes.
2. CLO 2 (Unit II): Explain the basic concepts of radar systems and satellite communication, encompassing orbits, transmission path, and noise considerations.</td></tr>
</table>

Unit-I

Digital Communication: Fundamentals of digital communication systems. Characteristics of data transmission system such as Band-Width requirement, speeds, SNR, cross talk, echo suppressors, distortion equalizer, Digital codes, Bar dot code, binary code, ASCII code (EBCDIC), Hollerith code, Error detection, constant ratio codes, Redundant codes, parity check codes, Communication system using modem interfacing, Network organization.

Unit-II

Satellite Communication: Introduction to radar systems, fundamental radar range equation, basic pulsed radar. Satellite frequencies, orbits (geostatic, equatorial/polar, Synchronous) station keeping, satellite attitude, transmission path, path loss, noise considerations, satellite system.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDCP125. 1	3	2	2	1	3	2	1	2
MPHYDCP125. 2	3	2	3	2	3	2	2	2.43
Average PLO	3	2	2.5	1.5	3	2	1.5	**2.21**

Text Books:

1) Electronic communications –Rooddy–Coolen (PHI)electronic
2) Communication Systems–George Kennedy (TMH)
3) Principles of Electronic Communication System–Louis Frenzel
4) Communication Electronics–Katre
5) Telecommunication switching systems &Network–T.Vishwanathan.(PHI)

<table>
<tr><td colspan="2">Course Code</td><td colspan="3">Course Title</td><td>Type of Course</td></tr>
<tr><td colspan="2">MPHYDNM125</td><td colspan="3">Physics of Nanomaterials</td><td>D</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Total Credits</td><td>Max. Marks</td><td>Total Contact Hrs.</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>50</td><td>32</td></tr>
<tr><td colspan="6">Course Learning Objectives (CLOs) : By the end of this course, students will be able to:
● CLO 1 (Unit I): Understand the fundamental concepts of nanoscience including size-dependent properties, crystal structures, and confinement regimes, and explain their significance in physical phenomena and applications.
● CLO 2 (Unit II): Apply quantum mechanics to model low-dimensional systems and analyze their density of states, optical properties, and band engineering in heterostructures.</td></tr>
</table>

Unit I:

Introduction to Nanoscience, Definitions, historical context, and societal impact. Key questions in nanoscience: size-dependent properties, synthesis (brief overview), and applications.

Crystal Structure and Symmetry, Bravais lattices, unit cells, Miller indices. Common nanostructure crystal systems: FCC, BCC, zinc blende, wurtzite. Surface-to-volume ratio and its implications for catalysis.

Length Scales in Nanoscience, de Broglie wavelength, Bohr radius, excitons. Confinement regimes: strong, intermediate, weak. Fermi energy, Fermi velocity, Kubo Gap, mean free path, Drude–Lorentz Model, and charging energy.

Unit II:

Wave Mechanics and the Schrödinger Equation, Free particles, bound particle (quantum well), and optical absorption in quantum wells. Model problems: particle in a box (1D, 2D, 3D) applied to quantum wells, wires, and dots. Harmonic oscillator and finite potential wells.

Density of States (DOS), DOS for bulk, quantum wells, wires, and dots. Joint density of states (JDOS) and optical transitions. Heterostructures and Band Engineering, Band alignment, heterostructures, and their applications. Effective mass approximation and effective mass theory in heterostructures.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDNM125. 1	3	2	3	2	2	2	2	2.28
MPHYDNM125. 2	3	2	3	2	3	2	2	2.41
Average PLO	3	2	3	2	2.5	2	2	**2.35**

Textbooks:

1) Masaru Kuno, Introductory Nanoscience: Physical and Chemical Concepts, Garland Science.
2) J.H. Davies, The Physics of Low-Dimensional Semiconductors, Cambridge University Press.
3) S.K. Kulkarni, Nanotechnology: Principles and Practices, Springer.

Reference Books:

1) C. P. Poole Jr. and F. J. Owens – *Introduction to Nanotechnology*, Wiley
2) G. Cao and Y. Wang – Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific
3) K. K. Chattopadhyay and A. N. Banerjee – *Introduction to Nanoscience and Nanotechnology*, PHI Learning
4) M. A. Ratner and D. Ratner – Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson
5) C. Binns – Introduction to Nanoscience and Nanotechnology, Wiley
6) B. S. Murty, P. Shankar, B. Raj, B. B. Rath, and J. Murday – *Textbook of Nanoscience and Nanotechnology*, Springer

Course Code		Course Title			Type of Course
MPHYDMS125		**Materials Science**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Outcomes (CLOs):
Upon successful completion of this course, students will be able to:

- **CLO 1 (for Unit I):** Explain the fundamental principles of crystal growth mechanisms and the influence of defects on material properties and microstructure.
- **CLO 2 (for Unit II):** Utilize and interpret data from advanced materials characterization techniques (e.g., XRD, spectroscopy, various microscopies, thermal analysis) to analyze crystal structure and properties.

Unit I:

Crystal Growth Phenomena: The significance of single crystals, Nucleation and Crystal growth, Theories of nucleation- Gibb's Thomson equation – kinetic theory of nucleation, the energy of formation of the spherical nucleus- homogenous and heterogeneous nucleation - kinetics of crystal growth, singular and rough faces, KSV theory, BCF theory - periodic bond chain theory, Point defects, dislocations, grain boundaries, Formation, texture, and anisotropy Polycrystalline Materials, Grain boundary effects on mechanical/electrical properties.

Unit II:

Characterization Methods: Introduction to materials characterization techniques; Power X-ray Diffraction, Spectroscopic methods- UV-visible and vibrational spectroscopy- Infrared and Raman, Electron spectroscopies - X-ray photoelectron spectroscopy, Ultra-violet photoelectron spectroscopy, Auger electron spectroscopy; Optical microscopy, Electron microscopy- SEM, TEM; Scanning Probe Microscopies: STM, AFM; Thermal analysis- TGA, DTA, DSC.

CLO-PLO Matrix for the Course

Unit Wise CLos	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**Average CLO**
MPHYDMS125. 1	3	2	2	3	2	2	2	2.28
MPHYDMS125. 2	3	3	2	3	2	2	2	2.43
Average PLO	3	2.5	2	3	2	2	1.5	**2.36**

Text Books:

1) H.E.Buckley, Crystal growth. John Wiley & Sons, New York,1981.

2) Materials Characterization: Modern Methods and Applications ed. by Narottam P. Bansal (Wiley, 2016, ISBN 978-1118896093).

Reference Books:

1) D.Elwell and H.J.Scheel, Crystal growth from high-temperature solution. Academic Press, New York,1995.
2) Crystal Growth for Beginners: Fundamentals of Nucleation, Crystal Growth, and Epitaxy by Ivan V. Markov (World Scientific, 3rd Ed., 2017, ISBN 978-9813143858).
3) R.A.Laudise, The growth of single crystals. Prentice Hall, Englewood,1970.
4) P. Ramasamy and P.Santhanaraghavan, Crystal growth processes and methods. KRU Publications, 2000.
5) Introduction to Crystallography by Donald E. Sands (Dover Publications, 1994, ISBN 978-0486678399).
6) Physics and Chemistry of Materials, Joel I. Gersten, Frederick W. Smith, Willey
7) Theory of Dislocations by John P. Hirth & Jens Lothe (Oxford Univ. Press, 1982, ISBN 978-0894646172).
8) Materials Science and Engineering: An Introduction by Callister & Rethwisch (Wiley, 10th Ed., 2018, ISBN 978-1119405498).

Semester II

Course Code		Course Title			Type of Course
MPHYCQM225		**Quantum Mechanics-II**			**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**64 (48L+16T)**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Apply Approximation Methods in Quantum Systems, Utilize time-independent and time-dependent perturbation theory, variational methods, and WKB approximation to analyze systems such as oscillators, atomic transitions, and tunneling phenomena.
- **CLO 2 (Unit II):** Analyze Quantum Scattering Phenomena, Interpret and compute scattering processes using partial wave analysis, Lippmann-Schwinger equations, Born approximation, and understand bound states, resonances, and cross-sections in different frames.
- **CLO 3 (Unit III):** Understand Quantum Statistics and Field Formalisms, Apply the principles of identical particles, spin-statistics, and second quantization to bosonic and fermionic systems; use density matrix formalism and describe quantum transitions under semi-classical radiation theory.
- **CLO 4 (Unit IV):** Explore Relativistic Quantum Mechanics, Formulate and interpret the Klein-Gordon and Dirac equations, analyze relativistic effects including spin, probability current, and negative energy solutions, and derive their non-relativistic limits.

UNIT-I

Time-independent perturbation theory: Non-degenerate & degenerate cases, Applications such as linear harmonic oscillator, Zeeman effect, Stark effect, Perturbation of the type X^2, X^3, X^4. Variational method and its applications, WKB approximation: Solution of bound state and Tunnelling problems.

Time-dependent perturbation theory: Harmonic perturbation, Fermi's golden rule, Adiabatic and sudden approximation.

UNIT-II

Scattering Matrix: Bound States and Resonances. Collision in 3-D and scattering, Laboratory and CM reference frames, Scattering amplitude, differential and total scattering cross sections. Lippman-Schwinger Equation. Born and Eikonal Approximation. Partial Wave Analysis: Low energy Scattering, Bound states and Resonance scattering. Complex potential and absorption.

UNIT-III

Identical particles, Symmetric and antisymmetric wave functions, Spin and Statistics. Collision of identical particles; Spin angular momentum. Second Quantization: Weakly interacting Bosonic and Fermionic systems.

Semi classical theory of radiation, Transition probability for absorption and induced emission, Electric dipole and forbidden transitions

UNIT-IV

Relativistic QM: The Klein-Gordon equation, Free particle solutions, probability density & probability current density, interpretation of negative energy solutions of the K-G equation. The Dirac equation, Free particle solutions, Probability density and probability density current for the free particle Dirac equation, Spin of an electron, Interpretation of negative energy states. Non-relativistic limit of KG and Dirac Equations.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCQM225.1	3	3	3	3	2	2	3	2.7
MPHYCQM225.2	3	3	3	3	2	2	3	2.7
MPHYCQM225.3	3	3	2	3	2	2	3	2.5
MPHYCQM225.4	3	3	2	3	2	2	3	2.5
Average PLO	3	3	2.5	3	2	2	3	**2.65**

Text Books:

1. J. J. Sakurai, Modern Quantum Mechanics, Pearson Publications
2. W. Greiner, Relativistic Quantum Mechanics, Springer-Verlag.

Course Code		Course Title			Type of Course
MPHYCCE225		**Classical Electrodynamics**			**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**64 (48L+16T)**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Apply advanced mathematical techniques, including Poisson's and Laplace's equations, boundary conditions, Green's functions, and the method of images, to solve complex electrostatic problems in various coordinate systems.
- **CLO 2 (Unit II):** Analyze the behavior of electromagnetic fields in dielectric media and at interfaces, formulate and solve boundary value problems, and apply Maxwell's equations to understand energy and momentum conservation, including Poynting's theorem.
- **CLO 3 (Unit III):** Characterize electromagnetic wave propagation in various media and waveguides, understand the concept of electromagnetic potentials and gauge transformations, and calculate radiation fields and power from accelerating charges and dipoles.
- **CLO 4 (Unit IV):** Formulate and solve relativistic electrodynamics problems using four-vector and tensor notation, apply Lorentz transformations to electromagnetic fields, and analyze the motion of relativistic charged particles in external electromagnetic fields using Lagrangian and Hamiltonian formalisms.

UNIT-I

Electrostatics: Gauss Law and Scalar Potential. Poisson's and Laplace's equation, Boundary Conditions. Green's theorem, Uniqueness theorem, Formal solution of boundary-value problem, Green's functions, Electrostatic potential energy. Method of images:Point-charge and grounded conducting sphere, Point charge and conducting sphere in uniform field, Method of inversion, Green's function for sphere, Conducting sphere with hemi-spheres at different potentials. Boundary value problems in cylindrical co-ordinates, Expansion of Green's function in spherical co-ordinates, Mixed boundary conditions, charged conducting disc.

