MOTHER TERESA WOMEN'S UNIVERSITY
KODAIKANAL

DEPARTMENT OF PHYSICS

M.Sc. PHYSICS

SYLLABUS TO BE IMPLEMENTED FROM THE ACADEMIC YEAR 2021-2022

(CHOICE BASED CREDIT SYSTEM)

Mother Teresa Women's University, Kodaikanal
Department of Physics
Choice Based Credit System (CBCS)
(2021-2022 onwards)
M.Sc. Physics

1. About the Programme:

M.Sc Physics is a two-year Postgraduate Programme that provides the learners with the theoretical and practical knowledge of Physics and its allied subjects. The Programme, with its strong emphasis on skill development, enriches the learners' research, technological, and employability skills and thereby ensures their broad-based futuristic developments with sound knowledge and ethical values.

2. Program Educational Objective

PEO 1	To pursue their Higher Studies in Leading Institutes.
PEO 2	To attain significant position in Academics with proficiency.
PEO 3	To cultivate their research acumen for resolving challenging research issues, and secure a position in Research Organization.
PEO 4	To create inclusive society with gender equality.
PEO 5	To work in Defence Organization with shrewdness, courage, and confidence.
PEO 6	To imbibe communicative skills and value system and work ethically in a multidisciplinary environment.

3. Eligibility

B.Sc. Physics, Applied Physics, with Mathematics as allied subject at the UG level

4. General Guidelines for PG Programme

i. **Duration:** The programme shall extend through a period of 4 consecutive semesters and the duration of a semester shall normally be 90 days or 450 hours. Examinations shall be conducted at the end of each semester for the respective subjects.

ii. **Medium of Instruction:** English

iii. **Evaluation:** Evaluation of the candidates shall be through Internal Assessment and External Examination.

- **Evaluation Pattern**

Evaluation Pattern	Theory		Practical	
	Min	**Max**	**Min**	**Max**
Internal	**13**	**25**	**13**	**25**
External	**38**	**75**	**38**	**75**

- **Internal (Theory): Test (15) + Assignment (5) + Seminar/Quiz(5) = 25**
- **External Theory: 75**

- **Question Paper Pattern for External examination for all course papers.**

Max. Marks: 75 **Time: 3 Hrs.**

S.No	Part	Type	Marks
1	**A**	**10*1 Marks=10** Multiple Choice Questions(MCQs): 2 questions from each Unit	**10**
2	**B**	**5*4=20** Two questions from each Unit with Internal Choice (either / or)	**20**
3	**C**	**3*15=45** Open Choice: Any three questions out of 5 : one question from each unit	**45**
		Total Marks	**75**

*** Minimum credits required to pass: 90**

- **Project Report**

A student should select a topic for the Project Work at the end of the third semester itself and submit the Project Report at the end of the fourth semester. The Project Report shall not exceed 75 typed pages in Times New Roman font with 1.5 line space.

- **Project Evaluation**

There is a Viva Voce Examination for Project Work. The Guide and an External Examiner shall evaluate and conduct the Viva Voce Examination. The Project Work carries 100 marks (Internal: 25 Marks; External (Viva): 75 Marks).

5. Conversion of Marks to Grade Points and Letter Grade (Performance in a Course/Paper)

Range of Marks	Grade Points	Letter Grade	Description
90 – 100	9.0 – 10.0	O	Outstanding
80-89	8.0 – 8.9	D+	Excellent
75-79	7.5 – 7.9	D	Distinction
70-74	7.0 – 7.4	A+	Very Good
60-69	6.0 – 6.9	A	Good
50-59	5.0 – 5.9	B	Average
00-49	0.0	U	Re-appear
ABSENT	0.0	AAA	ABSENT

6. Attendance

Students must have earned 75% of attendance in each course for appearing for the examination. Students with 71% to 74% of attendance must apply for condonation in the Prescribed Form with prescribed fee. Students with 65% to 70% of attendance must apply for condonation in the Prescribed Form with the prescribed fee along with the Medical Certificate. Students with attendance less than 65% are not eligible to appear for the examination and they shall re-do the course with the prior permission of the Head of the Department, Principal and the Registrar of the University.

7. Maternity Leave

The student who avails maternity leave may be considered to appear for the examination with the approval of Staff i/c, Head of the Department, Controller of Examination and the Registrar.

8. Any Other Information

In addition to the above mentioned regulations, any other common regulations pertaining to the PG Programmes are also applicable for this Programme.

9. Programme Outcomes (POs):

On completion of this Programme, the learners

PO1	will acquire knowledge about the nature, concepts, methods, techniques and objectives in the core subject
PO2	will be able to cultivate scientific approach and culture of research aptitude.
PO3	will be able to face the national level competitive exams like NET, GATE, and SET etc
PO4	will be able to link Physics with other disciplines and also to the societal issues.
PO5	will be confident with their employability skills and entrepreneurial Skills

10. Program Specific Outcomes (PSO):

On the completion of this Programme the learners will

PSO1	get mastery over the field of Materials Science and Astrophysics and prepare them for research
PSO2	understand and apply inter-disciplinary concepts of Physics for understanding and describing the natural phenomenon
PSO3	gain strong foundations with a sound knowledge of underlying principles along with recent developments
PSO4	work with state-of-the art technologies
PSO5	acquire the ability to plan and execute their own innovative ideas in the form of projects, product design, and development.
PSO6	understand the importance of research methodology in science by acquiring knowledge through project, summer internship and field/industrial visit.

M.Sc. Physics

S.No.	Course Code	Course Title	Credits	Hours T	Hours P	CIA	ESE	Total
		Semester I						
1	P21PHT11	Core I **Mathematical Physics I**	4	5	0	25	75	100
2	P21PHT12	Core-II **Classical Mechanics**	4	5	0	25	75	100
3	P21PHT13	Core-III **Analog and Digital Electronics**	4	5	0	25	75	100
4	P21PHT14	Core-IV **Laser Physics and Non-Linear Optics**	4	5	0	25	75	100
5	P21PHP11	Core-V **Practical I (Electronics)**	4	0	6	25	75	100
6	P21CSS11	Supportive Course I **Computer Skills for Web Designing and Video Editing**	2	0	4	25	75	100
		Total	**22**	**30**		**-**	**-**	**600**
		Semester II						
7	P21PHT21	Core VI **Mathematical Physics II**	4	5	0	25	75	100
8	P21PHT22	Core-VII **Quantum Mechanics I**	4	5	0	25	75	100
9	P21PHT23	Core-VIII **Thermodynamics and Statistical Mechanics**	4	4	0	25	75	100
10	P21PHT24	Core-IX **Condensed Matter Physics I**	4	4	0	25	75	100
11	P21PHP22	Core-X **Practical II (Non-Electronics)**	4	0	6	25	75	100
12		Non Major Elective	4	4	0	25	75	100
13	P21PHS221/ P21PHS222	Supportive Course II (Skill) **Data Analysis by Origin Software/ Matlab Programming**	2	2	0	25	75	100
		Total	**26**	**30**		**-**	**-**	**700**
		Semester III						
14	P21PHT31	Core XI **Electromagnetic Theory**	4	5	0	25	75	100
15	P21PHT32	Core-XII **Quantum Mechanics II**	4	5	0	25	75	100
16	P21PHT33	Core-XIII **Condensed Matter Physics II**	4	4	0	25	75	100
17	P21PHT34	Core-XIV **Nuclear and Particle Physics**	4	4	0	25	75	100
18	P21PHT35	Core XV **Spectroscopy**	4	4	0	25	75	100
19	P21PHP33	Core-XVI **Practical III - (C** programming)	4	0	6	25	75	100
20	P21WSS33	Supportive Course III **(Women Empowerment)**	2	2	0	25	75	100
		Total	**26**	**30**				**700**
		Semester IV						
21	P21PHE411/ P21PHE412/ P21PHE413/	Elective-I* Astronomy and Astrophysics/Numerical	4	4	0	25	75	100

	P21PHE414	Methods/Modern Optics and Imaging/Any MOOC Course$						
22	P21PHE421/ P21PHE422/ P21PHE423/ P21PHE424	Elective-II* Materials Characterization Techniques / Physics of non-conventional Energy Resources/Physics of Nano-materials/ Any MOOC Course$	4	4	0	25	75	100
23	P21PHR41	Project	8	0	22	25	75	100
		Total	**16**	**30**				**300**
Total			**90**	**120**				**2300**

Non Major Elective (NME)

1. **NME I -** P21PHN211- **Elements of Nanoscience and Nanomaterials**
2. **NME II -** P21PHN212- **Fundamentals of Astrophysics**

Additional Credit Courses

1. **P21PHV11** - Value Added Program I-Two Credits (First Semester)

   P21PHV111 Classification of Solar Flares in X-Rays

   P21PHV112 Estimation of Solar Differential Rotation of Sunspots from Kodaikanal Solar Observatory (KSO) Data

2. **P21PHI21** - Internship/Industrial Training – Two Credits- (Second Semester)
3. **P21PHO31** - Online Courses-Two Credits- (Third Semester)
4. **P21PHV42** - Value Added Program II-Two Credits (Fourth Semester)

   P21PHV421 Identification of the Solar Radio Bursts

   P21PHV422 Estimation of Coronal Shock Speed

   P21PHV423 Estimation of Coronal Magnetic Field from Type II Radio Burst

*Those who have CGPA as 9, and want to do the project in industry/institution during IV semester, may opt for these two papers in III semester.

$ Students can take one 4 credit course in MOOC as elective or two 2 credit courses in MOOC as elective with the approval of Department committee.

Outside class hours

- Health, Yoga and Physical Fitness
- Library Information access and utilisation
- Employability Training

SEMESTER - I

Course Code	P21PHT11	MATHEMATICAL PHYSICS – I	L	T	P	C
Core-I			5	-	-	4

OBJECTIVES:
- To develop knowledge in Mathematical Physics and its applications.
- To expertise in Mathematical formulations required for Physics.
- To enhance problem solving skills.
- To enable students to interpret and draw inferences from Mathematical Solutions.

UNIT-I: VECTOR ANALYSIS AND VECTOR SPACES
Concept of gradient, divergence and curl - Gauss's divergence theorem, Green's theorem and Stoke's theorem (statement and proof) - Orthogonal curvilinear coordinates - Expression for gradient, divergence, curl and Laplacian in cylindrical and spherical co-ordinates (Theory). Linearly dependent and independent sets of vectors - Inner product (problems)- Schmidt's orthogonalization process.

UNIT-II: MATRICES
Types of Matrices and their properties, Rank of a Matrix, Eigenvalue Equations and their solutions, Theorems on Matrices; Diagonalisation and Diagonalisation of different matrices; Cayley-Hamilton's theorem; Problems.

UNIT–III: TENSOR ANALYSIS
Definition of Tensors – Contravariant, covariant and mixed tensors – addition and subtraction of Tensors – Summation convention- Symmetry and Anti-symmetry Tensor – Contraction and direct product – Quotient rule.

UNIT-IV: COMPLEX VARIABLE
Functions of complex variable-Analytic functions – Cauchy- Riemann equations- integration in the Complex plane-Cauchy's theorem- Cauchy's integral formula-Taylor and Laurent expansions- Singular Points- Cauchy's residue theorem - poles - evaluation of residues - evaluation of definite integrals.

UNIT-V: GROUP THEORY
Definition - Subgroups - Cyclic groups and abelian groups - Homomorphism and isomorphism of groups - Classes - Symmetry operations and symmetry elements - Representations of groups - Reducible and irreducible representations - Character tables for simple molecular types.

TEXT BOOKS:

1. Ken F. Riley, Mike P. Hobson, Stephen J. Bence, Mathematical Methods for Physics and Engineering Cambridge University Press, Third edition, 2018
2. B.S. Rajput, Mathematical Physics, Pragati Prakashan, 20th Edition, 2008.
3. B.D. Gupta, Mathematical Physics, Vikas Publishing House Pvt. Ltd, 1995.
4. Giampaolo Cicogna, Exercises and Problems in Mathematical Methods of Physics, Springer International Publishing, 2020

BOOKS FOR REFERENCE:

1. H.K. Dass and Rama Verma, Mathematical Physics, S. Chand and Company Ltd, 2010.
2. P.K. Chattopadhyay, Mathematical Physics, Wiley Eastern Limited, 1990.
3. Charlie Harper, Introduction to Mathematical Physics, Prentice Hall of India Pvt.Ltd, 1993.
4. L.A. Pipes and L.R. Havevill, Applied Mathematics for Engineers and Physicists, McGraw Hill Publications Co., 3rd Edition, 1971.
5. Murray R. Spigel, Theory and Problems of Laplace Transforms, Schaum's outline series, McGraw Hill, 1986.
6. Matrices and Tensors in Physics, A.W. Joshi, Wiley Eastern limited, 3rd Edition, 1995.

Course Outcomes (CO):

CO1: Expose to solve vector analysis and vector space [K2]
CO2: Acquire sound knowledge on matrices and tensors [K4]
CO3: Evaluate complex variables [K3]
CO4: Grasp problem solving skills in group theory [K4]
CO5: Understand the physics concepts using mathematics [K2]

K1- Remember K2- Understand K3- Apply K4- Analyze
K5-Evaluate K6-Create

Outcome Mapping

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	3	2	3	3	3	2	3	1	3
CO2	2	2	3	3	3	3	3	3	3	2	2
CO3	2	2	3	2	3	3	3	2	3	1	3
CO4	1	3	3	3	3	3	3	3	3	2	2
CO5	3	3	3	3	3	3	3	3	3	2	2

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHT12	CLASSICAL MECHANICS	L	T	P	C
Core-II			5	-	-	4

OBJECTIVES:

- To solve the equation of motion using Lagrangian, Hamilton and Hamilton-Jacobi equations.
- To study the kinematics of the rigid body through Euler equation.
- To get knowledge in central force field and relativity.