UNIT-II

Multipole expansion and energy of charge distribution. Gauss Law in dielectrics. Induced and bound charges. Boundary Value problems in presence of linear dielectrics. Vector potential and multipole expansion. Boundary conditions and calculation of vector field. Maxwell's equations in free space and linear isotropic media, Boundary conditions on the fields at interfaces, Charge and energy, Poynting's theorem and Conservation of Energy and momentum.

UNIT-III

Electromagnetic waves: Waves in one-dimension, Electromagnetic waves in vacuum and matter, Energy and momentum in electromagnetic waves, Wave Guides and modes in a rectangular wave guide. Scalar and Vector potentials, Gauge transformations, Coulomb and Lorentz Gauge, Maxwell's equations in terms of potentials, Retarded potentials, Lienard-Wiechert potentials, fields of a moving point charge, Electric and Magnetic dipole radiation, power radiated by a point charge.

UNIT-IV

Four-Vectors in Electrodynamics, Transformation of electric and magnetic fields under Lorentz transformations, Field Tensor, Electrodynamics in tensor notation, Relativistic potentials, Covariant form of Maxwell's equations, Lorentz force on a relativistic charged particle. Lagrangian and Hamiltonian for a relativistic charge particle in external electromagnetic fields. Motion in uniform, static, magnetic field, Motion in combined uniform, static, electric and magnetic fields, Particle drifts in non-uniform magnetic fields.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCCE225.1	3	2	3	3	3	1	2	2.43
MPHYCCE225.2	3	2	3	3	3	1	2	2.43
MPHYCCE225.3	3	2	3	3	3	1	2	2.43
MPHYCCE225.4	3	2	3	3	3	2	3	2.71
Average PLO	3	2	3	3	3	1.25	2.25	2.50

Text Books:

1) Classical Electrodynamics: J. D. Jackson, Wiley Press
2) Electrodynamics: D. J. Griffiths, Pearson Edition.

Reference Books:

1) Classical Theory of Fields: L. D. Landau and E. M. Lifshitz, Permagon Press
2) Classical Electrodynamics: J. Schwinger, John Wiley Press
3) Modern Electrodynamics: A. Zhangwll, Cambridge University Press.

Course Code	Course Title				Type of Course
MPHYCSM225	**Statistical Mechanics**				**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**64 (48L+16T)**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Explain and apply fundamental concepts of statistical distributions and ensembles (microcanonical, canonical, grand canonical) to derive statistical quantities and understand fluctuations.
- **CLO 2 (Unit II):** Utilize the Gibbs distribution to derive thermodynamic relations and analyze various physical systems, including rotating bodies and systems with a variable number of particles.
- **CLO 3 (Unit III):** Differentiate and apply Fermi-Dirac and Bose-Einstein statistics to analyze degenerate electron and Bose gases, including their properties under various conditions and phenomena like black-body radiation and virial coefficients.
- • **CLO 4 (Unit IV):** Analyze conditions for phase equilibrium and various types of phase transitions (first and second order), applying concepts like the Clapeyron-Clausius formula, critical point phenomena, and critical indices.

Unit - I

Statistical Distributions; Statistical independence, Liouvilles theorem, Significance of energy, Statistical Matrix, Statistical Distributions in quantum Statistics, Microcanonical, Canonical and Grand Canonical ensemble, Partition Function, Calculation of Statistical Quantities, Energy and Density Fluctuations.

Unit - II

Gibbs distribution, Maxwellian distribution, Probability distribution for an Oscillator, Free energy in the Gibbs distribution,

Gibbs distribution for rotating bodies and for a variable number of particles, Derivation of thermodynamics relations from the Gibbs distribution.

Unit - III

Fermi distribution, Bose distribution, Fermi and Bose gases of elementary particles, Degenerate electron gas, Specific heat of degenerate electron gas, Weak fields, Strong fields, Relativistic degenerate electron gas, Degenerate Bose gas, Black body Radiation.

Deviation of gases from the ideal state, Expansion in powers of density, Relationship of the virial coefficients.

Unit - IV

Conditions for phase equilibrium; the Clapeyron-Clausius formula, Critical point, Law of Corresponding states, Phase transitions of the second kind, Discontinuity of Specific heat, Effect of an external field on a phase transition, Change in symmetry in a phase transition of the second kind, Fluctuations of the order parameter, Critical indices, scale invariance.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCSM225.1	3	2	3	2	2	1	1	2
MPHYCSM225.2	3	2	3	3	2	1	1	2.14
MPHYCSM225.3	3	2	3	3	3	1	2	2.43
MPHYCSM225.4	3	2	3	3	3	1	2	2.43
Average PLO	3	2	3	2.75	2.5	1	1.5	**2.25**

Text Books:

1) Statistical Physics, Landau and Lifshitz, Butterworth-Heineman, An imprint of Elsevier, Linacre House, Jordan Hill, Oxford OX2 8DP, UK

Reference Books:

1) Statistical Mechanics by K Huang
2) Statistical and Thermal Physics by F. Reif
3) Statistical Mechanics by Pateria
4) Fundamentals of Statistical Mechanics by B. B. Laud
5) Thermodynamics and Statistical Mechanics by Greiner, Neise and Stocke

Course Code		Course Title			Type of Course
MPHYCLB225		**Lab-II**			**Laboratory**
L	T	P	Credits	Max. Marks	Total Contact Hrs.
0	**0**	**4**	**4**	**100**	**128**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1:** Design, realize, and characterize electronic circuits using operational amplifiers and logic gates, and analyze the properties of semiconductor devices like UJT.
- **CLO 2:** Conduct experiments involving radioactivity and gamma-ray spectroscopy, including energy calibration and resolution measurements of detectors.
- **CLO 3:** Perform experiments to determine fundamental material properties such as Hall voltage, carrier concentration, mobility, electrical conductivity, band gap energy, and magnetic susceptibility.
- **CLO 4:** Utilize advanced optical techniques for phenomena like the Zeeman effect, and employ ultrasonic waves to determine properties of liquids, along with general proficiency in laboratory instrumentation.

List of Experiments

S.No	**Expt-No.**	**Aim/Objective**	**Credit**	**Lab**
1	Expt-14:	Design and realize an op – amp based first order Butterworth (a) low pass (b) high pass and (c) band pass filters for a given cut off frequency/frequencies to verify the frequency response characteristic.	3	II
2	Expt-15:	The aim of this experiment is to determine that V_H, the Hall Voltage, is proportional to BI, the applied magnetic field times the applied current. Also, for a Ge crystal, we measure R_H, along with the carrier concentration, mobility, and electrical conductivity.	3	II
3	Expt-16:	DESIGN i) a 450KHZ CLOCK USING NAND/NOR GATES ii) a 4 bit Adder / Subtractor.	3	II
4	Expt-17 :	To determine the characteristics of an UJT 2n2646 at various Base to base Voltages and determine η and to construct and study UJT as a relaxation oscillator of a given frequency.	3	II
5	Expt-18:	Obtain γ -ray energy spectra of Cs-137, Co-60 and Na-22, identify the processes taking place. Calibration of a spectrometer for a particular gamma-ray energy and to compute the energy resolution of the NaI detector at various energies.	2	II
6	Expt-19:	Simplify any given Boolean function (f) using the k-map method and implement your result using minimum NAND/NOR gates?	3	II

7	Expt-20:	To calculate the band gap energy (Eg) in Germanium (Ge) semiconductor by four-point probe resistivity measurement method.	3	II
8	Expt-21:	To determine the velocity of ultrasonic waves in liquids and measure their adiabatic compressibility.	2	II
9	Expt-22:	To determine the velocity of ultrasonic waves in liquids and measure their adiabatic compressibility.	2	II
10	Expt-23:	Measurement of Magnetic Susceptibility of Paramagnetic sample(liquid/solution) by QUINCKE'S TUBE METHOD.	3	II
11	Expt-24:	UV- VIS Absorption spectrometry of some compounds	3	II
12	Expt-25:	Quantitative study transverse normal Zeeman effect by observing the splitting of the rings due to magnetic field resolved by Fabry-Perot etalon using a CMOS camera and evaluate the value of Bohr's magneton (μB). Observe the polarization of the rings using a polarizer	3	II
13	Expt-26	To be able to use common electronic test and measurement instruments, such as oscilloscopes, mustimeters, function generators, and soldering equipment.	2	II

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCLB225.1	2	3	3	2	3	1	2	2.29
MPHYCLB225.2	2	3	3	3	3	1	2	2.43
MPHYCLB225.3	2	3	3	3	3	1	2	2.43
MPHYCLB225.4	2	3	3	3	3	1	2	2.43
Average PLO	2	3	3	2.75	3	1	2	**2.39**

Course Code		Course Title			Type of Course
MPHYDAA225		**Astrophysics-I**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** On the completion of Unit I, students should be able to describe what a star is and to classify different types of stars. They should be able to analytically calculate and solve problems related to the structure of stars including the use of stellar structure equations.
- **CLO 2 (Unit II):** On completion of unit students should be able to describe the stages of star formation, from initial collapse of interstellar clouds to the ignition of nuclear fusion in the Protostars core.

UNIT – I

Spectral classification, Stellar distances, Absolute magnitude and distance modulus, The H-R diagram of stars.

Stellar interiors: equation of conservation of mass, hydrostatic equilibrium, thermal equilibrium and energy transport, Equation of State, Stellar Opacity, Stellar Energy Sources. Application of virial theorem to isothermal spheres. Polytropic model, Laneemden's equation, Central temperature and pressure.

UNIT – II

Evolution of stars, interstellar dust and gas, Jean's criteria for stability, formation of stars, Evolution of stars on the basis of HR diagram, Binary stars, masses of binary stars, Fate of massive stars, Supernovae, White dwarfs, Chandershker limit, neutron stars, Pulsars, black holes.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDAA225.1	3	2	2	3	3	1	1	2.14
MPHYDAA225.2	3	2	3	3	3	1	2	2.43
Average PLO	3	2	2.5	3	3	1	1.5	**2.28**

Text books

1) Steller Structure by S. Chanderskher
2) An Introduction to Modern Astrophysics" by Carroll and Ostlie

Reference Books:

1) An Introduction to Astronomy by Robert H. Baker

2) Exploration of the Universe by George O. Abell

Course Code		Course Title			Type of Course
MPHYDEC225		**Electronics-II**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**
Course Learning Objectives (CLOs): By the end of this course, students will be able to: • **CLO 1 (Unit I):** To develop a deep understanding of digital electronics by learning different logic families and how digital technology evolved. • **CLO 2 (Unit II):** To be able to analyze and synthesize different kinds of combinatorial and sequential digital systems for real-world use.					

Unit-I:

Special purpose devices: Tunnel diode, Silicon Control Rectifier, Special-Purpose Diodes, Gunn diode, Pin Diode, UJT and Programmable UJT. Multivibrators: Astable Multivibrator, Monostable Multivibrator and Bistable Multivibrator, Schmitt Trigger.

Unit-II:

Digital Electronics: Fundamentals of Digital Electronics, Boolean Algebra, Rules and properties of Boolean Algebra, Boolean Laws, Demargon's Laws, Realization of Boolean expressions using logic gates., Sum of Product (SOP) form, Product of Sum (POS) form, K-Map simplification, Karnaugh Map simplification exercises.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDEC225.1	3	2	3	2	3	1	1	2.14
MPHYDEC225.2	3	2	3	3	3	2	2	2.57
Average PLO	3	2	3	2.5	3	1.5	1.5	**2.36**

Text Book:

1) R. Boylestad and L. Nashelski: Electronic Devices and Circuit Theory

Reference Books:

1) J. Millman and C. Halkias: Integrated Electronics
2) B.G. Streetman, S. Banerjee: Solid State Electronic Devices
3) H. Taub and D. Schilling: Digital Integrated Electronics
4) P. Bhattacharyya: Semiconductor Optoelectronic Devices
5) S.M. Sze: Physics of Semiconductor Devices
6) A. P. Malvino and A. Brown, *Digital Computer Electronics*

Course Code	Course Title				Type of Course
MPHYDEM225	**Electronic Instrumentation and Measurements**				**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** The aims of the course are for candidates to develop: knowledge and understanding of key concepts in electronics a range of practical skills in electronics, including skills in analysis and problem-
- **CLO 2 (Unit II):** Solving, design skills, skills in the safe use of tools and equipment awareness of the importance of safe working practices in electronics an understanding of the role and impact of electronics in changing and influencing society and the environment**.**

Unit-I:

Theory: Review of circuit variables: Interpreting node voltages on schematics and in physical circuits. circuit analysis, Resistivity, voltage measurement, and power loss for nonideal conductors. Oscilloscope trigerring , Function Generator, DMM, Sensors ,Review of Digital electronics. Introduction to Microprocessor and Microcontroller.

Unit-II:

Practical's:

Activity	**Exercise**
General Guidance	Lab safety protocols, Power supply measurements Protoboard lay out,a voltage divider with nom. 3.3 V output, with different resistance regimes (from 100's of Ohms to 100 kOhm).discuss loading of dividers!
Bridge Circuits	Build bridge rectifier with LEDs and use the load resister to limit current. Measure voltage drop across load for both polarities
Oscilloscopes and Function generator	Measurement applications of Function Generator and Oscilloscope , common wave forms
Sensors	Measure resistance of CdS cells under low and high levels of light.Use results to select a fixed resistor, use that resistor and CdS cell to make voltage divider circuit to detect light
Digital circuits	Latch and flip-flop, JK flip-flop, Analog-to-digital conversion, Logic Simplification With Karnaugh Maps, NAND, NOR implementation,) Full Adder ,Full subtractor using basic logic gates and NAND gates.
8085 Microprocessor	Study 8085 microprocessor kit.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDEM225. 1	3	2	2	2	2	2	1	2
MPHYDEM225. 2	2	3	3	3	3	3	2	2.71
Average PLO	2.5	2.5	2.5	2.5	2.5	2.5	1.5	**2.36**

Reference Books:

1) Electronic Instrumentation by H. S. Kalsi, TMH, 2004.
2) Electronic Instrumentation and Measurements by David A Bell
3) Electrical and Electronic Measurements and Instrumentation by A. K. Sawhney, 17th Edition
4) Principles of Measurement Systems by John P. Beately, 3rdEdition, Pearson Education, 2002.
5) Modern Electronic Instrumentation and Measuring Techniques by Cooper D & A D Helfrick, PHI, 1998.

Course Code		Course Title			Type of Course
MPHYDMP225		**Mathematical Physics-II**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs) : Upon successful completion of this course, students will be able to:

- **CLO1: Apply Green’s Function Techniques**: Solve differential equations using Green’s functions in one and multiple dimensions, including applications to boundary value problems in physics.
- **CLO2: Analyze Partial Differential Equations (PDEs)**: Understand the role of Green’s functions in solving second-order PDEs in various coordinate systems and apply them to Dirichlet and Neumann boundary conditions.
- **CLO3: Understand Group Theory in Physics**: Utilize group representations, character theory, and orthogonality relations to classify eigenfunctions and analyze symmetries in physical systems.
- **CLO4: Apply Lie Groups and Representations**: Explore continuous groups, Lie groups, their representations, and Casimir operators to study symmetries and conservation laws in quantum mechanics and field theory.

UNIT-I

Green's Functions in One Dimension: Calculation of Green's Functions for simple differential operators, Green's Functions for Second order Linear Differential Operators (SOLDOs), Self Adjoint SOLDOs, Generalized Green’s identity. Multidimensional Green's Functions: Second-Order PDEs in m Dimensions, Inhomogeneous BC. Multidimensional GFs and Delta Functions, Spherical Coordinates in m Dimensions, Green's Function for the Laplacian. Dirichlet’s and Neuman type Problems.

UNIT-II

Group representations, Characters, Construction of Representations, Invariances of functions, Operators and classification of eigenfunctions, Unitary Representation, Hilbert space, Irreducible Representation, Schur's Lemas, Orthogonality Relations, Analysis of Representations. Continuous Groups: Summary of results for discrete groups. Lie groups, examples, Isomorphism. Casimer Operators.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDMP225. 1	3	3	3	3	2	2	3	2.7
MPHYDMP225.2	3	3	3	3	2	2	3	2.7
MPHYDMP225. 3	3	2	2	3	2	1	2	2.14
MPHYDMP225.4	3	2	3	3	2	1	3	2.4
Average PLO	3	2.5	2.75	3	2	1.5	2.4	**2.5**

Text Book:

1) Mathematical Physics: A Modern Introduction to Its Foundations, Sadri Hassani, Springer Press.
2) Groups and Symmetries: From Finite Groups to Lie Groups, Yvette Kosmann-Schwarzbach, Springer Press.
3) Lie Groups, Physics, and Geometry, Robert Gilmore, Cambridge University Press.

<table>
<tr><td colspan="2">Course Code</td><td colspan="3">Course Title</td><td>Type of Course</td></tr>
<tr><td colspan="2">MPHYDQI225</td><td colspan="3">Quantum Information Theory</td><td>D</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Total Credits</td><td>Max. Marks</td><td>Total Contact Hrs.</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>50</td><td>32</td></tr>
<tr><td colspan="6">Course Learning Objectives (CLOs) : Upon successful completion of this course, students will be able to:
• CLO1 (Understand Fundamental Concepts of Quantum Mechanics and Information): Explain the postulates of quantum mechanics, quantum entanglement, Bell inequalities, and the density operator formalism, including Bloch sphere representation and measurement techniques.
• CLO2 (Analyze Quantum Channels and Entanglement Measures): Utilize operator sum representation, purification techniques, and distance measures such as trace distance and fidelity to quantify quantum states and entanglement.
• CLO3 (Explore Quantum Communication and Information Theory): Understand key quantum communication protocols such as quantum teleportation, superdense coding, and entanglement distribution, along with the implications of the No-Cloning theorem.
• CLO4 (Apply Quantum Algorithms and Information Measures): Implement quantum algorithms such as Deutsch-Jozsa and Quantum Fourier Transform, analyze Shannon and von Neumann entropies, and evaluate quantum channel capacities using mutual information</td></tr>
</table>

UNIT-I

Postulates of quantum mechanics, qubits, composite quantum systems, Quantum entanglement, Bell Inequality. Density Operator: General properties, Bloch sphere representation, projective measurement, POVM, Schmidt decomposition, reduced density operator. Operator sum representation and its applications. Distance Measures: Norms, Trace Distance and its properties, Fidelity and its properties, relation between Trace Distance and Fidelity. Entanglement measures. Purification: Purification of a density operator, isometric extension of single qubit channels.

UNIT-II

No-Cloning theorem. Quantum Circuits. Entanglement distribution, super dense coding, quantum teleportation, optimality of these protocols, unit source capacity region. Shannon and von Neumann Entropies: Basic properties, Data Processing Inequalities, coding theorems, channel capacities. Mutual Information. Quantum Algorithms: Parallelism, Deustch-Jozsa, Quantum Fourier Transform and its applications.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDQI225. 1	3	2	2	2	2	1	1	1.8
MPHYDQI225. 2	3	3	2	3	2	2	2	2.4
MPHYDQI225. 3	2	2	3	2	2	1	2	2
MPHYDQI225. 4	2	3	3	3	2	3	3	2.8
Average PLO	2.5	2.5	2.5	2.5	2	1.75	2	**2.25**

Text Book:

1) Quantum Computation and Quantum Information: M. A. Nielson and I. Chaung , Cambidge University Press.

Reference Books:

1) Quantum Information Second Edition (Cambridge University Press): Mark Wilde
2) Quantum Information Theory: Mathematical Foundations (Springer) : M. Hayashi
3) Lecture Notes by John Preskill (Caltech USA)
4) http://theory.caltech.edu/~preskill/ph219/index.html#lecture

Course Code	Course Title				Type of Course
MPHYDES225	**Energy Studies**				**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

1. CLO 1 (Unit I): Understand the principles of conventional and renewable energy systems, including thermodynamics, fossil fuels, nuclear energy, and various forms of renewable energy production and utilization.
2. CLO 2 (Unit II): Analyze advanced energy storage systems and emerging energy technologies, including hydrogen energy, smart grids, and energy harvesting mechanisms

UNIT I:

Fundamentals and Conventional Energy Systems

Energy Fundamentals: Concepts of energy, power, and work, Thermodynamics: Laws, entropy, energy conversion, Energy density and efficiency, energy components: Battery, Capacitor, Inductor, Thermal Storage, Flywheel, SMES (Superconducting Magnetic Energy Storage), Gravitational Potential System.

Conventional Energy Sources: Fossil fuels: Coal, oil, natural gas, Combustion processes and emissions, Nuclear energy: Fission and fusion, Reactor design and safety measures, Waste management and disposal

Renewable Energy Sources: Solar energy: Photovoltaics, solar thermal systems, Wind energy: Wind turbines and power generation, Hydropower: Dams, tidal and wave energy, Biomass and biofuels: Production and utilization, Geothermal energy: Power plants and direct heating,

UNIT II:

Advanced Energy Storage and Emerging Technologies

Advanced Energy Storage Systems: Electrochemical storage: Lead-acid, lithium-ion, sodium-ion, flow batteries, Supercapacitors: High-capacitance energy storage, Mechanical storage: Flywheels, compressed air energy storage, Thermal storage: Molten salts, phase-change materials

Emerging Energy Technologies: Hydrogen energy systems: Production, storage, fuel cells, Magnetic energy storage: Superconducting Magnetic Energy Storage (SMES) systems, Energy harvesting: Piezoelectric, thermoelectric, electromagnetic, Smart and microgrid technologies: Integration and optimization

CLO-PLO Matrix for the Course

Unit Wise Clos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDES225.1	3	2	2	2	2	2	2	2.14
MPHYDES225.2	3	2	3	2	2	2	2	2.28
Average PLO	3	2	2.5	2	2	2	2	**2.21**

Text Books:

1) Energy Systems Engineering: Evaluation and Implementation by Francis M. Vanek and Louis D. Albright, Publisher: McGraw-Hill Education
2) Fundamentals of Thermodynamics by Richard E. Sonntag and Claus Borgnakke, Publisher: Wiley
3) Renewable Energy: Power for a Sustainable Future by Godfrey Boyle, Publisher: Oxford University Press
4) Waste to Energy by Sethi Amrinder Singh, Publisher : LAP Lambert Academic Publishing

Reference Books:

1) Solar Energy: Principles and Possibilities by G. N. Tiwari, Publisher: Narosa Publishing House
2) Nuclear Reactor Physics by Weston M. Stacey, Publisher: Wiley-VCH
3) Hydrogen and Fuel Cells: Emerging Technologies and Applications by Bent Sørensen, Publisher: Academic Press (Elsevier)
4) Smart Grids: Fundamentals and Technologies in Electricity Networks by Stuart Borlase, Publisher: CRC Press

<table>
<tr><td colspan="2">Course Code</td><td colspan="3">Course Title</td><td>Type of Course</td></tr>
<tr><td colspan="2">MPHYSRM225</td><td colspan="3">Research Methodology-I</td><td>S</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Total Credits</td><td>Max. Marks</td><td>Total Contact Hrs.</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>50</td><td>32</td></tr>
<tr><td colspan="6">Course Learning Objectives (CLOs): By the end of this course, students will be able to:
• CLO 1 (Unit I): Explain the principles, types, and methodologies of research in physics; design research problems through critical literature review; and apply ethical guidelines in scientific inquiry.
• CLO 2 (Unit II): Apply research tools and software for data analysis and simulation; demonstrate proficiency in scientific writing, proposal preparation, and presentation techniques; and understand publication ethics and peer review systems.</td></tr>
</table>

Unit 1:

Fundamentals of Research Methodology: Introduction to Research in Physics: Definition and objectives of research. Types of research: Experimental, theoretical, computational. Research process and methodology. Literature Review and Research Problem Formulation: The Importance of literature review in scientific research. Sources of scientific information: Journals, books, databases (Scopus, Web of Science, arXiv, Shodganga). Identifying research gaps and defining research problems.

Research Design and Methodology: Experimental vs. computational vs. theoretical research design. Data collection methods in physics research. Sampling techniques and statistical considerations. Handling uncertainties and error analysis\Research Ethics and Scientific Integrity: Ethical considerations in scientific research. Plagiarism and academic misconduct.