UNIT-I: LAGRANGIAN FORMULATION:

Lagrangian formulation: System of particles-constraints and degrees of freedom-generalized coordinates, force and energy-conservation laws-conservations of linear and angular– momenta-symmetric properties-homogeneity and isotropy-D'Alembert's principle of virtual work-Lagrange's equation of motion – non–holonomic-systems-applications of Lagrange equations of motion: free particle in space-Atwood's-machine.

UNIT –II: HAMILTON'S EQUATION AND CANONICALTRANSFORMATION-

Calculus of variation- principle of least action-Hamilton's principle-Hamilton`s function-Lagrange's equation from Hamilton's principle-Hamilton's principle for non-holonomic-system- variational principle-Hamilton's equations from variational principle-Legendre transformation and Hamilton's equation of motion. Cyclic coordinates and conservation theorem-Canonical transformations-Hamilton's canonical equations-Generating Functions – Examples -Poisson brackets and its properties.

UNIT-III: HAMILTON-JACOBITHEORYAND SMALL OSCILLATIONS

Hamilton-Jacobi equation for Hamilton's principle function-Example: Harmonic oscillator problem-Hamilton's characteristic function-Action-angle variable-application to Kepler problem in action angle variables. Eigen value equation-Normal Coordinates-Normal frequencies of vibration-vibrations of linear tri-atomic molecule.

UNIT-IV: KINEMATICS OF RIGIDBODY

Independent coordinates of rigid body-orthogonal transformation-properties of transformation matrix-Euler angle and Euler's theorem-infinitesimal rotation-Coriolis-force-angular momentum and kinetic energy of motion about appoint–moment of inertia tensor-non-inertial frames and pseudoforces-Euler's equations of motion-torque free motion of a rigid body.

UNIT-V: CENTRAL FORCE PROBLEM AND THEORY OF RELATIVITY -

Reduction to the equivalent one body problem-Centre of mass-Equation of motion and first integral-classification of orbits-Kepler problem: Inverse-Square law of force-Scattering in a central force field-transformation of scattering to laboratory coordinates. Orbits of artificial satellites, Virial theorem – Lorentz transformation, Relativistic Mechanics, Relativistic Lagrangian and Hamiltonian for a particle, Space time and energy – Momentum vectors.

TEXT BOOKS:

1. H. Goldstein, C. Poole and J. Safko, Classical Mechanics, Pearson Education Asia, New Delhi, Third Edition, 2002. (Unit 1-5)

2. G.Aruldhas, Classical Mechanics PHI Learning Private Limited, New Delhi, 2015.
3. P.C. Deshmukh, Foundation of Classical Mechanics, Cambridge University Press, 2021
4. Reinhard Hentschke, Classical Mechanics- Including an Introduction to the Theory of Elasticity, Springer International Publishing, 2017
5. Hyunsoo Min, Choonkyu Lee, Essential Classical Mechanics, World Scientific Publishing Co Pte Ltd, 2018.

BOOKS FOR REFERENCE:

1. S.L. Gutpa, V. Kumar and H.V. Sharma, Classical Mechanics, Pragati Prakashan, Meerut, 2016.
2. K.C.Gupta, Classical Mechanics of Particles and Rigid Bodies, New Age International Publishers, New Delhi, Third edition,2018.
3. N.C.Rana and P.J. Joag, Classical Mechanics, Tata Mc Graw Hill, New Delhi,2015.
4. J.C.Upadhaya, Classical Mechanics, Himalaya Publishing House Pvt. Ltd,Bangalore, Secondedition,2017.
5. B.D.Gupta, Satya Prakash, Classical Mechanics, Keder Nath Publishers, Meerut, Revised Edition, 2015.
6. R.G.Takwale and P.S.Puranik, Introduction to Classical Mechanics, Tata Mc Graw Hill, New Delhi, 1989.

Course Outcomes (CO):

CO1: Learn about the dynamics of system of particles using Hamiltonian, Lagrangian and Jacobi [K1]

CO2: Understand the planetary motion using Kepler's law [K2]

CO3: Get exposure about kinematics of rigid motion [K4]

CO4: Solve small oscillations using Legendre transformations and Hamiltonian [K3]

CO5: Solve harmonic oscillator problem using canonical transformation and Hamiltonian Jacobi [K5]

K1- Remember K2- Understand K3- Apply K4- Analyze K5-Evaluate K6 Create

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	3	3	3	3	3	3	3
CO2	3	3	1	3	3	3	3	3	3	1	2
CO3	3	3	1	3	3	3	3	3	3	2	3
CO4	3	3	2	3	3	3	3	3	3	2	1
CO5	3	3	1	3	3	3	3	3	3	2	1

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHT13	ANALOG AND DIGITAL ELECTRONICS	L	T	P	C
Core-III			5	-	-	4

OBJECTIVES:
- Give an insight to the students about basic concepts and techniques of electronic devices.
- Give in depth knowledge of operational Amplifiers, Memories and converters etc., to the students.
- Acquire skills in drawing electronic circuits
- Understand the concepts of CCD devices.
- The theoretical knowledge gained in the class room can be experimented in the practical classes.

UNIT-I: ELECTRONIC DEVICES
Construction, operation and I-V characteristics: Silicon controlled rectifiers (SCR) – Unijunction transistors (UJT) – Diode for alternating current (DIAC) – Triode for alternating current (TRIAC); Insulated gate bipolar junction transistor (IGBT).

UNIT-II: ELECTRONIC CIRCUITS AND CONTROLS
Converters: Chopper – Cycloconverters – Matrix converters; Rectifiers: Single-phase halfwave rectifiers – Single-phase full-wave rectifiers; Inverters: Single-phase inverters – Three-phase inverters – Multilevel inverters – Line-commutated inverters.

UNIT-III: OPERATIONAL AMPLIFIER APPLICATIONS
Operational Amplifier- CMRR-Slew rate -Instrumentation amplifier – V to I and I to V converter – Op-amp stages- Equivalent circuits - Sample and Hold circuits.
Applications of Op-Amp: Inverting, Non- inverting Amplifiers- circuits – Adder-Subtractor- Differentiator- Integrator- Electronic analog Computation solving simultaneous and differential equation –. Schmitt Trigger – Triangular wave generator – Sine wave generator – Active filters: Low, High and Band pass first and second order Butterworth filters – wide and narrow band reject filters.

UNIT-IV: SEMICONDUCTOR MEMORIES
Classification of memories and sequential memory – Static Shift Register and Dynamic Shift Register, ROM, PROM and EPROM principle and operation Read & Write memory - Static RAM, dynamic RAM, Content Addressable Memory - principle, block diagram and operation. Programmable Logic Array (PLA) - Operation, Internal Architecture. Charge Couple Device (CCD) - Principle, Construction, Working and Data transfer mechanism.

UNIT-V: A/D AND D/A CONVERTER
Sampling theorem-Time division multiplexing – Quantization – DAC- Weighted resistor method – Binary Ladder network – ADC – successive approximation, Dual slope and Counter method – Voltage to Frequency conversion and Voltage to Time conversion.

TEXT BOOKS:
1. Timothy L. Skvarenina, The Power Electronics Handbook – Industrial Electronics Series CRC press LLC, USA: 2002 (Unit I, II)

2. R.F. Coughlin and F.F, Driscol, Op-Amp and linear integrated circuits - Prentice Hall of India, New Delhi, 1996. (Unit III)
3. Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits - Pearson Education: Fourth Edition, 2015. (IV, V)
4. Charles H. Roth, Jr., Larry L. Kinney, Raghunandan G. H., Analog and Digital Electronics. Cengage Learning India Pvt. Ltd. 2019

BOOKS FOR REFERENCE:

1. Albert Malvino, David J Bates, Electronic Principles- 7th Edition, McGraw Hill, 2007.
2. V.K.Mehta, Principles of Electronics, 6th Revised Edition, S.Chand and Company, 2001.
3. David A. Bell, Electronic Devices and Circuits, 4th Edition, Prentice Hall. 2007.
4. R.P. Jain, Modern Digital Electronics, Tata McGraw Hill, 2007.

Course Outcomes (CO):

CO1: Learn the features of electronic devices. [K1]
CO**2 :**Study the operation of circuits used in electronic devices [K2]
CO3: Understand the concept of OPAMP applications [K2]
CO4: Able to carry out experiments based on applications of OPAMP: [K3]
CO5: Know the industrial applications of Semiconductor devices: [K5]

K1- Remember K2- Understand K3- Apply K4- Analyze K5-Evaluate K6-Create

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	3	2	2	3	2	2	2
CO2	3	2	3	3	2	2	2	3	3	2	2
CO3	3	2	2	3	2	3	3	3	3	2	2
CO4	3	2	1	3	3	3	3	3	3	2	2
CO5	2	2	2	3	3	3	2	3	2	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 MarksNo correlation (N) : -

<table>
<tr><td>Course Code</td><td>P21PHT14</td><td rowspan="2">LASER PHYSICS AND NON-LINEAR OPTICS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">Core-IV</td><td>5</td><td>-</td><td>-</td><td>4</td></tr>
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OBJECTIVES:

- To understand about fundamentals and types of laser.
- To know the basic principles of laser operation
- To grasp knowledge about characteristics and focusing of laser beam
- To know nonlinear optics.

UNIT I: LASERS-FUNDAMENTALS AND TYPES

Basic Construction and Principle of Lasing-Einstein Relations and Gain Coefficient - Creation of a Population Inversion- Three-Level System - Four-Level System - Threshold Gain Coefficient for Lasing- Laser types-He-Ne Laser-CO2 Laser- Nd:YAG Laser-Semiconductor Laser.

UNIT II: LASER OPERATION

Optical Resonator-Laser Modes-Axial modes- Transverse Modes-Modification in Basic Laser Structure- Basic Principle of Mode Locking- Active Mode Locking -Passive Mode Locking-Q-Switching- Pulse Shaping.

UNIT III: LASER BEAM CHARACTERISTICS

Wavelength-Coherence-Mode and Beam Diameter-Polarizations-Introduction to Gaussian Beam Width-Divergence-Radius of Curvature-Rayleigh Range-Guoy Phase Shift-3-D Gaussian Beams.

UNIT IV: FOCUSING OF LASER BEAM

Diffraction- Limited spot size-Concept of Beam Quality-Spherical Aberration- Thermal Lensing Effects-Depth of Focus-Tight focusing of laser beam - Angular Spectrum Representation of Optical Near Field-Aplanatic lens-Focusing of Higher- order laser modes-Radially Polarized Doughnut mode-Azimuthally Polarized Doughnut mode.

UNIT V: NON-LINEAR OPTICS

Introduction-Nonlinear Optical Media-The Nonlinear Wave Equation-Scattering Theory Born Approximation-Second-order Nonlinear Optics-Second-Harmonic Generation (SHG) and Rectification-The Electro-Optic Effect-Three-Wave Mixing- Frequency and Phase Matching- Optical Kerr Effect- Self-Focusing

TEXT BOOKS:

1. D.L. Mills - Nonlinear Optics - Basic Concepts, Springer, Berlin 1998.
2. B.B. Laud, Lasers and Nonlinear Optics - 2ndEdn. New Age International (P) Ltd., New Delhi, 1991
3. Guang S He, Song-Hao Liu, Advanced Nonlinear Optics, World Scientific Publishing Co Pte Ltd; 2nd edition. 2018
4. Peter E. Powers, Joseph W. Haus, Fundamentals of Nonlinear Optics, CRC Press, 2nd Edition, 2017

BOOKS FOR REFERENCE:

1. Subhash Chandra Singh, Haibo Zeng, Chunlei Guo, and Weiping Cai, Nanomaterials: Processing and Characterization with Lasers, Wiley-VCH Verlag GmbH & Co.K GaA. (2012).
2. Walter Koechner, Solid state Laser Engineering-6th edition-Springer (2006)
3. L. Novotny and B. Hecht- Principles of Nano Optics, Cambridge University Press (2006)
4. R.G.Driggers, C.Hoffman, Encyclopedia of Optical Engineering- Marcel Dekker(2003)
5. M. Steen, J.Mazumder, Laser Material Processing, Springer (2010)
6. Bahaa E. A. Saleh, Malvin Carl Teich Fundamentals of Photonics, John Wiley Sons, Inc, 1991.

COURSE OUTCOME

CO1: Know about laser fundamentals and characteristics [K2]
CO2: Understand the laser operation [K3]
CO3: Apply the knowledge for experimentation [K4]
CO4: Develop a skill in laser focusing [K5]
CO5: Understand non-linear optics [K5]

K1- Remember **K2- Understand** **K3- Apply**
K4- Analyze **K5-Evaluate** **K6- Create**

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	2	2	2	2	2	2	2	2	1
CO2	3	3	2	2	3	2	2	2	3	2	1
CO3	3	3	2	3	3	3	3	3	3	2	1
CO4	3	3	2	3	3	3	3	3	3	3	2
CO5	3	3	3	3	3	3	3	3	3	3	2

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHP11	PRACTICAL I (Electronics)	L	T	P	C
Core-V			-	-	6	4

Objectives:

This paper aims at providing an in- depth knowledge of the operational amplifier. The students will also get the opportunity to practically work out during the lab sessions.