Unit 2:

Research Tools, Data Analysis, and Scientific Communication: Software for data analysis: Excel, Origin, Mathematica. LaTeX for scientific writing. Reference management tools: Mendeley and EndNote. Simulation tools in physics research (e.g., DFT calculations, Monte Carlo methods)

Scientific Writing and Presentation Skills: Structure of a research paper: Abstract, introduction, methodology, results, and discussion. Writing a thesis/dissertation. Conference presentations and poster design. Writing research proposals and grant applications.

Publishing and Peer Review Process: Citation metrics: Impact factor, h-index, citation analysis.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYSRM225.1	3	2	1	3	2	1	3	2.14
MPHYSRM225.2	2	3	3	3	3	3	2	2.71
Average PLO	2.5	2.5	2.0	3.0	2.5	2.0	2.5	**2.155**

Recommended Books and References:

1. C.R. Kothari, Research Methodology: Methods and Techniques, New Age International.
2. Peter Pruzan , Research Methodology The Aims, Practices and Ethics of Science , Springer
3. P.R. Bevington & D.K. Robinson, Data Reduction and Error Analysis for the Physical Sciences, McGraw-Hill.
4. J. Pallant, SPSS Survival Manual: A Step by Step Guide to Data Analysis, McGraw-Hill.
5. Selected research papers and journal articles.

Course Code		Course Title			Type of Course
MPHYSSM225		**Seminar-I**			**S**
L	T	P	Credits	Max. Marks	Total Contact Hrs.
0	**0**	**2**	**2**	**50**	**64**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1:** Conduct a comprehensive literature review on a selected physics topic, critically evaluate existing research, and compile findings into a structured seminar report.
- **CLO 2:** Develop and deliver clear and well-organized scientific presentations, demonstrating audience engagement and the ability to answer questions effectively.

Seminar Guidelines

- Each student will select a specific topic in physics in consultation with an assigned faculty supervisor.
- Students are expected to carry out a comprehensive literature survey, compile findings, and organize them into a seminar report.
- The seminar presentation will be conducted in front of students and departmental faculty.
- Evaluation is based on content understanding, quality of presentation, clarity of presentation, engagement with the audience, and ability to answer questions.
- Successful completion of Seminar-I is a prerequisite for continuation into the next phase (i.e. Seminar-II in third semester and internship/dissertation in the fourth semester.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYSSM225. 1	3	1	2	3	2	2	3	2.28
MPHYSSM225. 2	2	1	2	2	2	1	3	1.86
Average PLO	2.5	1	2	2.5	2	1.5	3	**2.07**

Semester III

Course Code	Course Title				Type of Course
MPHYCNP325	**Nuclear and Particle Physics**				**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**64 (48L+16T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Analyze and explain the fundamental principles of nuclear forces, including the various models and theories (such as Yukawa theory and meson theory) that describes the nucleon-nucleon interactions and the mechanisms of nuclear decay processes (e.g, beta and alpha decay).
- **CLO 2 (Unit II):** Analyze and compare the different nuclear models (including liquid drop model and the shell model), articulate the significance of magic numbers and shell model, and apply concepts from nuclear scattering experiments to evaluate properties of nuclei.
- **CLO 3 (Unit III):** Understand and articulate the properties and quantum numbers of elementary particles, including charge, spin, parity, isospin and strangeness, and apply the Gell-Mann Nishijma formula to classify baryons and mesons, and analyze the implications of symmetry principles, including parity violation and CP invariance, in particle interactions and collisions. and Standard Model to particle physics scenarios.
- **CLO 4 (Unit IV):** Apply Feynmann calculus methodologies to analyze particle decay processes, compute cross sections, and understand the implications of the Golden Rule in quantum field theories, with a specific focus on the interactions described by quantum electrodynamics (QED) and quantum chromodynamics (QCD) , including concepts such as asymptotic freedom and Higgs mechanism.

Unit - I

Nuclear Forces and Two Nucleon System: Deuteron, Deuteron Magnetic Dipole Moment, Deuteron Electric quadrupole Moment, Tensor force and deuteron D-state, Yukawa theory of nuclear forces, Properties of nucleon-nucleon force, Meson theory of nucleon-nucleon force.

Nuclear Interaction and Decays: Weak Interaction, Fermi Theory of Beta decay, Gamow theory of alpha decay.

Unit - II

Nuclear Models: Liquid drop model. semi-empirical mass formula (applications), Magic numbers, closed shells, single-particle shell model, its validity and limitations, Evidence of shell structure, Fermi gas model, Collective motion: rotational states. Nuclear deformations.

Rutherford scattering, Mott scattering, Properties of Nuclei: Electron scattering form factor, Charge radius and charge densities, Nucleon form factor, High energy lepton scattering (Deep inelastic scattering).

Unit - III

Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Eight folded way, Gellmann- Nishijima formula. baryons and mesons, Quark model, Standard model. Parity (non-conservation in weak interaction), charge conjugation and CPT invariance, CP violation. Application of symmetry arguments to particle reactions. Relativistic collisions, classical collisions, Examples and applications.

Unit - IV

Feynman calculus: Decays and scattering, Decay rates, Cross sections, The Golden Rule (for decays), Two particle decays. Feynman rules for a Toy Theory, Muon deacy and pion decay.

Electrodynamics and Chromodynamics of Quarks: Quark-Quark, Quark-Antiquark, Pair annhilation in QCD, Asymptotic Freedom, Spontaneous symmetry breaking, Higgs mechanism.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCNP325.1	3	2	3	2	3	1	1	2.14
MPHYCNP325.2	3	2	3	2	3	1	1	2.14
MPHYCNP325.3	3	2	3	3	3	1	2	2.43
MPHYCNP325.4	3	3	3	3	3	3	2	2.86
Average PLO	3	2.25	3	2.5	3	1.5	1.5	**2.39**

Text Books:

1) Introduction to elementary particles by David J. Griffiths, John Wiley and Sons.
2) Introduction to Nuclear Physics by Samuel S. M. Wong.

Reference Books:

1) 1.Introduction to high energy physics by D. H. Perkins
2) Introductory Nuclear Physics by David Halliday and Robert Resnick.
3) The Standard Model of Particle Physics by David Griffiths.
4) An Introduction to the Physics of Nuclear Reactions by M. H. McCarthy.

Course Code	Course Title				Type of Course
MPHYCCM325	**Condensed Matter Physics**				**C**
L	T	P	Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**64 (48L+16T)**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Demonstrate advanced understanding of crystal structures, symmetry operations, and reciprocal lattice theory, and apply these principles to analyze wave diffraction patterns using Fourier techniques.
- **CLO 2 (Unit II):** Apply quanum mechanical models—such as the free electron model, Bloch-Floquet formalism, and tight binding approximation—to analyze the origin of energy bands and gaps in solids. Interpret the electronic structure of semiconductors and metals using band theory concepts like constant energy surfaces, Fermi surfaces, and effective mass. Demonstrate understanding of experimental methods such as cyclotron resonance for probing electronic properties.
- **CLO 3 (Unit III):** Evaluate the quantum behavior of electrons in low-dimensional systems, including 1D/2D electron gases and nanostructures, and apply formal models such as Landauer's theory and quantum Hall effect to interpret experimental phenomena.
- **CLO 4 (Unit IV):** Critically examine models of ferromagnetism and ferroelectricity—including Weiss theory, spin wave theory, and Landau theory—to describe phase transitions, domain formation, and their technological implications.

Unit-I

Crystal lattice; crystal planes and directions. Crystal symmetry, crystallographic point groups, non-centrosymmetric points, and their applications. Space groups, diffraction of waves by crystals, scattered wave amplitude, Fourier Analysis of a crystal. Reciprocal lattice and its applications to diffraction techniques, Bragg's law in reciprocal space. Diffraction condition in reciprocal space, Brillouin zones, Crystal Structure Factor, and Atomic Scattering Factor. Calculation of atomic scattering factor for the ground state hydrogen.

Unit-II

The quantum mechanical free electron model, electrons in a periodic lattice, the origin of energy gaps. Bloch-Floquet functions, Bloch's theorem, Bloch modes, the Schrödinger wave equation in reciprocal space; Tight binding approximation. Band structure of semiconductors (Si, Ge, GaAs) and metals (Cu, Al,). Constant Energy Surface, Fermi surface of solids; Concept of effective mass and its experimental determination; the cyclotron resonance method.

Unit-III

Low-dimensional electron systems: One-dimensional systems; density of states (DOS), 1D sub-bands, Van Hove singularities and their applications; electron motion in a uniform magnetic field; Landau levels; the electronic structure of a two-dimensional electron gas and the integral quantum Hall effect (IQHE). Conductance quantization and the Landauer formalism. Resonant tunnelling, two potential barriers in the series. Zero-dimensional systems: quantised energy levels of semiconductor nanocrystals.

Unit-IV

Ferromagnetism: Weiss's theory of ferromagnetism, the Curie-Weiss law for susceptibility, Heisenberg model and molecular field theory. Ising model in one-dimensions. Spin waves and magnons, Dispersion relation. Specific heat of ferromagnets at low temperature, Bloch $T^{3/2}$ law. Formation of domains, Bloch wall energy. Ferroelectricity: Classification of ferroelectric crystals, Landau's theory of the ferroelectric phase transition. Phonon softening and ferroelectricity, Soft-mode theory. Applications of ferroelectric materials.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCCM325.1	3	2	2	2	1	2	1	1.86
MPHYCCM325.2	3	3	3	2	1	2	2	2.29
MPHYCCM325.3	3	3	3	3	1	2	2	2.43
MPHYCCM325.4	3	2	2	3	1	1	2	2.0
Average PLO	3.0	2.5	2.5	2.5	1.0	1.75	1.75	**2.14**

Text Books:

1) Introduction to Solid State Physics, Charles Kittel, John Wiley and Sons
2) Elementary solid-state physics by Ali Omer , Pearson Publications
3) The physics of low dimensional semiconductors: An introduction by John H. Davis, Cambridge University Press.
4) Quantum Mechanics for Nanostructure by Dmitry I. Sementsov, Nizami Z. Vagidov, and V. V. Mitin,, Cambridge University Press.

Reference Books:

1) Modern course in quantum theory of solids by Fuxuang Han, Wiley Scientific.
2) Solid state physics by Neil W. Ashcroft and N. David Mermin, Black Well Pub.

Course Code	Course Title				Type of Course
MPHYCAM325	**Atomic and Molecular Physics**				**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Interpret fine and hyperfine structure in atomic spectra based on quantum mechanical principles including relativistic and magnetic interactions.
- **CLO 2 (Unit I):** Analyze and apply selection rules and transition probabilities to atomic and molecular systems.
- **CLO 3 (Unit II):** Examine vibrational and rotational spectra of diatomic molecules and understand the basis of Raman and electronic transitions.
- **CLO 4 (Unit II):** Understand the quantum mechanical and classical description of the Raman effect and apply it in spectroscopic structure analysis.

Unit I:

One-electron atoms: Fine structure of hydrogenic atoms, energy shifts, the Lamb shift, hyperfine structure, Zeeman effect (normal and anomalous), Stark effect, selection rules, and transition probabilities. Two-electron atoms: The Schrödinger equation for two-electron atoms, spin wave functions and the role of the Pauli exclusion principle, electron correlation effects, L–S coupling and j–j coupling, possible terms of a multi-electron configuration in L–S coupling, Hund's rules, fine structure of terms in L–S coupling, Landé interval rule.

Unit II:

Rotation and vibration of diatomic molecules, the Born–Oppenheimer approximation, Franck–Condon principle, electronic transitions in molecules, vibrational progressions. Raman Effect: Classical theory and quantum mechanical theory of Raman Effect, rotational and vibrational–rotational Raman spectroscopy, polarization of Raman lines, resonance Raman effect, application of Raman spectroscopy in structural analysis.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCAM325.1	3	3	3	2	2	1	2	2.14
MPHYCAM325.2	3	3	3	3	2	2	2	2.57
MPHYCAM325.3	2	3	3	3	2	2	3	2.57
MPHYCAM325.4	2	2	2	2	2	2	3	2.43
Average PLO	2.5	2.75	2.75	2.75	2	1.75	2.5	**2.43**

Text Books:

1) Physics of Atoms and Molecules by B. H. Bransden and C. J. Joachain, 2nd Ed.
2) Spectra of Atoms and Molecules by Peter F. Bernath, Oxford University Press
3) Atoms and Molecules by Mitchel Weissbluth

Reference Books:

1) Fundamentals of Molecular Spectroscopy by C. N. Banwell
2) Introduction to Molecular Spectroscopy by G. M. Barrow

Course Code	Course Title				Type of Course
MPHYDLP325	**Laser Physics**				**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Understand the principles of absorption, spontaneous and stimulated emission, Einstein coefficients, and population inversion in atomic systems.
- **CLO 2 (Unit I):** Analyze the operation of laser systems using rate equations and evaluate the physical basis of spectral line broadening and resonator conditions.
- **CLO 4 (Unit II):** Identify and describe various laser systems, including gas, solid-state, dye, and excimer lasers, with insight into their operating mechanisms.
- **CLO 3 (Unit II):** Evaluate the physical properties of laser beams and apply laser principles in real-world applications like fusion and isotope separation.

Unit-I

Absorption, spontaneous and stimulated emission, Einstein coefficients, transition probability and lifetime of an atom in an excited state, population inversion, laser rate equations: the three level and four level systems, line broadening mechanism, shape and width of spectral lines, optical resonators: quality factor, losses inside the cavity, threshold conditions, Schawlow-Townes condition, transverse and longitudinal mode selection.

Unit-II

Laser systems: He-Ne laser, CO_2 laser, four level solid state lasers, dye lasers, Ar^+ laser, excimer lasers, properties of laser beam: directionality, monochromaticity, intensity, coherence (temporal and spatial), applications of lasers: laser induced fusion, isotope separation.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDLP325.1	3	3	2	1	1	1	1	1.71
MPHYDLP325.2	3	3	3	3	2	2	2	2.57
MPHYDLP325.3	2	3	3	2	2	1	3	2.29
MPHYDLP325.4	2	2	3	3	3	2	3	2.57
Average PLO	2.5	2.75	2.75	2.25	2	1.5	2.25	**2.28**

Textbooks:

1) Lasers: Theory and Applications by K. K. Thyagarajan and A. K. Ghatak

2) Laser and Non-linear Optics by B. B. Laud

Reference Books:

1) Optical Electronics – Ajoy Ghatak and K. Thyagarajan

2) Principles of Lasers – Orazio Svelto

3) Fundamentals of Photonics – B.E.A. Saleh and M.C. Teich

4) Laser Fundamentals – William T. Silfvast

Course Code		Course Title			Type of Course
MPHYDME325		**Microwave Electronics**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Describe the fundamental concepts of microwave frequencies, the challenges of conventional devices at microwave frequencies, different types of microwave propagation (ground wave, sky wave, line of sight), and the characteristics of microwave transmission lines (primary parameters, equations, characteristic impedance, propagation constant, low loss lines, line impedance under load, reflection and transmission coefficient, SWR), and apply the Smith Chart for impedance matching.
- **CLO 2 (Unit II):** Explain the working principles, velocity modulation, bunching, output powers, and qualitative aspects of different types of Klystrons (Reflex, Multicavity), Travelling Wave Tubes (slow wave structures, amplification process, axial electric field, wave modes, gain), and Magnetrons (cylindrical, linear, coaxial, voltage tunable, inverted coaxial, forward cross-field, backward cross-field), as well as the Gunn effect and Gunn oscillation in Gunn diodes.

Unit-I

Basic Idea: Microwave frequency, Difficulties of conventional devices at microwave frequencies, Microwave devices and systems, Ground wave, sky wave, Line of sight propagation. Applications of microwaves.

Microwave transmission lines: Primary parameters RLGC, Transmission line equation and its solution, Characteristic impedance and propagation constant, Low loss transmission line, Line impedance under load, Reflection and Transmission coefficient, Standing wave Ratio, Smith Chart, Impedance matching,

Unit-II

Klystrons: Velocity modulation and bunching, Output powers, Reflex klystron, multicavity klystron (qualitative). Travelling Wave Tube: Slow waves structures, Amplification process, Axial electric field, wave modes, gain consideration, .

Magnetron: Cylindrical magnetron, linear magnetron, coaxial magnetron, Voltage tunable magnetron, Inverted coaxial magnetron, Forward cross field and backward cross field magnetron.
Gunn diode: Gunn effect Gunn oscillation.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDME325. 1	3	2	3	2	3	1	2	2.29
MPHYDME325. 2	3	2	3	3	3	2	2	2.57
Average PLO	3	2	3	2.5	3	1.5	2	**2.43**

Text Books:

1) Microwave Devices and circuits: S.Y.Liao.PHI
2) Microwave and Radar Engineering 3rd edition: M. Kulkarni. Umesh Publication, New Delhi Microwaves: Introduction to Circuits Devices and Antennas: M.L. Sisodia and Vijay Laxmi gupta. New Age Publications.

Reference Books:

1) Microwave electronics: A. D. Grigoriev, V. A. Ivanov, S. I. Molokov. Springer Microwave electronic devices: T.G. Roer. Springer
2) Microwave Electronics: Measurement and Materials Characterization: L. F. Chen, C. K. Ong, C. P. Neo, V. V. Varadan and V. K. Varadan. Wiley

Course Code	Course Title				Type of Course
MPHYDHE325	**High Energy Physics**				**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Analyze and evaluate the results of heavy ion collision experiments and the formation of heavy ion collision experiments and the formation of Quark Gluon Plasma, with a compressive understanding of experiments setups such as the compressed Baryonic Matter (CBM), at FAIR, ALICE at LHC, ATLAS, CMS and STAR at RHIC, and their contributions to high energy physics research.
- **CLO 2 (Unit II):** Critically assess the MIT Bag model of hadrons , describe the MIT bag model of hadrons, describe the equation of state for the hadronic phase and Quark Gluon Plasma, and analyze phenomena such as j/psi suppression, dilepton production, and strangeness enhancement, providing insight into the signatures of the QGP and its phase transitions.

Unit I

Heavy ion collisions and formation of Quark Gluon Plasma, Overview of different experiments at high energy: Compressed Baryonic Matter (CBM) at FAIR, A Large Ion Collider Experiment (ALICE), A Toroidal LHC Apparatus (ATLAS), Compact Muon Solenoid (CMS) at CERN. Solenoidal Tracker at RHIC (STAR). Discoveries of High energy experiments.

Unit II

MIT Bag model of hadrons, Equation of state for Hadronic phase and Quark Gulon Plasma, Quark-Hadron phase transition, Quark Gluon Plasma at High Temperature scenario, High Baryon Density scenario, QGP signatures: J/Psi suppression and production in Quark Gluon Plasma, Dilepton production in QGP, Photon production in Quark Gluon Plasma and Strangeness enhancement.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDHE325. 1	3	3	2	2	3	2	1	2.29
MPHYDHE325. 2	3	2	3	3	3	2	2	2.57
Average PLO	3	2.5	2.5	2.5	3	2	1.5	**2.43**

Text Books:

1) Introduction to High Energy Physics by Donald H. Perkins.
2) Introduction to High-Energy Heavy-Ion Collisions by Cheuk-Yin Wong (Oak Ridge National Laboratory, USA).

3) The CBM Physics Book by B. Friman, C. Höhne, J. Knoll, S. Leupold, J. Randrup, R. Rapp, P. Senger.

Reference Books:

1) QCD and Heavy Ion Collisions by Miklos Gyulassy et al.
2) Quarks and Leptons: An Introductory Course in Modern
3) Particle Physics by F. Halzen and J. D. Martin.
4) Introduction to elementary particles by David J. Griffiths, John Wiley and Sons.

<table>
<tr><td colspan="2">Course Code</td><td colspan="3">Course Title</td><td>Type of Course</td></tr>
<tr><td colspan="2">MPHYDAA325</td><td colspan="3">Astrophysics-II</td><td>D</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Max. Marks</td><td>Total Contact Hrs.</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>2</td><td>50</td><td>32</td></tr>
<tr><td colspan="6">Course Learning Objectives (CLOs): By the end of this course, students will be able to:
• CLO 1 (Unit I): At the end of the course students can comprehend the basic knowledge of galaxies like their morphology and classification. Students should be able to apply the virial theorem to systems in equilibrium, such as galaxies, clusters of galaxies, to relate kinetic energy and their gravitational potential energy.
• CLO 2 (Unit II): On completion of course, students should be able to recall the basic principles and assumption of cosmology. They should be able to solve simple cosmological models to understand the expansion of universe</td></tr>
</table>

UNIT – I

The Milky way Galaxy, size and shape, Rotation curves of the Galaxy, Missing mass problem, Radio observation, star counts, interstellar extinction, Hubble's classification of galaxies.

Stellar dynamics; types of forces on a star in the stellar system, Tidal radii, star - star encounter, time of relaxation, determination of time of relaxation, application to Galaxy & star cluster. Masses of double galaxies, Masses of cluster of galaxies by virial theorem observational determination of masses.

UNIT – II

Cosmology; cosmological principle, Newtonian cosmology, deceleration parameters critical density, Robertson walker equation and its properties, solution of Robertson-Walker equations. Einstein field equation in cosmology, Energy tensor of Universe, solution of Friedman's equation, Einstein de-sitter model, open model, particle horizon, Event horizon.

Thermal History of the Universe; Temperature red shift relation, distribution in the early Universe, relativistic and non-relativistic limits, decoupling of matter and radiation, Cosmic microwave background radiation (CMBR), isotropy and anisotropy of CMBR.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDAA225.1	3	2	2	3	3	1	1	2.14
MPHYDAA225.2	3	2	3	3	3	1	2	2.43
Average PLO	3	2	2.5	3	3	1	1.5	**2.28**

Text Books:

1) Introduction to Cosmology By J. V. Narliker
2) Modern Astrophysics by B.W. Carroll and D. A. Ostlie, Addison Wesley Publishing Co.

Reference Books:

1) Structure Formation in the Universe by T. Padmanabhan, Cambridge University
2) Stellar Dynamics by S.Chandersakher
3) Stellar Evolution by Kippenhahn

Course Code	Course Title	Type of Course
MPHYDSC325	**Superconductivity**	**D**

L	T	P	Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**26+8**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

CLO 1:

- Explain superconductivity, unusual properties of the superconducting state, the basic superconducting parameters and the characteristics lengths.
- Understand the classical aspects of superconductivity, along with their thermodynamical and magnetic properties, the concept of the superconducting quantum interference and the Josephson effect.

CLO 2:

- Understand the models and theories of superconductivity along with their limitations and drawbacks.
- Describe the High Temperature superconductors, in particular the Cuprate family. Understand the challenges in developing a complete theory of High Temperature superconductivity.
- Describe the numerous applications of superconductivity and the future in superconductivity research.

Unit - I

The superconducting state, Basic properties of the superconducting state: Zero resistance, Critical temperature, The Meissner effect (Perfect diamagnetism), Flux quantization, Isotope effect, Critical magnetic fields, Type-I and Type-II superconductors, Critical Current, Penetration depth, Coherence length, Thermodynamics of transition, First and Second order transitions, Entropy, specific heat, Energy gap, The Josephson effects.

Unit - II

Models and theories: Two fluid model, London equations, Ginzburg-Landau theory, main results of Bardeen Cooper and Schrieffer (BCS) theory: Instability of the Fermi Surface in the presence of attractive Interaction between electrons, Electron distribution in the ground state of a Superconductor, Critical temperature, Energy gap, Origin of the attractive interaction. Introduction to Hi TC superconductivity.

Applications: SQUIDS, Magnetic Shielding, Power Transmission, Energy Storage devices, and Medical Applications.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDSC325. 1	3	3	3	3	3	1	2	2.57
MPHYDSC325. 2	3	2	3	3	3	1	2	2.43
Average PLO	3	2.5	3	3	3	1	2	**2.50**

Text Books:

1) A. C. Rose-Innes, Introduction to superconductivity (Pregamon Press)

Reference Books:

1) C. P. Poole, Handbook of superconductivity (Academic Press 2000)
2) Andre Mourchakine, Room temperature superconductivity (Cambridge 2004)
3) Jeffery W. Linn, High temperature superconductivity (Springer Verlag 1990)
4) T. V. Rama krishnan and C. N. Rao, Superconductivity today (Wiley 1992)
5) M. Tinkham, Introduction to superconductivity (McGraw Hill, 2004)

Course Code		Course Title			Type of Course
MPHYDQF325		**Quantum Field Theory**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs) : Upon successful completion of this course, students will be able to:

- **CLO1 (Understand Lorentz Invariance and Field Quantization)**: Analyze the Lorentz invariance of the Dirac equation, identify bilinear invariants, and apply canonical quantization to scalar, Dirac, and electromagnetic fields.
- **CLO2 (Apply Lagrangian Formulation and Symmetry Principles)**: Utilize Noether's theorem to derive conserved quantities, explore PCT symmetries, and understand the mechanisms of symmetry breaking and the Higgs mechanism.
- **CLO3 (Compute Scattering Processes Using QED)**: Derive the S-matrix expansion using Wick's theorem, apply Feynman rules to QED processes such as electron-electron scattering, Compton scattering, and scattering by an external field.
- **CLO4 (Analyze Higher-Order Corrections and Gauge Invariance)**: Understand loop corrections in quantum electrodynamics, including the Lamb shift and vacuum polarization, and explore the implications of gauge invariance in particle interactions.