1. Operational Amplifier – Design – Phase – Shift Oscillator,
2. Operational Amplifier – Design – Wein Bridge Oscillator
3. Operational Amplifier – Square wave generator
4. Operational Amplifier – Saw tooth wave generator
5. Operational Amplifier – Triangular wave generator
6. Operational Amplifier – Design of Schmitt Trigger
7. Operational Amplifier – Construction of Monostable Multi vibrator
8. Timer IC NE 555 Schmitt Trigger
9. Clock Generators using 7400 and 7413 ICs
10. Up- Down Counters – Design of modulus counters
11. Arithmetic operations using IC 7483
12. 7490 as modulus counters and display using 7447
13. Study of Multiplexer and Demultiplexer
14. Active Filters using IC 741

COURSE OUTCOME

On successful completion of this practical course the students will able to construct and understand the working principle of OP-Amp based circuits and circuits construct using different ICs.

SEMESTER - II

Course Code	P21PHT21	MATHEMATICAL PHYSICS – II	L	T	P	C
Core-VI			5	-	-	4

OBJECTIVES:

- To develop knowledge in mathematical physics and its applications.
- To develop expertise in mathematical techniques required in physics.
- To enhance problem solving skills.
- To enable students to formulate, interpret and draw inferences from mathematical solutions.

UNIT-I: DIFFERENTIAL EQUATIONS

Homogeneous linear equations of second order with constant coefficients and their solutions – ordinary second order differential with variable coefficients and their solution by power series and Frobenius methods – extended power series method for indicial equations.

UNIT-II: SPECIAL FUNCTIONS – I

Gamma and Beta function- Legendre's differential equation: Legendre polynomials - Generating functions - Recurrence relation - Rodrigue's formula - Orthogonality; Bessel's differential equation: Bessel polynomials - Generating functions - Recurrence relation - Rodrigue's formula – Orthogonality.

UNIT-III: SPECIAL FUNCTIONS – II

Hermite differential equation – Generating functions – Hermite polynomials - Recurrence relations – Rodrigue's formula - Orthogonality:

FOURIER SERIES:

Fourier Series - Functions of Any Period p = 2L - Even and Odd Functions- Half-Range Expansions

UNIT-IV: PARTIAL DIFFERENTIAL EQUATIONS

Solution of Laplace Differential Equation - Two-dimensional flow of heat in cartesian and cylindrical co-ordinates. Solution of heat flow equation in one dimension - Solution of wave equation - Transverse vibrations of a stretched string (Theory).

UNIT - V: INTEGRAL TRANSFORMS

Fourier transforms - cosine and sine transforms - Linearity theorem - Parseval's theorem - solution of differential equation. Laplace transforms - Definition - Linearity, shifting and change of scale properties. Inverse Laplace transforms – Definition - Problems - Solution of differential equation (problems using the above methods).

TEXT BOOKS:

1. A.B. Gupta, Fundamentals of Mathematical Physics, Books and Allied (P) Ltd. 6th Edn., 2016. (Chapter 8, Chapter 14, Chapter 10, Chapter 12 and Chapter 13)

2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons Pvt. Ltd., 2002 (Chapter 2, Chapter 6)
3. Ken F. Riley, Mike P.Hobson, Stephen J. Bence, Mathematical Methods for Physics and Engineering , Cambridge University Press; Third edition, 2018
4. Giampaolo Cicogna, Exercises and Problems in Mathematical Methods of Physics, Springer International Publishing, 2020

BOOKS FOR REFERENCE:

1. B.D. Gupta, Mathematical Physics, Vikas Publishing, 1995.
2. B.S. Rajput, Mathematical Physics, Pragati Prakashan, 20th Edition, 2008.
3. H.K. Dass and Rama Verma, Mathematical Physics, Chand and Company Ltd, 2010.
4. P.K. Chattopadhyay, Mathematical Physics, Wiley Eastern Limited, 1990.
5. Charlie Harper, Introduction to Mathematical Physics, Prentice Hall of India Pvt. Ltd, 1993.
6. L.A. Pipes and L.R. Havevill, Applied Mathematics for Engineers and Physicists, 3rd Edition, McGraw Hill, 1971.
7. Murray R. Spigel, Theory and problems of Laplace Transforms, International edition, McGraw Hill, 1986.

Course Outcomes (CO):

CO1: Understand about differential equation [K2]
CO2: Solve Physics problem using partial differential equations [K3]
CO3: Gain knowledge about special functions[K4]
CO4: Evaluate physical problem using Hermite polynomials and Fourier series [K4]
CO5: Identify right transforms to solve problem in Physics. [K5]

K1- Remember **K2- Understand** **K3- Apply** **K4- Analyze**
K5-Evaluate **K6-Create**

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	2	3	3	3	3	2	3	1
CO2	3	3	3	3	3	3	3	3	3	3	1
CO3	3	3	3	2	3	2	3	2	2	2	1
CO4	3	3	3	3	3	3	3	3	3	2	2
CO5	3	3	3	3	3	3	3	3	3	3	2

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHT22	QUANTUM MECHANICS –I	L	T	P	C
Core-VII			5	-	-	4

OBJECTIVES:

- To understand the basic concepts of wave mechanics.
- To study the stationary state and Eigen spectrum of systems using time dependent Schrodinger Equation.
- To solve the exactly soluble Eigen value problems.
- To know the matrix formulation of quantum theory and how it can be used to understand the equation of motion.
- To understand the theory of identical particles and Angular momentum.

UNIT-I: FOUNDATIONS OF WAVE MECHANICS

Postulates of wave mechanics – adjoint and self-adjoint operators-degeneracy-eigen value, eigen functions- Hermitian operator- parity - observables-Physical interpretation-expansion coefficients-momentum eigen functions-Uncertainty principle-states with minimum value-commuting observables -Matter waves – Equation of motion – Schrodinger equation for the free particle–physical interpretation of wave function - normalized and orthogonal wave functions-expansion theorem- admissibility conditions-stationary state solution of Schrodinger wave equation-expectation values-probability current density-Ehrenferts theorem.

UNIT-II: STATIONARY STATE AND EIGEN SPECTRUM

Time independent Schrodinger equation Particle in a square well potential–Bound states–eigenvalues, Eigen functions–Potential barrier–quantum mechanical tunneling- alpha emission.

Identical Particles and Spin:

Identical Particles– symmetry and antisymmetric wave functions–exchange degeneracy – Spin and statistics: Pauli's exclusion principle-Slater determinant-spin and Pauli's matrices.

UNIT-III: EXACTLY SOLUBLE EIGEN VALUE PROBLEMS

One dimensional linear harmonic oscillator–properties of stationary states-abstract operator method- Angular momentum operators-commutation relation – spherical symmetry systems – Particle in a central potential– radial wave function– Hydrogen atom: solution of the radial equation–functions – bound states-rigid rotator.

UNIT-IV: MATRIX FORMULATION OF QUANTUM THEORY, EQUATION OF MOTION & ANGULAR MOMENTUM

Quantum state vectors and functions – Hilbert space - Dirac's Bra-Ket notation-matrix theory of Harmonic oscillator–Equation of motions-Schrodinger, Heisenberg and Interaction representation. **Angular Momentum:** Angular momentum-commutation relation of J_Z, J_+, J_- -eigen values and matrix representationofJ^2, J_Z, J_+, J_-Spin angular momentum –spin½, spin-1-addition of angular momenta- Clebsch - Gordan coefficients.

UNIT – V: SCATTERING THEORY
Kinematics of scattering process – wave mechanical picture - Green's functions–Born approximation and its validity –Born series–screened coulombic potential scattering from Born approximation.

Partial wave analysis
Asymptotic behavior–phase shift–scattering amplitude in terms of phase shifts–differentialandtotalcrosssections–opticaltheorem–lowenergy scattering–resonant scattering–non-resonant scattering-scattering length and effective range.

TEXT BOOKS:

1. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw– Hill Publications, Second Edition,2010 (Unit I –V)
2. G. Aruldhas, A Textbook of Quantum Mechanics, Prentice Hall of India Pvt., Ltd., 2002
3. Satya Prakash, Quantum Mechanics, KedarNath RamNath and Co. Publications,2018.
4. Alastair I. M. Rae, Jim Napolitano, Quantum Mechanics, CRC Press, 2016

BOOKS FOR REFERENCE:

1. A. K. Ghatak and Lokanathan, Quantum Mechanics–Theory and applications, Macmillan India Ltd Publication, Fifth Edition, 2015.
2. Leonard I. Schiff, Quantum Mechanics, McGraw-Hill International Publication, Third Edition, 1968.
3. V.K. Thankappan, Quantum Mechanics, New Age International (P) Ltd. Publication, Second Edition,2003.
4. E. Merzbacher, Quantum Mechanics, John Wiley Interscience Publications, Third Edition, 2011.
5. Claude Cohen -Tannoudji, Bernard Diu, Franck Laloë, Quantum Mechanics (Vol.I) John Wiley Inter science Publications, First Edition,1991.
6. Pauling &Wilson, Quantum Mechanics, Dover Publications, New Edition, 1985.
7. R. Shankar, Principle of Quantum Mechanics Plenum US Publication, Second Edition, 1994.

COURSE OUTCOME:

CO1: Gain knowledge about the fundamentals of wave mechanics. [K1]
CO2: Apply wave mechanics in three dimensions. [K3]
CO3: Estimate the various components of angular momentum. [K5]
CO4: Evaluate the addition of two spin angular momenta. [K5]
CO5: Understand scattering theory and the approximation methods employed in solving quantum mechanical problems. [K2]

K1- Remember **K2- Understand** **K3- Apply** **K4- Analyze**
K5-Evaluate **K6- Create**

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	2	3	3	2	3
CO2	3	3	3	2	3	3	3	3	2	3	3
CO3	3	3	3	3	3	2	3	3	3	2	3
CO4	2	3	3	3	3	3	3	3	2	3	3
CO5	3	3	3	3	2	3	3	3	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHT23	THERMODYNAMICSAND STATISTICAL MECHANICS	L	T	P	C
Core-VIII			4	-	-	4

OBJECTIVES:

- To provide a phenomenological introduction to thermodynamics through thermodynamics postulates, quantities and relations.
- Studying the micro and macroscopic properties of the mater through the statistical probability laws and distribution of particles.
- Understanding the classical and quantum distribution laws and their relations.
- Studying transport properties, different phases of maters, equilibrium and non-equilibrium process.

UNIT- I: THERMODYNAMICS, MICROSTATES AND MACROSTATES

Basic postulates of thermodynamics – Phase space and ensembles – Fundamental relations and definition of intensive variables – Intensive variables in the entropic formulation – Equations of state – Euler relation, densities - Gibbs-Duhem relation for entropy - Thermodynamic potentials– Maxwell relations – Thermodynamic relations – Microstates and macro-states – Ideal gas – Microstate and macro-state in classical systems – Microstate and macro-state in quantum systems – Density of states and volume occupied by a quantum state

UNIT-II: MICROCANONICAL, CANONICAL AND GRAND CANONICAL ENSEMBLES

Microcanonical distribution function – Two level system in microcanonical ensemble – Gibbs paradox and correct formula for entropy – The canonical distribution function – Contact with thermodynamics - Partition function and free energy of an ideal gas –The grand partition function – Relation between grand canonical and canonical partition functions – One-orbital partition function

UNIT-III: BOSE-EINSTEIN, FERMI-DIRAC AND MAXWELL-BOLTZMANN DISTRIBUTIONS

Bose-Einstein and Fermi-Dirac distributions – Thermodynamic quantities – Non-interacting Bose gas and thermodynamic relations – Chemical potential of bosons – The principle of detailed balance – Number density of photons and Bose condensation - Thermodynamic relations for non-interacting Fermi gas – Fermi gas at zero and low temperature – Fermi energy and Fermi momentum - Maxwell-Boltzmann distribution law for microstates in a classical gas - Physical interpretation of the classical limit – Fluctuations in different ensembles

UNIT-IV: TRANSPORT AND NON-EQUILIBRIUM PROCESSES

Derivation of Boltzmann transport equation for change of states without and with collisions – Boltzmann equation for quantum statistics – Equilibrium distribution in Boltzmann equation – Transport processes; One speed and one dimension - All speeds and all directions - Conserved properties - Distribution of molecular velocities – Equipartition and Virial theorems –Random walk - Brownian motion - Non-equilibrium process; Joule-Thompson process - Free expansion and mixing - Thermal conduction - The heat equation.

UNIT-V: HEAT CAPACITIES, USING MODEL AND PHASE TRANSITIONS
Heat capacities of hetero nuclear diatomic gas – Heat capacities of homonuclear diatomic gas – Heat capacity of Bose gas –One-dimensional using model and its solution by variational method – Exact solution for one-dimensional using model - Phase transitions and criterion for phase transitions – Classification of phase transitions by order and by symmetry – Phase diagrams for pure systems – Clausius-Clapeyron equation – Gibbs phase rule

BOOK FOR STUDY

1. E.S.R.Gopal, Statistical Mechanics and Properties of Matter (Theory and Applications), Ellis Horwood Ltd, 1974. (Unit 1-5)

BOOKS FOR REFERENCE:

1. Reif, Fundamentals of Statistical and Thermal Physics, Sarat Book Distributors (2010).
2. B.B. Laud, Fundamentals of Statistical Mechanics, New Age International Private Limited, 2012.
3. C.Kittel, Elementary Statistical Physics, John Wiley & Sons, 2004.
4. F.Reif, Statistical and Thermal Physics, McGraw Hill, Fifth Edition, 2010.
5. Gupta & Kumar, Statistical Mechanics, 20th Edition, Pragati Prakashan, Meerut, 2003.
6. B.K.Agarwal and M.Eisner, Statistical Mechanics, Second Edition, New Age International Private Limited, Delhi, 2016.
7. Keith Stowe , An Introduction to Thermodynamics and Statistical Mechanics, Cambridge University Press; 2ndedition, 2013
8. Piero Olla, An Introduction to Thermodynamics and Statistical Physics, Springer International Publishing, 2015

Course Outcomes (CO):

CO1: Learn basic concept of ensembles [K2]
CO2: Explore the different theories and functions related to properties of gases [K3]
CO3: Distinguish between Bose –Einstein and Fermi- Dirac statistics [K4]
CO4: Exposure about kinetic theory of gases [K2]
CO5: Get knowledge about the different fluctuations in thermodynamics [K2]

K1- Remember **K2- Understand** **K3- Apply**
K4- Analyze **K5-Evaluate** **K6-Create**

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	2	3	3	3	3	3	3	3	3
CO3	3	3	3	2	3	3	3	3	2	3	2
CO4	3	2	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	2	3	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

<table>
<tr><td>Course Code</td><td>P21PHT24</td><td rowspan="2">CONDENSED MATTER PHYSICS – I</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">Core – IX</td><td>4</td><td>-</td><td>-</td><td>4</td></tr>
</table>

OBJECTIVES:

- To study about structure of crystal and crystal binding
- To grasp knowledge about diffraction of waves by crystals
- To enhance knowledge about crystal imperfections
- To know about lattice dynamics
- To understand theory of electrons

UNIT-1: CRYSTAL PHYSICS: CRYSTAL STRUCTURE

Lattice representation - Simple symmetry operations - Bravais Lattices, Unit cell, Wigner - Seitz cell - Miller planes and spacing - Characteristics of cubic cells - Structural features of NaCl, CsCl, Diamond, ZnS – Close packing.