UNIT-I

Lorentz Invariance of Dirac equation. Bilinear invariants. Lagrangian formulation and Noether's theorem. Canonical quantisation and particle interpretation: Scalar field, Dirac field. Electromagnetic field. Radiation Gauge quantization. PCT symmetries. Symmetry Breaking and Higgs Mechanism.

UNIT-II

The S-matrix expansion and Wick's theorem. Feynman diagrams and Rules. Yukawa interaction: decay of a scalar. Cross section for QED processes: Electron-electron scattering. Consequence of gauge invariance. Compton scattering, Scattering by an external field. Idea of Loop diagrams: Lamb Shift and Vacuum Polarization.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDQF325. 1	3	3	2	2	1	1	2	2
MPHYDQF325. 2	3	3	3	3	2	2	3	2.75
MPHYDQF325. 3	3	3	3	3	2	2	3	2.7
MPHYDQF325. 4	3	3	3	3	2	3	3	2.8
Average PLO	3	3	2.75	2.75	1.75	2	2.75	**2.5**

Text Books:

1) A first book of quantum field theory, Lahiri and Pal, Narosa Publishing House
2) Quantum Field Theory, Lewis H Ryder, Cambridge University Press.

Reference Books:

1) Quantum Field Theory and Standard Model, M. D. Schwartz, Cambridge University Press
2) S Wienberg, Quantum theory of fields, Vol I. Cambridge University Press.
3) Quantum Field Theory, Claude Itzkyson, Cambridge University Press.

Course Code		Course Title			Type of Course
MPHYDRP325		**Radiation Physics**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Explain fundamental dosimetric concepts and quantities related to radiation, describe the interaction of X-rays and gamma rays with matter, and outline essential radiation safety measures and protection laws.
- **CLO 2 (Unit II):** Identify and describe the principles and applications of various radiation detection instruments, including area survey meters and personal monitors, and explain the theory behind gas-filled detectors.

UNIT I:

Dosimetric concepts and quantities: Electromagnetic Radiation, Ionizing and Non-Ionizing Radiation, Radiation Units, Exposure and Dose, Dose equivalent Unit, Particle flux, X Rays and Gamma Rays, their interaction with matter, Photoelectric and Compton effect, Exposure, Roentgen, photon fluence and energy fluence, Kerma and absorbed dose, stopping power, relationship between the dosimetric quantities, Safety measures, Radiation Protection laws.

Unit - II

Principles of radiation detection: Radiation monitoring, Area survey meters, Ionization chambers, proportional counters, neutron area survey meters, GM survey meters, scintillation detectors, Personal monitoring, film badge, TLD.

Properties of personal monitors, Radiophtoluminesce glass dosimetry system, OSLD. Principles of Radiation detection, properties of dosimeters, Theory of gas filled Detectors.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDRP325.1	3	2	2	2	3	1	1	2
MPHYDRP325.2	3	3	3	2	3	2	2	2.57
Average PLO	3	2.5	2.5	2	3	1.5	1.5	**2.29**

Text Books:

1) The physics of radiation therapy by F. M. Khan, 3rd Ed. Lippincott Williams and Wilkins, USA, 20003

Reference Books:

1) The Physics of radiology by H. E. Jones and J. R. Cunnigham, Charles C. Thomas, New York 2002
2) Fundamental physics of radiology by W. J. Meredith and J. B. Massey, John Wright and Sons UK, 2002
3) Medical radiation physics by W. R. Handee, Yearbook medical publishers Inc. London, 2003

Course Code	Course Title				Type of Course
MPHYDIS325	**Introduction to Spintronics**				**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (for Unit I):** Explain the fundamental principles of spintronics, including the quantum mechanical nature of spin, various magnetic interactions, and the classification of magnetic materials.
- **CLO 2 (for Unit II):** Analyze various spin transport phenomena and explain the operating principles of common spintronic devices such as spin valves, magnetic tunnel junctions, and spin field-effect transistors.

Unit I:

Fundamental Principles of Spintronics: Overview of Spintronics, Basics of magnetostatics and magnetism, The discovery and quantum mechanical nature of spin, Spin and orbital angular momenta, Fundamental magnetic interactions including exchange, dipole-dipole, and anisotropy, Classification of magnetic materials such as paramagnetism, diamagnetism, ferromagnetism, and antiferromagnetism, Band magnetism in transition metals, Surface and interface magnetism, Spin-orbit physics at interfaces, Micromagnetics and magnetization dynamics, Magnetic domain walls and their dynamics

Unit II:

Spin Transport and Device Applications: Electronic and spin transport in metals, spin-dependent tunneling effects, spin transfer and pumping phenomena, current-driven magnetization dynamics, spin dynamics in complex magnetic textures, emerging applications in spintronic devices, spin valve and magnetic tunnel junctions (MTJs), spin field-effect transistors (SpinFETs), giant magnetoresistance (GMR) and tunneling magnetoresistance (TMR), spin transfer torque and spin-orbit torque phenomena.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDIS325. 1	3	2	2	3	3	1	2	2.28
MPHYDIS325. 2	3	3	3	3	3	2	3	2.86
Average PLO	3	2.5	2.5	3	3	1.5	2.5	**2.57**

Textbooks:

1) Spintronics: Materials, Devices, and Applications by Kaiyou Wang, Meiyin Yang, Jun Luo; 1st Editon; ISBN: 978-1-119-69895-1, Pages 336, Publisher: Wiley; Publishing Year 2022.

References:

1) Introduction to Spintronics by Supriyo Bandyopadhyay and Marc Cahay; 2nd Editon; Publisher: CRC Press; ISBN-13: 978-0367656447 (2015).
2) Spintronics Handbook: Spin Transport and Magnetism by Evgeny Y. Tsymbal and Igor Žutić; Edition: 2nd (Multi-volume); Publisher: CRC Press; Pub Date: 2021-03-31 (3-Vol Paperback Set); ISBN-13: 978-0367777876 (3-Vol Paperback Set).
3) Fundamentals of Magnetism and Spintronics by Atowar Rahman; Latest Edition: 1st; Publisher: Zorba Books; Pub Date: 2022-08-16; ISBN-13: 978-9393029799.
4) Spintronics for Next Generation Innovative Devices edited by Katsuaki Sato, Eiji Saitoh; Latest Edition: 1st; Publisher: John Wiley & Sons, Inc.; Pub Date: 2015-09-18; ISBN-13: 978-1118751916; (Wiley Series in Materials for Electronic & Optoelectronic Applications).
5) Spintronics: Fundamentals and Applications" by David D. Awschalom, David Loss, and Nathaniel Samarth, Reviews of Modern Physics, Volume 76, Page 323-410 (2004)

Course Code	Course Title				Type of Course
MPHYSRM325	**Research Methodology-II**				**S**
L	T	P	Credits	Max. Marks	Total Contact Hrs.
1	**1**	**0**	**2**	**50**	**32** (16L+16T)

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Apply appropriate research tools and statistical methods for data collection, interpretation, and analysis; perform error estimation, regression analysis, and hypothesis testing; and effectively present results through scientific writing and oral presentations while adhering to research ethics and peer-review standards.
- **CLO 2 (Unit II):** Basic Demonstrate in Python programming for scientific computing, including data handling, visualization, and statistical analysis using libraries such as NumPy and Matplotlib, with practical implementation in physics-related research problems.

UNIT-I

Data Analysis and Interpretation: Sources of data collection include primary and secondary data. Methods of collecting primary data, Measurement scales and sources of error, Statistical analysis techniques: Mean, standard deviation, regression analysis. Data interpretation and analysis involve understanding precision and accuracy, error analysis, least squares fitting, linear and nonlinear regression, and correlation analysis.

Curve fitting and data visualization techniques. Hypothesis testing methods include T-tests and F-tests, along with tests of significance. The significance of goodness-of-fit tests, such as the Chi-square test, is also examined.

UNIT-II

Programming: Introduction to Python, Anaconda, Jupyter Notebook, Python Basics including data types, variables, arrays, functions, dictionaries, loops, and conditional statements. Working with Files, NumPy & Matplotlib.

Python Programming for Data Analysis: Data Analysis in Jupyter Notebook. Statistical Analysis & Hypothesis Testing, Curve Fitting (Linear Fitting and non-linear Fitting).

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYSRM325.1	3	1	2	3	3	1	2	2.14
MPHYSRM325.2	2	3	3	3	3	3	2	2.71
Average PLO	2.5	2	2.5	3	3	2	2	**2.43**

Text Books

1) Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (2014), J. W. Creswell, Sage Publications
2) Data Reduction and Error Analysis for the Physical Sciences (2003), Philip R. Bevington & D. Keith Robinson, McGraw-Hill
3) Statistical Treatment of Experimental Data (2013), H. D. Young, McGraw-Hill Book Company Inc
4) Python for Data Analysis, 2nd Edition (2017), Wes McKinney, O'Reilly Media, Inc.
5) Learn Python the Hard Way (2019), S. Wróbel, Addison-Wesley Professional
6) Applied Regression Analysis (1998), N. R. Draper & H. Smith, John Wiley & Sons

Web Resources:

1) Jupyter Notebook: https://jupyter.org
2) NumPy: https://numpy.org
3) Matplotlib: https://matplotlib.org

Additional Books:

1) Data Reduction and Error Analysis for the Physical Sciences, 3rd Edition, Philip R. Bevington & D. Keith Robinson, McGraw-Hill (2003)
2) Numerical Methods, Balagurusamy, Tata McGraw-Hill (2000)
3) Numerical Analysis, 2nd Edition, Francis Scheid, McGraw-Hill (2009)
4) Numerical Mathematical Analysis, James B. Scarborough
5) Numerical Methods for Scientists and Engineers, K. Sankara Rao, 3rd Edition, PHI

Course Code	Course Title				Type of Course
MPHYSSM325	**Seminar-II**				**S**
L	T	P	Credits	Max. Marks	Total Contact Hrs.
0	**0**	**2**	**2**	**50**	**64**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Extend and deepen research on a chosen physics topic by incorporating advanced literature review, data analysis, and critical evaluation of methodologies.
- **CLO 2:** Prepare and deliver a professional-level seminar presentation, demonstrating improved technical communication skills, confident defense of ideas, and readiness for dissertation or internship work.