Crystal Binding*:* Interactions in inert gas crystals Van der Waals Interaction – Repulsive Interaction – Equilibrium lattice constant - cohesive energy - ionic crystals and Madelung energy - Covalent bonding – Hydrogen bonding – metallic bonding.

UNIT-2: DIFFRACTION OF WAVES AND PARTICLES BY CRYSTALS

Diffraction of waves by Crystals X-ray diffraction – The Laue equations – Equivalence of Bragg and Laue equations – Interpretation of Bragg equation – Ewald construction – Brillouin zones- Reciprocal lattice – Reciprocal lattice to SC, BCC and FCC crystals- Importance properties of the Reciprocal lattice – Diffraction Intensity - The Powder method – Powder Diffractometer - The Laue method -The Rotating Crystal method - Neutron Diffraction - Electron diffraction.

UNIT-3: CRYSTAL IMPERFECTIONS AND ORDERED PHASES OF MATTER

Point imperfections – Concentrations of Vacancy, Frenkel and Schottky imperfections – Line Imperfections – Burgers Vector – Presence of dislocation – surface imperfections-Polorans – Excitons.

Ordered phases of matter: Translational and orientation order - Kinds of liquid crystalline order - Quasi crystals - Superfluidity.

UNIT-4: LATTICE DYNAMICS

Theory of elastic vibrations in mono and diatomic lattices - Phonons – Dispersion relations - Phonon momentum.

Heat Capacity

Specific heat capacity of solids – Dulong and Petit's law - Vibrational modes - Einstein model - Density of modes in one and three dimensions - Debye Model of heat capacity.

Anharmonic Effects

Explanation for Thermal expansion, Conductivity and resistivity – Umklapp process.

UNIT-5: THEORY OF ELECTRONS

Energy levels and Fermi-Dirac distribution for a free electron gas – Periodic boundary condition and free electron gas in three dimensions – Heat capacity of the electron gas – Ohm's law, Matthiessen's rule – Hall effect and magnetoresistance – Wiedemann – Franz law.

Nearly free electron model and the origin and magnitude of energy gap – Bloch functions - Bloch theorem - Motion of an electron in a periodic potential – Kronig – Penney model - Approximate solution near a zone boundary –Metals, semiconductors and insulators – effective mass – Limitations of K-P model – Tight binding approach - Construction of Fermi surfaces: Reduced and periodic zone schemes of construction- de Haas – van Alphen effect.

TEXT BOOKS:

1. Charles Kittel, Introduction to Solid State Physics, 7th Edition, Wiley India Pvt. Ltd, New Delhi, 2004. (Unit 1-V)
2. Rita John, Solid State Physics, Tata Mc Graw Hill Publications, 2014.
3. M. A. Wahab, Solid State Physics, Structure and Properties of Materials. Narosa, New Delhi, 1999.

BOOKS FOR REFERENCE:

1. Steven M. Girvin, Kun Yang, Modern Condensed Matter Physics, Cambridge University Press, 2019.
2. J. Blakemore, Solid State Physics, 2nd Edition, W. B. Saunders Co, Philadelphia, 1974.
3. J.D. Patterson, B.C. Bailey Solid-State Physics: Introduction to the Theory, Springer Publications, 2007.
4. M. Ali Omar, Elementary Solid-State Physics – Principles and Applications, Pearson, 1999.
5. C. M. Kachhava, Solid State Physics, Tata McGraw Hill, New Delhi, 1990.
6. N. W. Aschroft and N. D., Mermin, Solid State Physics, Rhinehart and Winton, New York. 1976.
7. M. Tinkham, Introduction to Superconductivity, Tata McGraw Hill, New Delhi, 1996.
8. K.K.Chattopadhyay, A.N.Banerjee, Introduction to Nanoscience & Nanotechnology, PHI learning private Ltd., Delhi 2014.
9. A. J. Dekker, Electrical Engineering Materials, Prentice Hall of India, 1975.
10. S.O. Pillai, Problems and Solutions in Solid State Physics, New Age international Publishers, New Delhi, 1994.

Course Outcomes

CO1: Understand about crystal structure and crystal binding [K1]

CO2: Calculate structure parameters of crystal and analyze reciprocal lattice of crystal [K4]

CO3: Analyze the defects in crystals [K4]

CO4: Understand the thermal parameters of crystal [K2]

CO5: Calculate parameters involved in Semiconductor. [K5]

K1- Remember	**K2- Understand**	**K3- Apply**
K4- Analyze	**K5- Evaluate**	**K6- Create**

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	3	3	3	2	2	3	2
CO2	3	3	3	2	3	3	3	3	3	3	3
CO3	3	3	2	2	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

<table>
<tr><td>Course Code</td><td>P21PHP22</td><td rowspan="2">PRACTICAL II (Non-Electronics)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">Core –X</td><td>-</td><td>-</td><td>6</td><td>4</td></tr>
</table>

Objectives:

The course aims at exposing the students to the intricacies of handling general equipment's and analysis of results. This laboratory session also aims the students to analysis the data given by Indian Institute of Astrophysics, Kodaikanal.

1. Solar Spectrum – Hartmann's Interpolation formula
2. Electrical resistance of a metal / an alloy by four probe method – as a function of temperature
3. Measure of numerical aperture (NA) of a telecommunication-grade Optic fiber
4. Fiber attenuation of a given optical fiber
5. Laser Experiments
6. Zeeman effect
7. Band Gap of Thermistor
8. Determination of Solar Constant
9. Michelson Interferometer – Wavelength and separation of wavelengths
10. Michelson Interferometer- Thickness of a mica sheet / thin film
11. Susceptibility – Quinke's or Gouy's method
12. Hall Effect
13. Spectral analysis of a salt by FTIR
14. Absorption spectra
15. Ultrasonics – Compressibility of a liquid
16. Ultrasonics – Compressibility of a solid
17. B-H curve using CRO
18. Calibration of a Gamma ray spectrometer and determination of the energy of unknown source
19. Any 4 experiments on Astrophysics to be recommended by **IIA**

Course Outcomes:

On successful completion of this course the students will

- Understand the concept and get hands on training on instruments
- Give acquaintance to measure and determine various physics constant using various physics instruments
- Apply different physics concept to analyze the data
- Analysis the data obtain from Indian Institute of Astrophysics, Kodaikanal and get information about different astronomical objects.

Course Code	P21PHS221	DATA ANALYSIS BY ORIGIN SOFTWARE	L	T	P	C
Supportive Course – II			2	-	-	2

Objectives:

- To develop understanding of the basics of Data analysis using Origin software.
- To enhance practical skills to analyse data using Origin software.
- To Determine baseline and curve fitting
- To Acquire skills to install and start-up origin software
- To Analyse data with Origin 7.5 version

Unit 1: Basic Data Analysis

Starting Origin, Reading Data, Subtracting Reference Data, Viewing Worksheet Data, Normalizing the Data, creating a Baseline, Fitting the Data, The Fitting Session, Calibration, Error analysis. Setting Range and Integrating the Data, Displaying the Integration Results, Plotting the Integration Area Data

Unit 2: Baseline Determinations & Curve Fitting

Starting the Baseline Session, User Adjustment of Linear Segments, choosing a Baseline Option, Cursor Draw Baseline -General Comment, Fitting Example 1, Fitting Example 2, Fitting Example3 χ 2 (chi-sqr) Minimization, Response Time – VP-DSC, Line Types for Fit Curves, Inserting an Origin graph into Microsoft® Word.

Unit 3: Origin version 7.5

Introduction, installing origin, uninstalling origin, selecting a User Files Folder, Licensing Origin, Registering Origin, Setting the Origin Display Language.

Introduction, Data Exchange, Analysis, Programming, The Origin Workspace, Origin Project Files, Project Windows, Window Templates, Themes, Tutorials

Reference

1. DSC Data Analysis in Origin ® Tutorial Guide Version 5.0 - October 1998
2. https://www.chem.purdue.edu/courses/chm224/Miscellaneous/INTRODUCTION%20TO%20ORIGIN%202012.pdf
3. https://www.originlab.com/pdfs/GettingStarted.PDF
4. https://www.originlab.com/pdfs/Origin_8.1_Getting_Started_Booklet.pdf

Course Outcome:

CO1: Understand basics of data analysis [K2]
CO2: Identify the selector tools and integrating the data [K4]
CO3: Determine baseline and curve fitting [K5]
CO4: Computing χ 2 and making use of details in Origin [K5]
CO5: Acquire skills to install and start-up origin software 7.5 version [K2]

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	3	3	2	3	3
CO2	3	3	3	2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	2	3	3	3	3	3	2	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

<table>
<tr><td>Course Code</td><td>P21PHS222</td><td rowspan="2">MATLAB PROGRAMMING</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">Supportive Course – II</td><td>2</td><td>-</td><td>-</td><td>2</td></tr>
</table>

The main objectives are:

1. Understanding the MATLAB environment
2. Know about MATLAB programming
3. Write simple programs in MATLAB to solve scientific and mathematical problems
4. Apply for Array operations and solving linear equations
5. Plotting using MATLAB

Unit I Basic features
Creating MATLAB variables - Overwriting variable - Error messages - Making corrections - Controlling the hierarchy of operations or precedence - Controlling the appearance of floating point number - Managing the workspace - Keeping track of your work session - Entering multiple statements per line - Miscellaneous commands - Getting help

Unit II Introduction to programming in MATLAB
Introduction - M-File Scripts - Examples - Script side-effects - M-File functions - Anatomy of a M-File function - Input and output arguments - Input to a script file - Output commands

Unit III Matrix generation
Entering a vector - Entering a matrix - Matrix indexing - Colon operator - Creating a sub-matrix - Deleting row or column – Dimension - Transposing a matrix - Matrix generators

Unit IV Array operations and solving linear equations
Matrix arithmetic operations - Array arithmetic operations - Matrix inverse - Matrix functions Introduction to programming in MATLAB

Unit V Basic plotting
Overview - Creating simple plots - Adding titles, axis labels, and annotations - Multiple data sets in one plot - Specifying line styles and colors.

Books for References:

1. David Houcque, Introduction to Matlab for Engineering Students, Northwestern University (version 1.2), August 2005
2. S.S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India (1983)
3. S.C. Chopra and R.C. Canale, Numerical Methods for Engineering, McGraw-Hill (1989).
4. Numerical Methods for Scientists and Engineers, Prentice Hall of India (1988). 49 I
5. http://www.mathworks.com/help/pdf_doc/matlab/getstart.pdf
6. http://www.mathworks.com/matlabcentral
7. http://www.mathworks.com/company/newsletters/

Course outcomes

CO1: Understand the necessity features of MATLAB [K1]
CO2: Learn about the programming in MATLAB [K2]
CO3: Expertise to write simple programme [K3]
CO4: Acquire skills to solve problems [K4]
CO5: Apply to plot graph [K5]

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	1	1	1	3	2	1	1	1	3	1
CO2	2	1	1	1	3	2	1	1	1	3	1
CO3	2	1	1	1	3	2	1	1	1	3	1
CO4	2	1	1	1	3	2	1	1	1	3	1
CO5	2	1	1	1	3	2	1	1	1	3	1

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

SEMESTER - III

Course Code	P21PHT31	ELECTROMAGNETIC THEORY	L	T	P	C
Core -XI			5	-	-	4

OBJECTIVES:

- To develop theoretical knowledge in electromagnetism.
- To develop skills on solving analytical problems in electromagnetism.
- To give basics of defining the complete electromagnetic response of complex systems.

UNIT -I: ELECTROSTATICS

Coulomb's law; the electric field – line, flux and Gauss's Law in differential form - the electrostatic potential; conductors and insulators; Gauss's law - application of Gauss's law – curl of E - Poisson's equation; Laplace's equation – work and energy in electrostatics – energy of a point charge distribution – energy of continuous charge distribution – induced charges – capacitors. Potentials: Laplace equation in one dimension and two dimensions – Dielectrics – induced dipoles – Gauss's Law in the presence of dielectrics.

UNIT- II: MAGNETOSTATICS

Lorentz force – magnetic fields – magnetic forces – currents – Biot-Savart Law – divergence and curl of B – Ampere's Law – Electromagnetic induction - comparison of magnetostatics and electrostatics – Magnetic vector potential. Magnetization: effect of magnetic field on atomic orbit – Ampere's Law in magnetized materials – ferromagnetism.

UNIT-III: ELECTROMOTIVE FORCE

Ohm's Law – electromotive force – motional emf – Faraday's Law – induced electric field – inductance – energy in magnetic field – Maxwell's equation in free space and linear isotrophic media – continuity equation – Poynting theorem.

Electromagnetic waves in vacuum: Waves in one dimension – wave equation – sinusoidal waves – reflection and transmission – Polarization.

UNIT-IV: ELECTROMAGNETIC WAVES

The wave equation for E and B – Monochromatic Plan waves – energy and momentum in electromagnetic waves – electromagnetic waves in matters –TE waves in rectangular wave guides – the co-axial transmission line. Potentials: potentials and fields – scalar and vector potentials – Gauge transformation – Coulomb Gauge and Lorentz Gauge – Lorentz force law in potential form.

UNIT-V: APPLICATION OF ELECTROMAGNETIC WAVES

Boundary conditions at the surface of discontinuity – Reflection and refraction of E.M waves at the interface of non – Conducting media – Kinematic and dynamic properties – Fresnel's equation – Electric field vector 'E' parallel to the plane of incidence and perpendicular to the plane of incidence – Reflection and transmission co-efficients at the interface between two non–Conducting media – Brewster's law and degree of polarization – Total internal reflection.

TEXT BOOKS:

1. B.B Laud, Electromagnetics, Wiley Eastern Company, 2000. (Unit 1-5)
2. David J. Griffiths, Introduction to Electrodynamics, 4th Edition, Pearson, 2015.
3. Sathya Prakash, Electromagnetic Theory and Electrodynamics, KedarNath Ram Nath and Co, 2017.
4. Wazed Miah, Fundamentals of Electromagnetic, Tata Mc Graw Hill, 1980.
5. George E. Owen, Introduction to Electromagnetic Theory, Dover Publications, 2013
6. Narayana Rao, Basic Electromagnetics with Application, (EEE) Prentice Hall, 1997.

BOOKS FOR REFERENCE:

1. John R.Reitz, Frederick J Milford and Robert W.Christy, Fundamentals of Electromagnetic Theory, Third edition, Narosa Publishing House, New Delhi, 1998.
2. J.D. Jackson, Classical Electrodynamics, II Edition, Wiley Eastern Limited, 1993.
3. P.Lorrain and D.Corson Electromagnetic Fields and Waves, W.H.Freeman & Co Ltd; 2nd edition,1970

Course Outcomes (CO):

CO1: Learn the fundamentals of electrostatics [K1]
CO2: Acquire the knowledge about magnetostatics [K2]
CO3: Gain knowledge about the Maxwell equation [K2]
CO4: Learn about electromagnetic waves [K2]
CO5: Apply electromagnetic waves for different field [K3]

K1- Remember K2- Understand K3- Apply K4- Analyze
K5-Evaluate K6- Create

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2	3	2	3
CO3	3	2	3	3	3	3	2	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	1	2
CO5	3	3	2	3	3	3	3	2	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHT32	QUANTUM MECHANICS –II	L	T	P	C
Core -XII			5	-	-	4

OBJECTIVES:

- To study the effect of magnetic and electric field on quantum particles.
- To learn about the approximation methods for time independent and time dependent perturbation theory.
- To understand the kinematics of scattering process
- To study the theory of relativistic quantum mechanics and field quantization.
- To study the quantum theory of atomic and molecular structures.

UNIT-I: APPROXIMATION METHODS FOR TIME INDEPENDENT PROBLEMS

Time independent perturbation theory –stationary theory - non-degenerate case: first and second order-Normal Helium atom– Zeeman effect without electron spin – Stark effect in hydrogen molecule - Degenerate case: Energy Correction-Stark effect in hydrogen atom.

UNIT-II: APPROXIMATION METHODS FORTIME DEPENDENT PERTURBATION THEORY

Time dependent Perturbation theory –first order transitions–constant perturbation-transition probability: Fermi Golden Rule–Periodic perturbation –harmonic perturbation– a diabatic and sudden approximation.

Semi-classical theory of radiation: Application of the time dependent perturbation theory to semi-classical theory of radiation – Einstein's coefficients – absorption – induced emission-spontaneous emission–Einstein's transition probabilities-dipole transition-selection rules– for bidden transitions.

UNIT-III VARIATION METHOD

Variation method: Variation Principle – upper bound states – ground state of Helium atom– Hydrogen molecule – WKB approximation – Schrodinger equation – Asymptotic solution - validity of WKB approximation – solution near a turning point– connection formula for penetration barrier– Bohr-Summer field quantization condition-tunneling through a potential barrier.

UNIT–IV: QUANTUM THEORY OF ATOMIC AND MOLECULAR STRUCTURE

Central field approximation: Residual electrostatic interaction-spin-orbit interaction-Determination of central field: Thomas Fermi statistical method – Hartree and Hartree-Fock approximations (self consistent fields) –Atomic structure and Hund's rule.

Molecules

Born – Oppenheimer approximation –An application: the hydrogen molecule Ion (H_2^+) – Molecular orbital theory: LCAO approximation- Hydrogen molecule.

UNIT-V: RELATIVISTIC QUANTUM MECHANICS &QUANTIZATION OF THE FIELD

Schrodinger relativistic equation – Klein-Gordan equation – charge and current densities– interaction with electromagnetic field – Hydrogen like atom – non relativistic limit - Dirac relativistic equation: Dirac relativistic Hamiltonian–probability density-Dirac matrices-plane wave solution–eigen spectrum –spin of Dirac particle –significance of negative eigenstates–electron in a magnetic field– spin magnetic moment.

Quantization of the Field
Quantization of wave fields- Classical Lagrangian equation- Classical Hamiltonian equation- Field quantization of the non-relativistic Schrodinger equation- Creation, destruction and number operators- Anti commutation relations- Quantization of Electromagnetic field energy and momentum.

TEXT BOOKS:

1. P.M. Mathews and K.Venkatesan, A Text book of Quantum Mechanics- TataMcGraw– Hill Publications, Second Edition,2010.**(Unit I – V)**
2. Satya Prakash, Quantum Mechanics, Kedar Nath Ram Nath and Co. Publications, 2018.
3. Claude Cohen-Tannoudji, Bernard Diu, Franck Laloë, Quantum Mechanic (Vol.II), Quantum Mechanics (Vol. II), John Wiley Publications, 2008.

BOOKS FOR REFERENCE:

1. V.K.Thankappan, Quantum Mechanics, New Age International (P) Ltd. Publication, Second Edition,2003.
2. Franz Schwabl, Quantum mechanics, Narosa Publications, Fourth Edition, 2007.
3. P.W. Atkins and R.S. Friedman, Molecular Quantum mechanics, Oxford University Press Publication, Fifth Edition, 2010.
4. A.K. Ghatak and Lokanathan, Quantum Mechanics–Theory and Applications, Macmillan India Ltd Publication, Fifth Edition, 2015.
5. Leonard I. Schiff, Quantum Mechanics, McGraw-Hill International Publication, Third Edition,1968.
6. E. Merzbacher, Quantum Mechanics-John Wiley Interscience Publications, Third Edition, 2011.
7. Edwin C. Kemble, Fundamental principles of Quantum mechanics with elementary applications - Dover Publications,2005.
8. R. Shankar, Principle of Quantum Mechanics - Plenum US Publication, Second Edition, 1994.

COURSE OUTCOMES:

CO1: Describe the advanced knowledge in quantum mechanics [K1]
CO2: Understand the effect of magnetic and electric field on quantum particles. [K2]
CO3: Analyze Approximation methods for time independent problems and for time dependent perturbation theory [K4]
CO4: Apply different approximation methods to quantum particles. [K3]
CO5: Analyze the theory of relativistic quantum mechanics and quantization of field. [K4]

K1- Remember K2- Understand K3- Apply
K4- Analyze K5-Evaluate K6-Create

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	2	3	3	3	3
CO2	3	3	3	3	3	2	3	3	3	3	3
CO3	3	2	3	2	3	3	3	2	3	2	3
CO4	3	3	2	3	3	3	3	3	2	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3

Strongly correlating (S) : 3 Marks
Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks
No correlation (N) : -

Course Code	P21PHT33	CONDENSED MATTER PHYSICS – II	L	T	P	C
Core – XIII			4	-	-	4

OBJECTIVES:

- To develop knowledge on dielectric properties of materials
- To understand the phenomenon of ferroelectrics and piezoelectrics
- To grasp knowledge on various magnetic properties of materials
- To know about superconductivity
- To acquire knowledge on physics involved in nanosolids

UNIT – I: THEORY OF DIELECTRICS

Dipole moment – Polarization – The electric field of a dipole – Local electric field at an atom – Clausius –Mosotti equation - Dielectric constants and its measurements - Polarizability – The Classical theory of electronic polarizability – Ionic polarizabilities - Orientational polarizabilities - The polarizability catastrophe - Dipole orientation in solids - Dipole relaxation and dielectric losses – Debye Relaxation time - Relaxation in solids - Complex dielectric constants and the loss angle - Frequency and temperature effects on Polarization – Dielectric breakdown and dielectric loss

UNIT – II: THEORY OF FERROELECTRICS AND PIEZO ELECTRICS

Ferroelectric Crystals – Classifications of Ferroelectric crystals - Dipole theory of ferroelectricity – Landau Theory of the phase transition – Second order Transition – First Order Transition - Ferroelectric Transition - One-Dimensional Model of the Soft Mode of Ferroelectric Transitions – Antiferroelectricity - Ferroelectric domains – Ferroelectric domain wall motion – Piezoelectricity - Phenomenological Approach to Piezoelectric Effects - Piezoelectric Parameters and Their Measurements -Piezoelectric Materials

UNIT – III: MAGNETIC PROPERTIES OF MATERIALS

Terms and definitions used in magnetism – Classification of magnetic materials – Atomic theory of magnetism – The quantum numbers- The origin of permanent magnetic moments – Langevin's classical theory of diamagnetism – Sources of paramagnetism – Langevin's classical theory of paramagnetism – Quantum theory of paramagnetism – Paramagnetism of free electrons - Ferromagnetism – The Weiss molecular field – Temperature dependence of Spontaneous magnetization – The physical origin of Weiss Molecular field - Ferromagnetic domains - Domain theory – Antiferromagnetism – Ferrimagnetism – Structure of Ferrite.

UNIT – IV: SUPERCONDUCTIVITY

Occurence of super conductivity - Destruction of super conductivity by magnetic fields - Meissner Effect – Type I and Type II Super conductors - Heat Capacity - Energy gap - Microwave and infrared properties - Isotope effect - Thermodynamics of the superconducting transition - London equation - Coherence Length - BCS theory of superconductivity, BCS ground state - Flux quantisation in a super conduction ring - Duration of persistence currents - Single particle tunnelling - DC Josephson effect - AC Josephson effect - Macroscopic quantum interference – High temperature super conductors – Applications.

UNIT – V: PHYSICS OF NANOSOLIDS

Definition of nanoscience and nanotechnology – Nanoparticles – Metal nanoclusters – Semiconductor nanoparticles - Preparation of nanomaterials – Surface to volume ratio – Quantum confinement – Qualitative and Quantitative description – Density of states of nanostructures – Bulk solid- quantum dots - quantum wires - quantum well - Excitons in Nano semiconductors – Properties of Nanomaterials – Carbon in nanotechnology – Graphite – Graphene –Fullerenes- Carbon nanotubes

TEXT BOOKS:

1. Charles Kittel, Introduction to Solid State Physics, 7th Edition, Wiley India Pvt. Ltd. , New Delhi, 2004. (Unit I-IV)
2. Rita John, Solid State Physics, Tata Mc Graw Hill Publications, 2014.
3. M. A. Wahab, Solid State Physics – Structure and Properties of Materials. Narosa, New Delhi, 1999.
4. J.D. Patterson, B.C. Bailey Solid-State Physics: Introduction to the Theory, Springer Publications, 2007.
5. M. Ali Omar, Elementary Solid-State Physics – Principles and Applications, Pearson, 1999.
6. G. Grosso, G. Parravicini, Solid State Physics, Academic Press, 2013

BOOKS FOR REFERENCE:

1. J. Blakemore, Solid State Physics, 2nd Edition, W. B. Saunders Co, Philadelphia, 1974.
2. C. M. Kachhava, Solid State Physics, Tata McGraw Hill, New Delhi, 1990.
3. N. W. Aschroft and N. D., Mermin, Solid State Physics, Rhinehart and Winton, New York. 1976.
4. M. Tinkham, Introduction to Superconductivity, Tata McGraw Hill, New Delhi, 1996.
5. K.K.Chattopadhyay, A.N.Banerjee, Introduction to Nanoscience & Nanotechnology, PHI Learning private Ltd., Delhi 2014.
6. A. J. Dekker, Electrical Engineering Materials, Prentice Hall of India, 1975.
7. S.O. Pillai, Problems and Solutions in Solid State Physics, New Age international Publishers, New Delhi, 1994.
8. A.K. Bain, P. Chand, Ferroelectrics, Wiley, 2017.
9. Kwan Chi Kao, Dielectric phenomena in solids with emphasis on physical concepts of electronic processes, Elsevier Academic Press, 2004
10. Alexander O. E. Animalu, Intermediate Quantum Theory of Crystalline solids, Prentice Hall of India, New Delhi, 1978.
11. Eleftherios N. Economou, The Physics of Solids – Essentials and Beyond, Springer, 2010.