Seminar-II Guidelines

- Topic Selection: Each student, in consultation with a faculty mentor, will choose a topic aligned with current research trends in physics.
- Literature Review: Students must survey recent journal publications, conference proceedings, and scientific preprints.
- Seminar Report: A concise but well-organized seminar report (8–10 pages) summarizing the selected topic must be submitted before presentation.
- Presentation and Viva: Students will present their findings before an evaluation committee and respond to questions during the viva session.
- Continuity to Internship/dissertation work: Topics may be selected to align with potential fourth-semester internship or dissertation work.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYSSM325. 1	3	1	2	3	2	2	3	2.28
MPHYSSM325. 2	2	1	2	2	2	1	3	1.86
Average PLO	2.5	1	2	2.5	2	1.5	3	**2.07**

Semester-IV
(CW+R)

Course Code		Course Title			Type of Course
MPHYIDI425		**Dissertation/Internship**			**I**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
0	**0**	**20**	**20**	**50**	**720**

Course Learning Outcomes (CLOs): After successfully completing this course, students will be able to:

- **CLO1 (Formulate and Plan Research):** Identify an original research problem in physics, conduct a critical literature review, and develop a clear proposal with well-defined objectives and methodology.
- **CLO2 (Design and Apply Research Methodology):** Select and justify suitable experimental, theoretical, or computational approaches, ensuring rigor and reproducibility.
- **CLO3 (Execute Research Independently):** Carry out the planned research, operating relevant instruments, software, or analytical techniques while demonstrating initiative and autonomy.
- **CLO4 (Collect, Analyze, and Interpret Data**): Acquire and process data systematically, apply appropriate statistical and computational tools, and critically evaluate findings against theoretical expectations.
- **CLO5 (Develop Problem-Solving and Critical Thinking Skills):** Identify challenges, assess limitations, and propose evidence-based solutions or future research directions.
- **CLO6 (Communicate Scientific Work Effectively** – Prepare a well-structured dissertation with high academic writing standards, proper citations, and clear data presentation; confidently present and defend findings in oral examinations.
- **CLO7 (Exhibit Professionalism and Ethical Research Practices):** Demonstrate integrity, time management, responsible conduct of research, and effective collaboration with mentors and peers.
- **CLO8 (Discuss Broader Impacts of Research):** Articulate the significance of research outcomes for scientific advancement, industry applications, or addressing societal challenges.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYIDI425. 1	3	2	3	3	3	2	3	2.71
MPHYIDI425. 2	2	3	3	3	2	3	3	2.71
MPHYIDI425. 3	2	3	3	2	3	3	3	2.71
MPHYIDI425. 4	2	3	3	3	2	3	3	2.71
MPHYIDI425. 5	2	2	3	3	2	2	3	2.43
MPHYIDI425. 6	2	2	3	3	2	2	3	2.43
MPHYIDI425. 7	2	2	2	2	3	2	3	2.29
MPHYIDI425. 8	2	2	2	3	3	2	3	2.43
Average PLO	2.125	2	2	3	3	2	3	**2.55**

Dissertation/Internship evaluation Guidelines	
Internal Assessment by Supervisor	**3** Credits
Ongoing evaluation based on research progress, commitment, and adherence to academic timelines, conducted by the designated supervisor	
Mid-Semester Evaluation/Attendance	**3** Credits
Interim assessment organized by the department/supervisor to evaluate the Regularity and attendance, research approach, methodology, and preliminary findings. May involve an external expert.	
Internship Dissertation	**4** Credits
Assessment of the quality, structure, and originality, of the dissertation/report submitted at the conclusion of the internship. Evaluated by a panel including external examiners. **Note:** A plagiarism report, along with the dissertation, should be submitted to the department and allowed plagiarism percentage will be governed as per the university Plagiarism Policy.	
Final Presentation and Viva Voce	**10** Credits
A comprehensive evaluation based on the final presentation and viva voce examination, conducted by a committee comprising supervisor, HOD, internal and external experts.	

Semester-IV (CW+CW)

Course Code	Course Title	Type of Course
MPHYCCP425	Computational Physics with Python	**C**

L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**2**	**4**	**100**	**96 (32L+64T)**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO1 (Unit I):** Acquire essential Python programming and Linux skills to design scripts, implement control structures, handle data, and create basic visualizations for solving introductory physics problems.
- **CLO2 (Unit II):** Apply numerical methods—including differentiation, integration, error estimation, Monte Carlo techniques, and optimization—to analyze computational physics problems with accuracy and stability.
- **CLO3 (Unit III):** Use scientific libraries (NumPy, SciPy, Matplotlib, VPython) to process, analyze, and visualize experimental and simulated datasets, demonstrating proficiency in computational tools.
- **CLO4 (Unit IV):** Model and simulate dynamical physical systems using ordinary and partial differential equations, explore nonlinear dynamics, and effectively present simulation outcomes through a capstone project.

Unit-I

Python Foundations for Computational Physics

- Python basics: interpreter, syntax, variables, data types, control structures
- Functions, modules, file I/O and data handling
- Graph plotting and visualization with Matplotlib
- Basic of Linux for computational work

Unit-II

Numerical Tools and Error Analysis

- Numerical integration and differentiation
- Error estimation, convergence and stability considerations
- Monte Carlo methods: random numbers, stochastic integration
- Least-squares curve fitting and optimization

Unit-III

Scientific Libraries and Data Visualization

- Numpy: arrays, linear algebra, and vectorization
- Scipy: solvers, optimization, and advanced calculations
- Matplotlib and VPython: 2D/3D data visualization and animation

- Handling, analyzing, and interpreting large datasets (experimental and simulation data)
- Handling experimental and simulation data

Unit-IV

Differential Equations and Applications

- Solving Ordinary differential equations: Euler, Euler-Cromer, Runge-Kutta methods
- Partial differential equations: Laplace, wave, and Schrödinger equations
- Chaos and nonlinear dynamics: phase space, Poincaré plots
- Capstone project: modeling a physical system

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCCP425.1	3	2	2	2	2	3	1	2.142
MPHYCCP425.2	3	3	2	3	3	3	2	2.714
MPHYCCP425.3	3	3	3	2	3	3	2	2.71
MPHYCCP425.4	3	3	3	3	3	3	3	3
Average PLO	3	2.75	2.5	2.5	2.75	3	**2**	**2.64**

Text Books:

1) Computational Physics: Problem Solving with Python by Rubin H. Landau, Manuel J. Páez, and Cristian C. Bordeianu (3rd Edition, Wiley-VCH, 2021)
2) Computational Physics with Python by Eric Ayars (California State University)

References Books:

1) Computational Physics by Mark Newman (2nd Edition, CreateSpace, 2013)
2) A Primer on Scientific Programming with Python by Hans Petter Langtangen (5th Edition, Springer, 2016)

Web Resources:

4) Jupyter Notebook: https://jupyter.org
5) NumPy: https://numpy.org
6) Matplotlib: https://matplotlib.org

Course Code		Course Title			Type of Course
MPHYDSS425		**Advanced Solid-State Physics**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs
3	**1**	**0**	**4**	**100**	**64** (48L+16T)

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Analyze Transport Properties in solids (Boltzmann equation, Fermi surfaces, quantum Hall effects) and explain their experimental manifestations (magnetoresistance, Landau levels).
- **CLO 2 (Unit II):** Analyze dielectric properties and derive macroscopic dielectric responses (local fields, polarizability) and classify emergent phenomena (ferroelectricity, piezoelectricity) using microscopic models.
- **CLO 3 (Unit III -):** Analyze optical properties and correlate optical constants with electronic band structures (direct/indirect gaps, excitons) and evaluate defect-mediated transitions (photoluminescence, plasmonics).
- **CLO 4 (Unit IV):** Apply quantum mechanical models (Heisenberg exchange, spin waves) to predict magnetic behaviors (ferromagnetism, ferrimagnetism, antiferromagnetism) and thermodynamic properties (Curie temperature) of magnetic ordered materials.

Unit-I

Transport Properties of Solids: Boltzmann transport equation, resistivity of metals and semiconductors, Fermi surfaces – determination, Landau levels, de Hass van Alphen effect, Quantum Hall effect- Integral quantum Hall effect and Magnetoresistance, Giant Magnetoresistance and Colossal Magnetoresistance.

Unit-II

Dielectric Properties of Solids: Dielectrics and ferroelectrics, macroscopic electric field, local field at an atom, dielectric constant and polarizability, ferroelectricity, antiferroelectricity, piezoelectric crystals, ferroelasticity, electrostriction.

Unit-III

Optical properties: Optical constants and their physical significance, Reflectivity in metals, plasmonic properties of metals, determination of band gap in semiconductors: direct and indirect band gap, defect mediated optical transitions, excitons, photoluminescence, Electroluminesence.

Unit-IV

Magnetism: Types of magnetic materials, Quantum theory of paramagnetism, Hund's rule, Ferromagnetism, antiferromagnetism: molecular field, Curie temperature. Domain theory, Magnetic Anisotropy, Magnetic interactions, Heitler-London method, exchange and superexchange, magnetic moments and crystal-field effects, spin-wave excitations and thermodynamics, antiferromagnetism, Magnetostriction.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCSS425. 1	3	2	2	2	3	2	1	2.14
MPHYCSS425. 2	3	2	3	3	3	2	2	2.57
MPHYCSS425. 3	3	2	3	3	3	2	2	2.57
MPHYCSS425. 4	3	2	3	3	3	2	2	2.57
Average PLO	3	2	2.75	2.75	3	2	1.75	**2.46**

Textbooks:

1) Condensed Matter Physics by M P Marder (John Wiley & Sons Inc; 2nd edition 2010)

Reference Books:

1) Introduction to solid state physics, Charles Kitte (Wiley; 8th edition 2012)
2) Solid State Physics, N. W. Ashcroft and N.D. Mermin (Brooks/Cole; New edition 2021)
3) Many-Particle Physics, Gerald D. Mahan (Kluwer Academic/Plenum Publishers; 3rd edition, 2000)
4) Principles and Applications of Ferroelectrics and Related Materials, M. E. Lines and A. M. Glass (Oxford University Press; 1st edition 2001)
5) Magnetism in Condensed Matter, Stephen Blundell (Oxford University Press; 1st edition 2001)

Course Code		Course Title			Type of Course
MPHYDAW425		**Antenna and Wave Propagation**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs
3	**1**	**0**	**4**	**50**	**64 (48L+16T)**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Explain radiation mechanisms, solve Maxwell's equations for radiation problems, and analyze resonant antennas (dipoles, Yagi-Uda, microstrip).
- **CLO 2 (Unit II):** Design and evaluate linear/phased arrays using array factor theory, and compare broadband antenna principles (helical, log-periodic).
- **CLO 2 (Unit III):** Calculate gain and analyze reflector antenna systems (parabolic, dual-reflector), including feed matching techniques
- **CLO 2 (Unit IV):** Apply antenna theory to satellite systems (GPS, DTH, VSAT) and emerging technologies (video conferencing, IoT).

Unit-I

Antenna Fundamentals and Definitions: Radiation mechanism - over view, Electromagnetic Fundamentals, Solution of Maxwell's Equations for Radiation Problems, Ideal Dipole, Radiation Patterns, Directivity and Gain, Antenna. Impedance, Radiation Efficiency. Antenna Polarization Resonant Antennas: Wires and Patches, Dipole antennas, Yagi - Uda Antennas, Micro strip Antenna

Unit-II

Arrays: Array factor for linear arrays, uniformly excited, equally spaced Linear arrays, pattern multiplication, directivity of linear arrays, non- uniformly excited -equally spaced linear arrays, Mutual coupling, multidimensional arrays, phased arrays, feeding techniques, perspective on arrays. Broad band Antennas: Traveling- wave antennas, Helical antennas, Biconical antennas; Principles of frequency - independent Antennas, spiral antennas, and Log - Periodic Antennas

Unit-III

Aperture Antennas: Techniques for evaluating Gain, reflector antennas - Parabolic reflector antenna principles, Axi -symmetric parabolic reflector antenna, offset parabolic reflectors, dual reflector antennas, Gain calculations for reflector antennas, feed antennas for reflectors, field representations, matching the feed to the reflector, general feed model, feed antennas used in practice

Unit-IV

INTELSAT Series, INSAT, VSAT, Remote sensing, Mobile satellite service: GSM. GPS, INMARSAT, Satellite Navigation System, Direct to Home service (DTH), Special services, E-mail, Video conferencing and Internet connectivity

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDAW125. 1	3	1	2	2	3	1	1	1.86
MPHYDAW125.2	3	2	3	3	3	2	1	2.43
MPHYDAW125.3	3	2	3	2	3	2	1	2.28
MPHYDAW125.4	3	3	3	3	3	2	2	2.71
Average PLO	3	2	2.75	2.5	3	1.75	1.25	**2.32**

Text Books:

1) Antenna Handbook by J. D. Kraus

References:

1) Bruce R. Albert, The Satellite Communication Applications Handbook, Artech House, Boston, 1997
2) Stutzman and Thiele, Antenna Theory and Design, 2nd Ed. John Wiley and Sons. Inc.
3) C. A. Balanis,Antenna Theory Analysis and Design, 2nd Ed. John Wiley

Course Code	Course Title				Type of Course
MPHYCDF425	**Density Functional Theory of Materials**				**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Formulate many-body electronic systems using quantum mechanical approximations such as Hartree-Fock and Density Functional Theory (DFT), and explain the conceptual evolution from wavefunction to electron density.
- **CLO 2 (Unit II):**Apply DFT-based computational methods to determine structural and electronic properties of materials, including band structures and density of states, using tools such as Quantum Espresso.