Course Outcomes (CO)

On completion of this course, the learners are able to

CO1: understand about dielectric properties [K2]

CO2: Gain knowledge about ferroelectrics and piezoelectrics materials [K1]

CO3: analyze the various kinds of magnetic materials [K4]

CO4: analyze different types of superconductors [K4]

CO5: understand about low dimensional physics behind different nanosolids. [K6]

K1- Remember K2- Understand K3- Apply

K4- Analyze K5-Evaluate K6- Create

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	3	3	2	3	3
CO2	3	3	3	3	2	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	2	3	2	3	3	3	2	3	3
CO5	3	3	3	3	2	3	3	3	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHT34	NUCLEAR AND PARTICLE PHYSICS	L	T	P	C
Core - XIV			4	-	-	4

Objectives:

- Know about the properties of nuclei
- Study the nuclear models
- Understand the concept of radioactivity
- Understand the elementary particles
- Thorough knowledge on nuclear reactions

UNIT-I: NUCLEAR FORCES

Characteristics of Nucleus Forces – Exchange forces and tensor forces – charge independence-Spin dependence of Nucleus Forces - Meson theory of nuclear forces- Ground state of deuteron- Nucleon-nucleon scattering singlet and triplet parameters – Nucleon-Nucleon scattering: Cross-section, Differential Cross-section, Scattering Cross-sections – magnetic moment- Quadrupole moment –S and D state admixtures - Effective range theory of n-p scattering at low energies.

UNIT-II: NUCLEAR MODELS

Binding energy & mass defect – Weizacker's formula – mass parabola - Liquid drop model - Bohr -Wheeler theory of fission- Activation energy for fission- Shell model- Spin –Orbit coupling-Spins of nuclei- Magnetic moments – Schmidt lines- Electric quadrupole moments - Collective model of Bohr and Mottelson: Nuclear vibration – Nuclear rotation –Nelson model.

UNIT-III: NUCLEAR REACTIONS

Nuclear reaction - Q- value – Nuclear reaction cross section – Direct Nuclear Reactions: Knock out reaction, Pick-up reaction, Stripping reaction – Nuclear fission –Nuclear fusion – Nuclear reactor-Compound nucleus theory – Formation – Disintegration energy levels – Resonance Scattering and Reaction cross-section (Breit-Wigner dispersion formula) – Scattering matrix - Reciprocity theorem – Breit -Wigner one level formula – Resonance scattering – Absorption cross section at high energy.

UNIT-IV: RADIOACTIVE DECAYS

Alpha decay - Beta decay –Energy release in beta decay – Fermi theory of beta decay – Shape of the beta spectrum – decay rate Fermi-Curie plot – Fermi & G.T Selection rules - Comparatives half - lives and forbidden decays- Gama decay - Multipole radation – Angular momentum and parity selection rules – Internal conversion – Nuclear isomerism.

UNIT-V: ELEMENTRY PARTICLE PHYSICS

Classification of elementary particles - Types of interaction between elementary particles – Unification of Different Interactions-Hadrons and leptons – Symmetry and conservation laws – Strangeness and associate production - CPT theorem – classification of hadrons – Quark model - Isospin multiples - SU(2)- SU(3) multiplets- Gell-Mann - Okubo mass formula for octet and decuplet hadrons – Phenomenology of weak interaction hadrons and leptons - Universal Fermi interaction –Cosmic rays-introduction-discovery.

TEXT BOOKS:

1. B. B. Cohen, Concepts of Nuclear Physics, TMGH, Bombay, 1971. (Unit I to II)
2. D.C. Tayal, Nuclear Physics, Himalaya Publishing House Pvt., Ltd., V edition, 2018.(III to IV)
3. D. Griffiths, Introduction to Elementary Particles, 2nd Ed., Wiley-Vch, 2008 (V)
4. K. Krane, Introductory Nuclear Physics, Wiley, New York, 1987.

BOOKS FOR REFERENCE:

1. V. Devanathan, Nuclear Physics, Narosa Publishing house, 2012.
2. S. N. Ghoshal, Nuclear Physics, S. Chand and Co., II edition, 1994.
3. Irving Kaplan, Nuclear Physics, Narosa Publishing House, 2012.
4. B.N. Srivatsava, Basic Nuclear Physics and Cosmic Rays, Pragati Prakashan publications, Meerut, Edition: XVII, 2016.
5. M.L. Pandya and P.R.S Yadav, Elements of Nuclear Physics, Kedar Nath Ram Nath publications, Meerut, 2016.

Course Outcomes (CO):

CO1: Learn about nuclear forces [K1]
CO2: Acquire knowledge about different nuclear models [K2]
CO3: Understand about different nuclear reactions [K2]
CO4: Gain knowledge about Q-value and theories of nuclear reactions [K4]
CO5: Learn about different classification and properties of elementary particles [K4]
K1- Remember **K2- Understand** **K3- Apply**
K4- Analyze **K5-Evaluate** **K6- Create**

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	2	2	2	2	2	2	3
CO2	3	3	3	3	3	2	3	2	3	2	2
CO3	3	3	2	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	2	3	3	3	3
CO5	3	2	3	3	3	3	3	2	3	2	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHT35	SPECTROSCOPY	L	T	P	C
Core – XV			4	-	-	4

OBJECTIVES:

- To give advanced knowledge infrared Spectroscopy
- To enhance knowledge about Raman Spectroscopy
- To study about electronic spectroscopy
- To know about NMR and ESR
- To gain knowledge about NQR and Mossbauer Spectroscopy

UNIT-I: INFRARED SPECTROSCOPY

Vibrational energy of a diatomic molecule- Infrared selection rules-Vibrating diatomic molecule Diatomic vibrating rotator- Vibrations of polyatomic molecules-Fermi resonance-Rotation vibration spectra of polyatomic molecules-Normal modes of vibration in crystal-Interpretation of vibrational spectra-Group frequencies-IR spectrophotometer-Instrumentation-Sample handling techniques-Fourier Transform Infrared spectroscopy-Applications

UNIT II: RAMAN SPECTROSCOPY

Introduction-Theory of Raman scattering-Rotational Raman spectra-Vibrational Raman spectra Mutual Exclusion principle-Raman spectrometer-Sample handling techniques-Polarization of Raman scattered light-Structure determination using IR and Raman spectroscopy-Raman investigation of phase transitions-Resonance Raman scattering-Nonlinear Raman phenomena Preliminaries-Hyper Raman effect-Stimulated Raman scattering-Inverse Raman effect-Coherent Anti-Stokes Raman scattering.

UNIT III: ELECTRONIC SPECTROSCOPY

Structure of atoms- Electronic Angular Momentum – Many Electron atoms – Angular momentum of Many Electron atom – Photoelectron Spectroscopy – Zeeman effect – Influence of Nuclear spin – Electronic spectra of Diatomic molecule – Electronic structure of diatomic molecules- Electronic spectra of Polyatomic molecule-Chemical analysis by Electronic Spectroscopy

UNIT IV: NUCLEAR MAGNETIC AND ELECTRON SPIN RESONANCE SPECTROSCOPY

Basic principles – Quantum theory of NMR - magnetic resonance – relaxation processes – chemical shifts – spin-spin coupling - Spectra and molecular structure – Fourier Transform NMR –Instrumentation – Applications. Basic principles – Quantum theory - g-factor – Nuclear Interaction and Hyperfine structure – Relaxation effects - Hyperfine interaction – line widths – ESR spectrometer – Instrumentation – applications.

UNIT V: NUCLEAR QUADRUPOLE RESONANCE AND MOSSBAUER SPECTROSCOPY

Basic theory - Nuclear Electric quadrupole interaction – Energy levels – Transition frequency – Excitation and Detection – Effect of magnetic field – Instrumentation – applications. Mossbauer effect - recoilless emission and absorption - hyperfine interaction - chemical isomer shift - magnetic hyperfine and electric quadruple interactions – ` Instrumentation – applications.

TEXT BOOKS:

1. Colin N. Banwell, Elaine M. McCash, Fundamentals of Molecular Spectroscopy (Fourth Edition), Tata McGraw-Hill Publishing Company Ltd, 2017. (Chapter 3-7)

BOOKS FOR REFERENCE:

1.Donald L. Pavia Introduction to Spectroscopy, Cengage Learning India Private Limited, 5th Edn. 2015
2. K. Veera Reddy, Symmetry and Spectroscopy of Molecules, New Age International Publisher, 2021.
3. J.D. Graybeal, Molecular Spectroscopy, McGraw-Hill, New York, 1988.
4. Hollas, Michael, Modern Spectroscopy (Fourth Edition) John Wiley, New York, 2004.
5.R.P Straughen, S.Walker, Spectroscopy Vols.I,II and III, Chapman & Hall, London, 1976.

Course Outcomes (CO):

CO1: Understand about principle and concept of different kinds of spectroscopy [K2]
CO2: Acquisition of knowledge about working procedure of spectroscopic instruments. [K2]
CO3: Analyze the properties of the materials using various spectroscopic techniques [K4]
CO4: Experimenting spectroscopic tools for research [K4]
CO5: Acquire sound instrumentation skills [K2]

K1- Remember **K2- Understand** **K3- Apply**
K4- Analyze **K5-Evaluate** **K6-Create**

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3
CO5	3	2	3	3	3	3	3	3	3	3	3

Strongly correlating (S) : 3 Marks **Moderately correlating (M): 2 Marks**
Weakly correlating (W) : 1 Marks **No correlation (N) : -**

Course Code	P21PHP33	PRACTICAL III (C Programming)	L	T	P	C
Core – XVI			-	-	6	4

Objectives:

The course aims at exposing the students to solve different numerical equation by C programming.

1. Ascending and descending order of numbers and characters
2. Matrix addition, subtraction and multiplication
3. Transpose of a matrix
4. Evaluating a root of non-linear equation by Newton-Raphson method using external function
5. Program to solve system of linear equations using simple Gaussian elimination method
6. Program for straight line fit using the method of least squares for a table of data points
7. Program for polynomial curve fitting
8. Program to integrate any function or tabulated data using trapezoidal rule
9. Program to integrate any function or tabulated data using Simpson's rule
10. Program to compute the solution of a first order differential equation of type y'=f(x,y) using the fourth order Runge-Kutta method
11. Program to compute the interpolation value at a specified point, given a set of data points using Lagrangian interpolation representation
12. Program to compute the interpolation value at a specified point, given a set of data points using Newton's interpolation representation
13. Program to calculate and print the mean, variance and standard deviation of set of N numbers
14. Program to solve the quadratic equation
15. Program to read a set of numbers, count them and find and print the largest and smallest numbers in the list and their positions in the list

Course Outcomes (CO):

Upon successful completion of this course the students will able to write C program for different mathematical problems.

SEMESTER - IV

Course Code	P21PHE411	ASTRONOMY AND ASTROPHYSICS	L	T	P	C
Elective -I			4	-	-	4

Objectives:

- To enhance knowledge on the concepts of coordinate system and stellar spectra
- To understand about astronomical instruments,
- To grasp knowledge about cosmology
- To acquire knowledge about concepts of stellar evolution

Unit I: BASIC CONCEPTS & CELESTIAL MECHANICS
Coordinate systems, systems of time, parallaxes, distances, Luminosity, Apparent and absolute magnitudes, stellar radial velocities, masses, Binary stars, stellar spectra, spectral classification, HR diagram, Variable stars (definition only)

Unit II: ASTRONOMICAL INSTRUMENTS AND OBSERVATIONAL TECHNIQUES & SOLAR PHYSICS
Varieties of optical telescopes (Reflecting, Refracting, Catadioptrics), Angular resolution, Focal length and Focal Ratio, Imperfections in optics, large telescopes - TMT, Segmented mirrors, spectrographs, Filters, Adoptive optics, Characteristics, Photometers, UBV System, color index, atmospheric effects, CCD camera.

Solar Interior structure (Pressure Density, temperature, generation of energy, radiative and convective zones), Solar Neutrino – future of Neutrino studies.

Solar Atmosphere: Photosphere, Model of solar photosphere, chromosphere, corona, sunspots, their properties, cyclic variation, connection with magnetic fields, solar prominences, solar flares, active regions, helioseismology

Unit III: SOLAR SYSTEM
Physical processes in solar system, the terrestrial planets, asteroid belt, Jupiter, Saturn, Uranus and Pluto, Kuiper belt objects, Comets, Asteroids, Meteoroid – formation of the solar system

Unit IV: COSMOLOGY
Hubble's Law: Newtonian Cosmology, Cosmic Background radiation, cosmological blue shifts, cosmological red shifts, Observational techniques

Unit V: STELLAR EVOLUTION, WHITE DWARFS, NEUTRON STARS AND BLACK HOLES
Vogt-Russel Theorem, mass luminosity relation - Proto stars, Pre-main sequence evolution, main sequence evolution, last stage of stellar evolution, fate of massive stars, discovery of Sirius – B, White dwarfs, Quantum mechanics of degenerate matter, mass radius relation for neutron stars, pulsars, crab nebula pulsar, stellar and super massive black holes

TEXT BOOK:

1. Shu F.H: The Physical Universe – An Introduction to Astronomy, University Science Books, 1981.
2. Nicola Vittorio, Cosmology, CRC Press; 1st edition 2017.

BOOKS FOR REFERENCE:

1. B.W.Carroll & D.A.Ostlie: An Introduction to Modern Astrophysics, 2nd Edn, Cambridge University Press, 2017
2. Karttunen, H., Kröger, P., Oja, H., Poutanen, M., Donner, K.J. : Fundamental Astronomy, Springer Verlag 2007
3. Astrophysics II: Interstellar Matter and Galaxies 1st Edition, Richard Bowers, Terry Deeming, 1984, Jones & Bartlett Pub.
4. Abhayankar K.D: Astrophysics of the Solar System, Cambridge university Press, 1999
5. Abhayankar K.D: Astrophysics; Stars and Galaxies, Cambridge university Press, 2001

Course Outcomes (CO):

CO1: Grasp basic knowledge about celestial mechanics [K1]
CO2: Understand the usage of various astronomical instruments [K2]
CO3: Know the physical processes involved in solar systems [K3]
CO4: Gain deep insight on cosmology and Cosmic radiation [K3]
CO5: Acquire the fundamental concepts of Stellar Evolution, White dwarfs, Neutron Stars and Black Holes [K2]

K1- Remember **K2- Understand** **K3- Apply**
K4- Analyze **K5-Evaluate** **K6 Create**

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	3	2	3	3	3	2	3	3
CO2	3	3	2	2	3	3	3	3	3	3	3
CO3	3	3	1	3	3	3	3	3	3	3	3
CO4	3	3	2	3	3	3	3	3	3	3	3
CO5	3	3	1	3	3	3	3	3	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHE412	NUMERICAL METHODS	L	T	P	C
Elective -I			4	-	-	4

OBJECTIVES:

- To understand the numerical techniques to solve the physical problems.
- To understand various methods used to solve the physical problems.
- To find out the roots of non linear equations
- To find out the solutions of linear equations
- To apply numerical methods of integration and differentiation to mathematical problems.

UNIT-I : INTERPOLATION

Introduction, Polynomial Forms, Linear interpolation, Lagrange Interpolation Polynomial, Newton Interpolation Polynomial, Divided difference table, Interpolation with equidistance points, Spline interpolation

UNIT-II: ROOTS OF NON-LINEAR EQUATIONS

Introduction, Methods of Solution, Iterative Methods, Starting and Stopping and Iterative Process, evaluation of Polynomials, Bisection method, False Position Method, Newton-Raphson Method, Secant Method, Fixed Point Method, Determining All Possible Roots.

UNIT-III: SOLUTIONS OF LINEAR EQUATIONS

Need and Scope, Existence of Solutions, Solution by Elimination, Basic Gauss Elimination Method, Gauss Elimination with Pivoting, Gauss- Jordan Method, Triangular Factorization Methods, Round-off Errors and Refinement, III-Conditioned Systems, Matrix Inversion Method, Jacobi Iteration Method, Gauss Seidel Method.

UNIT-IV: NUMERICAL DIFFERENTIATION ANDINTEGRATION

Numerical Differentiation: Need and Scope, differentiating continuous functions, Differentiating tabulated functions, Difference tables, Numerical Integration: Trapezoidal Rule, Simpson's1/3 Rule, Simpson's 3/8 Rule, Higher Order Rules.

UNIT-V: NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS

Need and Scope, Tailor Series Method – Improving accuracy, Picard's method, Euler's Method – accuracy of Euler's method, Heun's Method–Error analysis, Polygon Method, Runge-Kutta Methods- Determination of weights

BOOKS FOR STUDY:

1. E. Balagurusamy, Numerical Methods, Tata McGraw-Hill, India 1999 (Unit I-V).
2. M.K. Jain, S.R.K. Iyangar, R K. Jain, Numerical Methods: Problem and Solution, New Age International Publisher, New Delhi 2021

BOOKS FOR REFERENCE:

1. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw Hill International editions, 2ndedition) 1990.

COURSE OUTCOMES:

CO1: Distinguish Different Interpolation Method [K2]
CO2: Apply Numerical Methods of Integration and Differentiation to Mathematical Problems [K3]
CO3: Analyze Ordinary Differential Equation and Find Numerical Solution [K4]
CO4: Solve Linear and Nonlinear Equations [K3]
CO5: Understand the Numerical Techniques to Solve the Physical Problems [K2]

K1- Remember K2- Understand K3- Apply
K4- Analyze K5-Evaluate K6- Create

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	2	3	3	3	2	3	3
CO3	3	3	2	3	3	3	3	3	3	3	2
CO4	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	2	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHE413	MODERN OPTICS AND IMAGING	L	T	P	C
Elective -I			4	-	-	4

OBJECTIVES:

- To understand the concept wave and its propagation.
- To study the optical devices and Fourier optics.
- To obtain knowledge in non-linear optics, holography and microscopic techniques.

UNIT-I: WAVENATURE AND LIGHT PROPAGATION

Electromagnetic wave propagation, Harmonic waves, phase-velocity, group-velocity, energy flow–Poynting Vector-Wave motion–equation superposition of waves, interference, diffraction, basics of coherence theory, temporal and spatial coherence-Multi wave interference-Michelson and Fabry-Perot interferometer – Scattering and polarization – types – Birefringence.

UNIT – II: OPTICAL ENGINEERING AND FOURIER OPTICS

Image formation (first-order optics), aberrations, prisms and mirrors, stops and apertures, basic optical devices, the design of optical systems: general, aplanatic points, solid immersion lens, numerical aperture increasing lens. Fourier-optics- Thin lens as phase transformation–Thickness function-Various types of lenses.

UNIT - III: NON-LINEAR OPTICS

Non-linear optics-principle-nonlinear wave equation-Born approximation-second order non-linear optics-second harmonic generation-phase-matching-frequency conversion-electro-optic effect-three wave mixing. Third order non-linear optics-third harmonics generation-optical Kerr- effect-parametric oscillator-self focusing-soliton

UNIT –IV: HOLOGRAPHY

Basic Principles of Holography-Recording of amplitude and phase-There cording medium-Reconstruction of original wave-front-Image formation by wave front reconstruction-Gabor Hologram-Limitations of Gabor Hologram-Off axis Hologram**.**

UNIT -V: OPTICAL MICROSCOPY &IMAGING TECHNIQUES

Basics of optical microscopy, bright field and dark field microscopy, polarizing microscopy, phase contrast microscopy, fluorescence microscopy, light sheet fluorescence microscopy, nonlinear optical microscopy, two photon fluorescence microscopy.

TEXT BOOKS:

1. Francis Jerkins and Harvey White, Fundamental Optics - McGraw Hill Inc., New Delhi, Fourth Edition, 2011 (Unit 1,2, 3)
2. N.Subramaniyam, Brijlal and M.N. Avadhanulu, A Textbook of Optics S.Chand &Co, New-Delhi, Twenty Fifth-Edition, 2012.

BOOKS FOR REFERENCE:

1.W.J. Smith, Modern Optical Engineering, Third-Edition, McGraw-Hill, 2000.
2.J.W. Goodman, Introduction to Fourier optics, Roberts and Company Publishers, Third Edition, 2005 (Unit 4)
3.B.B. Laud, Lasers and Non-Linear optics, Wiley, Second Edition, 1992.
4.J. Mertz, Introduction to Optical Microscopy, Roberts &Company publishers, First Edition, 2010. (Unit 5)

Course Outcomes (CO):

CO1: Learn the fundamentals of wave nature and Light Propagations [K1]
CO2: Clear knowledge about Optical Engineering and Fourier Optics [K2]
CO3: Gain knowledge about the Nonlinear Optics [K2]
CO4: Learn the fundamentals of Holography [K3]
CO5: Get the Knowledge about different microscopy and image techniques [K2]

K1- Remember K2- Understand K3- Apply
K4- Analyze K5-Evaluate K6 - Create

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	2	3	2	3	2	S
CO3	3	3	3	3	2	2	2	3	3	3	2
CO4	3	3	3	3	3	3	3	2	3	1	2
CO5	3	3	2	3	2	2	3	2	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHE421	MATERIAL CHARACTERIZATION TECHNIQUES	L	T	P	C
Elective -II			4	-	-	4

OBJECTIVES:

- To know about measurement and error analysis in instrument
- To grasp knowledge instruments used for thermal analysis of materials
- To know about instrument for characterizing materials using x-rays
- To acquire knowledge on electron microscopes
- To acquit knowledge on instrument used to determine electrical parameters of material

UNIT - I: MEASUREMENTS, SIGNALS AND DATA

Signal to Noise ratio – Sensitivity and Detection Limit – Sources of Noise- Hardware Techniques for Signal to Noise Enhancement- Software Techniques for Signal to Noise Enhancement- Errors- Types of Error- Precision and Accuracy- Statistical Methods and Their Application- Accuracy and Instrument Calibration.

UNIT II: THERMAL ANALYSIS

Introduction – thermo gravimetric analysis – instrumentation - weight loss and decomposition products – differential scanning calorimetric – instrumentation – specific heat capacity measurements – determination of thermo chemical parameters – differential thermal analysis – basic principles – melting point- determination and analysis.

UNIT - III: X-RAY ANALYSIS

Single Crystal and powder diffraction – Diffractometer – interpretation of diffraction patterns – indexing – unknown and phase identification – thin film characterization – X-ray fluorescence spectroscopy- Different types – uses.

UNIT – IV: OPTICAL METHODS AND ELECTRON MICROSCOPY

Photoluminescence – light-matter interaction – fundamental transitions – excitons – instrumentation – electroluminescence – instrumentation – photo reflectance-electronic transitions – behavior of electronic transitions as a function of electric field. Principles of SEM, TEM, EDAX, AFM, EPMA – Instrumentation – sample preparation – analysis of materials – study of dislocations – ion implantation – uses – Nanolithogrphy.

UNIT – V: ELECTRICAL METHODS

Hall Effect – carrier density – resistivity – two probe and four probe methods – scattering mechanism – van der pauw method – CV characteristics – Schottky barrier capacitance – impurity concentration – electrochemical CV profiling – limitations.

TEXT BOOKS:

1. Willard.M, Steve.D, Instrumental Methods of Analysis - CBS Publishers, New Delhi, 1986.
2. Stradling, R.A, Electron Microscopy and Microanalysis of Crystalline materials, Applied Science Publishers, London, 1979.

3. Belk.J.A, Electron microscopy and Microanalysis of Crystalline Materials, Applied Science Publishers, London, 1979.
4. Philips V.A Modern Metallographic Techniques and their Applications, Wiley Interscience, 1971.

Course Outcomes

CO1: Understand about error analysis technique in different kinds of instrument [K1]
CO2: Analyze different thermal parameters of the sample [K2]

CO3: Estimate structural parameters and composition of the sample [K3]
CO4: Interpret surface morphology and composition of the materials [K1]
CO5: Deduce the electronic properties of the sample [K6]

K1- Remember K2- Understand K3- Apply
K4- Analyze K5-Evaluate K6-Create

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	2	3	3	3	3	2	3	3
CO2	3	3	2	3	3	3	3	3	3	3	3
CO3	3	3	2	3	3	3	3	3	3	3	3
CO4	3	3	2	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M) : 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHE422	PHYSICS OF NON-CONVENTIONAL ENERGY RESOURCES	L	T	P	C
Elective -II			4	-	-	4

OBJECTIVES:

- To develop the human recourse in non-conventional energy resources.
- To create the people who will teach the science of non-conventional Energy resources, this will be also helpful for the promotion of Research in this field.
- To create several self-employment opportunities in renewable energy and energy efficiency sectors.
- It will help to develop the skills required in renewable energy and energy management fields.
- To do useful research in this field.

UNIT-I: INTRODUCTION:
Introduction-Various non-conventional energy resources-Introduction, availability, classification, relative merits and demerits. Solar Cells: Theory of solar cells. Solar cell materials, DSSC, solar cell array, solar cell power plant, limitations.

UNIT-II: SOLAR THERMAL ENERGY:
Solar Thermal Energy: Solar radiation, flat plate collectors and their materials, applications and performance, focusing of collectors and their materials, applications and performance; solar thermal power plants, thermal energy storage for solar heating and cooling, limitations.

UNIT-III: GEOTHERMAL ENERGY AND FUEL CELLS:
Geothermal Energy: Resources of geothermal energy, thermodynamics of geo-thermal energy conversion-electrical conversion, non-electrical conversion, environmental considerations.
Fuel Cells: Principle of working of various types of fuel cells and their working, performance and limitations.

UNIT-IV: WIND POWER:
Wind power and its sources, sites election, criterion, momentum theory, classification of rotors, Concentrations and augments, wind characteristics. Performance and limitations of energy conversion systems.

UNIT-V: BIO-MASS:
Bio-mass: Availability of bio-mass and its conversion theory. Ocean Thermal Energy Conversion (OTEC): Availability, theory and working principle, performance and limitations. Wave and Tidal Wave: Principle of working, performance and limitations.

TEXT BOOKS:

1. A.K. Raja, M. Dwivedi, A.P. Srivasta, Introduction to Non-Conventional Energy Resources- Sci Tech Publications. (Unit I to V), 2006.

BOOKS FOR REFERENCE:

1. John Twideu and Tony Weir, Renewal Energy Resources, BSP Publications, 2006.
2. M.V.R. Koteswara Rao, Energy Resources: Conventional & Non-Conventional, BSP Publications, 2006.
3. D.S.Chauhan, Non-conventional Energy Resources- New Age International, 2006
4. C.S. Solanki, Renewal Energy Technologies: A Practical Guide for Beginners PHI Learning, 2008.

Course Outcomes (CO):

CO1: Understand importance of nonconventional energy (K1)
CO2: Gain insight in the materials used to fabricate solar panels K 2)
CO3: Explain the principles on which non conventional energy devices work (K3)
CO4: Apply the principles to create simple energy devices (K4)
CO5: Create plans for small scale device manufacturing set up (K5)

K1- Remember **K2- Understand** **K3- Apply**
K4- Analyze **K5-Evaluate** **K6-Create**

OUTCOME MAPPING

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	3	3	3	2	3	2	2
CO2	3	3	2	3	3	3	3	2	2	2	3
CO3	3	3	2	3	3	2	3	3	3	3	3
CO4	3	3	3	3	3	2	3	3	3	3	3
CO5	2	3	3	3	3	2	2	3	3	3	2

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

<table>
<tr><td>Course Code</td><td>P21PHE423</td><td rowspan="2">PHYSICS OF NANOMATERIALS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">Elective -II</td><td>4</td><td>-</td><td>-</td><td>4</td></tr>
</table>

OBJECTIVES:

- Know the properties of low dimensional Physics
- Understand the interdisciplinary importance of this course
- Learn about creation, manipulation and applications of materials at nanometer scale.
- Learn the characterization techniques for nanostructures.
- Take up nanotechnology as field of research.