Unit-I

Basic Equations for Interacting Electrons and Nuclei, Many-body Schrodinger equation, independent electrons approximation, Mean-field approximation Hartree Method, Hartree- Fock equations, Self-Consistent field method. Density functional theory: From wave-function to electron density function, Thomas–Fermi model. Hohenberg-Kohn theorem, Kohn-Sham equations, the local density approximation, Exchange and correlation energies of the electron gas, Self-consistent calculations

Unit-II

Equilibrium structures of materials, the adiabatic approximation, Atomic Forces, Hellmann Feynman theorem, Comparison of DFT structures with X-ray crystallography. Band structures, Kohn-Sham equations for a crystal, Kohn-Sham energies and wavefunctions, Calculation of band structures and Density of States using DFT, Plane wave methods, pseudopotentials. The band gap problem. Practical implementation of DFT using Quantum Espresso.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCDF425. 1	3	3	3	3	1	1	1	2.14
MPHYCDF425. 2	3	3	3	3	2	3	3	2.86
Average PLO	3	3	3	3	1.5	2	1.5	**2.43**

Text Books:

1) Materials Modelling Using Density Functional Theory Feliciano Giustino , Oxford Publishers.

2) Density Functional Theory: A Practical Introduction David S. Sholl, Janice A. Steckel (John Wiley & amp; Sons)
3) Electronic Structure Calculations for Solids and Molecules: Theory and Computational Methods , Jorge Kohanoff , Cambridge University Press
4) Electronic Structure: Basic Theory and Practical Methods Richard Martin , Cambridge University Press

Reference Books:

1) Fundamentals of neutrino physics and astrophysics by Carlo Giunti and Chung W. Kim

Course Code		Course Title			Type of Course
MPHYCNP425		**Neutrino Physics**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I - Foundations):** Explain the historical development, fundamental properties, and interaction mechanisms of neutrinos, including solar and atmospheric neutrino phenomena, using theoretical frameworks and experimental evidence.
- **CLO 2 (Unit II - Modern Challenges):** Analyze neutrino oscillation dynamics (vacuum/matter), mass determination methods, and current experimental limitations to evaluate open questions in neutrino physics.

Unit-I

Introduction and Historical Overview, motivation for proposing the neutrino, first discovery by Reines and Cowan and subsequent discoveries, the number of neutrinos, neutrino properties and interactions, neutrino electron elastic scattering, neutrino-nucleon quasi-elastic scattering, neutrino-nucleon deep inelastic scattering, solar neutrinos, atmospheric neutrinos, terrestrial neutrino sources

Unit-II

Neutrino mass, neutrino oscillations, flavour oscillations in vacuum and matter, solution of the solar and atmospheric problems, limitations of oscillation experiments, direct mass searches, kinematic mass determination, double beta decay, summary of understanding now, outstanding questions and the future of experimental neutrino physics

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCNP425. 1	3	2	2	2	3	1	1	2
MPHYCNP425. 2	3	2	3	3	3	2	2	2.57
Average PLO	3	2	2.5	2.5	3	1.5	1.5	**2.29**

Text Books:

1) Neutrino Physics by Kai Zubair, CRC Press
2) Current aspects of neutrino physics. Ed. by David O. Codwell, Springer Publications

Reference Books:

1) Fundamentals of neutrino physics and astrophysics by Carlo Giunti and Chung W. Kim

Course Code		Course Title			Type of Course
MPHYCTR425		**General Theory of Relativity**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I) Apply Tensor Calculus in Curved Spacetimes**
  Understand and manipulate tensorial quantities such as covariant derivatives, metric tensors, and curvature tensors to describe gravitational phenomena in curved spacetime.
- **CLO 2 (Unit I) Analyze Geodesics and Gravitational Effects**
  Derive and interpret the geodesic equation and study motion under gravity in curved spacetime using the principles of general covariance.
- **CLO 3 (Unit II) Solve Einstein Field Equations in Specific Contexts**
  Solve Einstein's equations under vacuum and non-vacuum conditions, including the derivation and interpretation of Schwarzschild and Kerr solutions.
- **CLO 4 (Unit II) Understand Physical Implications of General Relativity**
  Explore advanced concepts such as black holes, energy-momentum tensors, and gravitational waves, and analyze their physical significance in astrophysical and cosmological settings.

Unit-I

Principle of general covariance. Tensor Calculus Vector and tensor fields, Parallel transport. Connection coefficients. Metric tensor. Covariant derivative. Geodesic equation, Gravity in Simple Situations Motion along a geodesic. Riemann curvature tensor. Symmetry properties of Riemann tensor. Bianchi identity. Ricci and Einstein tensor.

Unit-II

Einstein equation, Solutions of Einstein equations, Einstein equation in vacuum, Schwarzschild solution, Schwarzschild solution extension in Kruskal-Szekeres coordinates. Energy momentum tensors, energymomentum tensor for a perfect fluid. Action principle for gravitational and matter fields. Kerr solution. Black holes. Gravitational waves.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCTR425.1	3	3	2	3	2	1	2	2.29
MPHYCTR425.2	3	3	3	3	2	1	2	2.43
MPHYCTR425.3	3	3	3	3	2	2	3	2.7
MPHYCTR425.4	3	3	3	3	2	2	3	2.7
Average PLO	3	3	2.75	3	2	1.5	2.5	**2.5**

Text Books:

1) Gravitation and cosmology: Principles and applications of GTR, S. Weinberg, Wiley
2) General theory of relativity, J. B. Hartle (Cambridge Press)

Reference Books:

1) Space time geometry by Sean Carrol, Cambridge University Press
2) General relativity by G. Wald,Cambridge University Press
3) Gravitation, foundations and frontiers by T. Padmanabhan

Course Code		Course Title			Type of Course
MPHYCRS425		**Radiation Physics**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Unit I - Fundamentals & Detection)**
  Analyze radiation types, interactions, and detection methods to evaluate biological impacts and apply appropriate dosimetry techniques in medical/industrial contexts.
- **CLO 2 (Unit II - Safety & Management)**
  Design radiation protection protocols using ICRP standards, including shielding calculations and waste management strategies, while adhering to regulatory frameworks (AERB/IAEA).

Unit-I

Fundamentals & Detection of Radiation

Basics of Radiation: Radioactive decay (α, β, γ, neutron), half-life, nuclear reactions. Radiation units: activity, absorbed/equivalent dose, KERMA, ALI, DAC. Natural vs. man-made sources; biological impact (acute/chronic exposure). Radiation Detection & Dosimetry: Interaction of radiation with matter (ionization, excitation). Detectors: GM counters, scintillators, semiconductors. Dosimeters: TLD, film badges; counting statistics, calibration. Applications: Medical (PET, radiotherapy), industrial (tracing, sterilization), archaeology.

Unit-II

Radiation Safety & Management

Protection Standards: ICRP principles, justification, optimization, dose limits. Shielding calculations; occupational/public exposure limits. Internal hazards (ALI, DAC), contamination control. Regulations & Waste Management: Radioactive waste classification (low/high-level), disposal methods. Regulatory roles (operator, government); accident response.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYCRS425. 1	3	3	2	1	1	1	2	1.9
MPHYCRS425. 2	2	2	3	2	0	2	3	2.0
Average PLO	2.5	2.5	2.5	1.5	0.5	1.5	2.5	**1.95**

Text Books:

1) The physics of radiation therapy by F. M. Khan, 3rd Ed. Lippincott Williams and Wilkins, USA, 2003

References:

1) The Physics of radiology by H. E. Jones and J. R. Cunnigham, Charles C. Thomas, New York 2002
2) Fundamental physics of radiology by W. J. Meredith and J. B. Massey, John Wright and Sons UK, 2002
3) Medical radiation physics by W. R. Handee, Yearbook medical publishers Inc. London, 2003

Course Code		Course Title			Type of Course
MPHYDEP425		**Environmental Physics**			**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs
2	**0**	**0**	**2**	**50**	**32**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1 (Unit I):** Analyze the physical principles and biological consequences of natural and anthropogenic radiation, including sources like radon, applications in medicine/research, and the impact of nuclear power (fission/fusion).
- **CLO 2 (Unit II):** Explain the physical processes of ozone layer dynamics and UV radiation effects and critically evaluate the causes and consequences of the greenhouse effect on Earth's climate.

Unit-I

These subjects include among other; Natural background radiation, radon, the benefits and risks related to radioactive sources and radioactive pollution, the use of ionizing radiation in medicine and research, nuclear power, fusion, fission, biological consequences of ionizing radiation, radiation induced cancers.

Unit-II

Production and destruction of ozone and the ozone layer, the development of the ozone hole, UV radiation, measurements of ozone and UV radiation, biological effects related to too much and too little UV-exposure, D-vitamin deficiency, skin cancer; The atmosphere and its composition, the greenhouse effect, the role of the greenhouse effect for life on earth, green house gasses, the variations in the global green house effect and its consequences.

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYDEP425. 1	3	3	2	2	2	2	2	2.28
MPHYDEP425. 2	3	3	3	2	2	2	2	2.42
Average PLO	3	3	2.5	2	2	2	2	**2.35**

Text Books:

1) Neutrino Radon in the environment by M. Wilkening, Elsevier Publishing Co.
2) Radon Prevalence, measurement , health risks and control byNiren Laxmichand, Nagda Astm Manual Series, Mnl 5 (1994)
3) Nigel Mason and Peter Hughes: Introduction to Environmental Physics: Planet Earth, Life and Climate, Taylor and Francis, 2001

Course Code		Course Title			Type of Course
MPHYPPJ425		**Project**			**P**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs
0	**0**	**8**	**8**	**200**	**240**

Course Learning Objectives (CLOs) : By the end of this course, students will be able to:

- **CLO 1 (Conduct Independent Scientific Project):** Plan, execute, and document an independent physics research project by applying appropriate theoretical, experimental, or computational methods
- **CLO 2 (Analyze and Synthesize Advanced Physics Concepts):** Critically evaluate recent research in the chosen field and integrate findings into the project work.
- **CLO 3 (Demonstrate Problem-Solving and Critical Thinking):** Analyze data, apply physics concepts and draw evidence-based conclusions.
- **CLO 4 (Communicate Research Effectively):** Present findings through a structured written report and defend them orally in a viva-voce examination.
- **CLO 5** (Demonstrate In-depth Knowledge): Exhibit a comprehensive understanding of the chosen project's experimental/theoretical framework and relevant literature.
- **CLO 5 (**Collaborate in a Team Environment): Work collaboratively, demonstrating effective communication, coordination, and contribution

Project Description:

Students, individually or in teams of up to four, will carry out an independent research project on an innovative topic in physics, under the guidance of a faculty supervisor. The project aims to develop in-depth subject knowledge, strengthen problem-solving and critical thinking skills, and apply theoretical, experimental, or computational concepts to real-world challenges. Students will critically evaluate relevant literature, analyze data, and synthesize findings into a comprehensive project report. The course concludes with an oral presentation and viva-voce examination before an internal and external review panel, emphasizing effective communication and collaborative research practices.

Assessment Structure:

Assessment Component	Marks	Criteria
Internal Assessment	40	**Supervisor Evaluation**: Supervisor evaluation based on regular progress, initiative, and problem-solving.
Project Report	60	Originality, depth, structure, and correct citations
Presentation	60	Clarity, organization, delivery, and Q&A handling.
Viva-Voce	40	Depth of understanding, concept mastery, and critical thinking.
Total	200	

CLO-PLO Matrix for the Course

Unit Wise CLos	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
MPHYPPJ425.1	3	3	3	3	3	2	3	2.86
MPHYPPJ425.2	3	2	3	3	3	2	3	2.71
MPHYPPJ425.3	3	3	3	3	3	2	3	2.86
MPHYPPJ425.4	2	2	2	2	3	2	2	2.14
MPHYPPJ425.5	3	2	3	3	2	2	3	2.57
MPHYPPJ425.6	2	1	2	2	2	2	3	2
Average PLO	2.67	2.17	2.67	2.67	2.67	2	2.83	**2.52**