UNIT – I: INTRODUCTION

Introduction – History of nanotechnology - Classification of nanomaterials: Definition of – Zero, one and two dimension nano structures – Examples - Classification of synthesis methods. Surface energy – Chemical potential as a function of surface curvature

UNIT – II: NANOMATERIALS

Carbon Fullerenes and Nanotubes: Carbon fullerenes, Fullerene derived crystals, Carbon nanotubes. Micro and Mesoporous Materials: Ordered mesoporous structures, Core-shell structures: Metal-oxide structures, Metal-polymer structures, Oxide-polymer structures. Organic- Inorganic Hybrids. Nanocomposites.

UNIT – III: PROPERTIES

Physical properties of nanomaterials: Melting points, Specific heat capacity and lattice constants – Mechanical properties – Optical properties: -Surface Plasmon Resonance – Quantum size effects – Electrical property: charge of electronic structure, Quantum transport, effect of microstructure: Ferroelectrics and dielectrics – Variation of magnetism with size-Super para magnetism.

UNIT – IV: SYNTHESIS

Synthesis of nano materials: Physical vapour deposition - Chemical vapour deposition plasma arching - Sol gel - Ball milling technique - Electro deposition. Synthesis of Semiconductors: Nanostructures fabrication by physical techniques – Nano lithography.

UNIT – V: CHARACTERIZATION AND APPLICATIONS

Structural Characterization: X-Ray diffraction – Scanning tunneling Microscopy – Transmission Electron Microscopy – Chemical Characterization: Optical spectroscopy.
Applications: Nano electronics, Nano electromechanical systems- Colorants and pigments – DNA chips – Drug delivery systems.

TEXT BOOKS:

1. T. Tsakalakos, I. Ovidko and A.K. Vasudevan (eds.), Synthesis, functional properties and applications of nanostructures Kluwer Academic Publishers, Dordrecht, 2003.
2. Kenneth F. Klablunde, Nanoscale Materials in Chemistry, John Wiley and sons, Inc., 2001.

BOOKS FOR REFERENCE:

1. Wilson M, K Kannangara, G. Smilt, M. Simmons and B. Boguse Nanotechnology, Overseas Press, 2005
2. Freitas R A, Landes., Nanomedicine, TX publication, 1996.
3. Viswanathan B, Nano Materials, Narosa publishing house, 2010.

Course Outcomes (CO):

CO1: Understand the physics of nanotechnology [K1]
CO2: Important features and unique properties of nanomaterials learnt along with emphasis on significant nanomaterials [K2]
CO3: Learn various synthesis techniques to prepare different nanostructures [K1]
CO4: Expertise in handling characterization tools to analyze nanomaterials [K3]
CO5: Prepare novel nanomaterials for interdisciplinary applications [K3]

K1- Remember K2- Understand K3- Apply
K4- Analyze K5-Evaluate K6-Create

OUTCOME MAPPING

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	2	3	2	2	2	2	3	3
CO2	3	3	2	3	3	2	2	2	2	3	3
CO3	3	3	2	3	3	3	3	3	3	3	2
CO4	3	3	3	3	3	2	2	3	3	3	3
CO5	2	3	3	3	3	2	2	3	3	3	3

Strongly correlating (S) : 3 Marks Moderately correlating (M): 2 Marks
Weakly correlating (W) : 1 Marks No correlation (N) : -

Course Code	P21PHR41	PROJECT	L	T	P	C
Core – XVII			22	-	-	8

Each Candidate will submit a project report on a topic in Physics/ Material Science/ Astrophysics after carrying out the project work under the supervision of a guide. The project may be theoretical or experimental or even a compilation of literature on a current topic. The duration of the project will be roughly two months (including the vacation of one month) in the final semester.

The project report will be evaluated by an external examiner and viva voce will be conducted by a committee consisting of the external examiner, guide and the department faculty.

NON-MAJOR ELECTIVE COURSES

Course Code	P21PHN211	ELEMENTS OF NANOSCIENCEAND NANOTECHNOLOGY	L	T	P	C
NME – I			5	-	-	4

OBJECTIVES:

- To provide the basic Knowledge about basics nanoscience and technology
- To acquire the knowledge about synthesis methods and characterization techniques and its applications.

UNIT I: OVERVIEW OF NANOSCIENCE

Introduction –Emergence of Nanotechnology- Bottom up and top-down approaches- chemical potential as a function of surface curvature-interaction between two particles: DLVO theory-applications: band gap engineering quantum devices-nano mechanics- photoelectrochemical cells.

UNIT II: DIFFERENT CLASSES OF NANOMATERIALS

Metal and Semiconductor Nanomaterials, Quantum dots, Wells and Wires, Molecule to Bulk Transitions Bucky Balls and Carbon Nanotubes.

UNIT III: SYNTHESIS OF NANOMATERIALS

Top-down (Nanolithography, CVD), bottom- up (sol-gel processing, chemical synthesis). Wet Deposition Techniques, Self-assembly (Supra molecular approach), Molecular Design and Modeling.

UNIT IV: CHARACTERIZATION

TEM, SEM and SPM Technique, Fluorescence Microscopy and Imaging.

UNIT V: APPLICATIONS

Solar Energy Conversion and Catalysis, Molecular Electronics and Printed Electronics Nanoelectronics, Polymers with a special architecture, Liquid Crystalline Systems, Linear and Nonlinear Optical and Electro Optical properties, Applications in Displays and other devices, Advanced Organic Materials for Data Storage, Photonics, Plasmonics, Chemical and Biosensors, Nanomedicine and Nano Biotechnology.

TEXT BOOKS:

1. Hari Singh Nalwa, Nanostructured Materials and Nanotechnology, Academic Press, 2002.
2. G. Cao, Y.Wong, Nanostructures and Nanomaterials (Synthesis, Properties and Applications),World Scientific, 2nd Edition, 2011 (Unit I- V)

BOOKS FOR REFERENCE:

1. Organic and Inorganic Nanostructures, A. Nabok-ArtechHouse,2005
2. Nanoscience: "Nanotechnologies and Nanophysics", C. Dupas, P.Houdy, M.Lahmani, Springer-Verlag Berlin Heidelberg, 2007
3. Introduction to Nanotechnology, Charles P. Poole, Frank JOwens, Wiley- Inter science, 2003.

Course Code	P21PHN212	FUNDAMENTALS OF ASTROPHYSICS	L	T	P	C
NME – I			5	-	-	4

Objectives:

- To provide the fundamental knowledge about electromagnetic spectrum and telescopes
- To gain knowledge about Planetary and Interplanetary space
- To know Stars, Suns, Planets, Asteroids, Meteors and Comets

UNIT I: ELECTROMAGNETIC SPECTRUM AND TELESCOPE:

The nature of light: Light as an electric vibration, the electromagnetic radiation from a heated object, Doppler shift. Tools of the astronomer: Optical & Space telescopes (Galielian, Newtonian, & Hubble Space Telescope), Magnifying power & Resolving power of telescopes

UNIT II: INTRODUCTION TO PLANETARY AND INTERPLANETARY SPACE:

Kepler's Laws, Earth-Moon System, Solar and Lunar types, Exploration of Solar System by Telescopes, Rockets and Satellites. Structure of Earth's Atmosphere- Lower, Middle and Upper Troposphere, Stratosphere, Ionosphere, Protonosphere, Interplanetary space, Earth as a Magnetic Comet.

UNIT III: STARS:

Measuring stellar characteristics (temperature, distance, luminosity, mass, size) - HR diagram - stellar structure (equilibrium, nuclear reactions, energy transport) - stellar evolution; Stellar Evolution (HR diagram): Life cycle; Stellar Processes (Nuclear) and spectral classification of Stars O, B, A, F, G, K, M.

UNIT IV: THE SUN AND PLANETS:

Origin of the solar system, Internal structure and surface features of sun, Sun spots and Magnetic field on the sun and Solar activity. Surface features of planets, Atmospheres and Magnetic fields of Planets and their moons.

UNIT V: ASTEROIDS, METEORS AND COMETS:

Asteroids: Discovery and designation, Origin, Nature and Orbits of Asteroids. Meteors: Meteor showers and sporadic meteors. Comets: Periodic comets, Brightness variation in Comets. Gas production rates, dust and ion tails.

TEXT BOOKS:

1. V.B. Bhatia, Textbook of Astronomy and Astrophysics with elements of cosmology, Alpha Science International Ltd. 2001.
2. B.W.Carroll & D.A.Ostlie: An Introduction to Modern Astrophysics, 2^{nd} Edn, Cambridge University Press, 2017
3. Shu F, The Physical Universe, University of Science Press,1981
4. K.D.Abhyankar, Astrophysics: Stars and Galaxies- Tata McGraw Hill Publication,1992

VALUE ADDED COURSES

Course Code	P21PHV111	CLASSIFICATION OF SOLAR FLARES IN X-RAYS	L	T	P	C
SEMESTER - I				30		2

Objective:

- To determine different types of Solar flares using WARM telescope data observed in Kodaikanal Solar Observatory

Unit I
Solar Interior structure (Pressure Density, temperature, generation of energy, radiative and convective zones), Solar Neutrino

Unit II
Solar Atmosphere: Photosphere-Model of solar photosphere- Chromosphere- corona

Unit III
Coronal Mass Ejection- Solar flares-Causes- Classification – A, B, C, M and X Classes-Hα classification- Hazards

Unit IV
Optical Observation- Radio Observation- Space telescopes- Whitelight Active Region Monitor (WARM)Telescope – components- GOES X-ray space satellite

Unit V
Observation of Solar flare using WARM telescope at Kodaikanal Solar Observatory- Identification of different class

Text Books

1. V.B. Bhatia, Textbook of Astronomy and Astrophysics with elements of cosmology, Alpha Science International India, 2000
2. B.W.Carroll & D.A.Ostlie: An Introduction to Modern Astrophysics, 2nd Edn, Cambridge University Press, 2017
3. Shu F, The Physical Universe, University of Science Press,1981
4. K.D.Abhyankar, Astrophysics: Stars and Galaxies- Tata McGraw Hill Publication 2001

<table>
<tr><td>Course Code</td><td>P21PHV112</td><td rowspan="2">ESTIMATION OF SOLAR DIFFERENTIAL ROTATION OF SUNSPOTS FROM KODAIKANAL SOLAR OBSERVATORY (KSO) DATA</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">SEMESTER - I</td><td></td><td>30</td><td></td><td>2</td></tr>
</table>

Objective:

- To estimate solar differential rotation of Sunspots from data observed from Kodaikanl Solar Observatory data

Unit I

Solar Interior structure (Pressure Density, temperature, generation of energy, radiative and convective zones), Solar Neutrino

Unit II

Solar Atmosphere: Photosphere-Model of solar photosphere- Chromosphere- corona

Unit III

Sunspots- their properties- cyclic variation- connection with magnetic fields- heliographic coordinates-Rotation periods.

Unit IV

Telescope-Different types of telescope- Telescopes available in Kodaikanal Solar Observatory Data Collection from Kodaikanal Solar Observatory

Unit V

Estimation of Solar Differential rotation of Sunspots from KSO data

References:

1. V.B. Bhatia, Textbook of Astronomy and Astrophysics with elements of cosmology, Alpha Science International India, 2000
2. B.W.Carroll & D.A.Ostlie: An Introduction to Modern Astrophysics, 2nd Edn, Cambridge University Press, 2017
3. Shu F, The Physical Universe, University of Science Press,1981
4. K.D.Abhyankar, Astrophysics: Stars and Galaxies- Tata McGraw Hill Publication 2001

<table>
<tr><td>Course Code</td><td>P21PHV421</td><td rowspan="2">ESTIMATION OF SOLAR DIFFERENTIAL ROTATION OF SUNSPOTS FROM KODAIKANAL SOLAR OBSERVATORY (KSO) DATA</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">SEMESTER - IV</td><td></td><td>30</td><td></td><td>2</td></tr>
</table>

Objective:

- To monitor Space weather using solar radio burst data observed in Kodaikanal Solar Observatory

Unit I

Solar Interior structure (Pressure Density, temperature, generation of energy, radiative and convective zones), Solar Neutrino

Unit II

Solar Atmosphere: Photosphere, Model of solar photosphere, Chromosphere, corona

Unit III

Sunspots, their properties, cyclic variation, connection with magnetic fields, solar prominences, solar flares, active regions

Unit IV

Solar Burst- Different types- Radio spectrometer- Detection

Unit V

Data collection from Radio spectrometer at Kodaikanal Solar Observatory- Analysis of Spectrum- Space Weather Monitoring

Text Books

1. V.B. Bhatia, Textbook of Astronomy and Astrophysics with elements of cosmology, Alpha Science International India, 2000
2. B.W.Carroll & D.A.Ostlie: An Introduction to Modern Astrophysics, 2nd Edn, Cambridge University Press, 2017
3. Shu F, The Physical Universe, University of Science Press,1981
4. K.D.Abhyankar, Astrophysics: Stars and Galaxies- Tata McGraw Hill Publication 2001

Course Code	P21PHV422	ESTIMATION OF CORONAL SHOCK SPEED	L	T	P	C
SEMESTER - IV				30		2

Objective:

- To estimate coronal shock speed using data observed in Kodaikanal Solar Observatory

Unit I

Solar Interior structure (Pressure Density, temperature, generation of energy, radiative and convective zones), Solar Neutrino

Unit II

Solar Atmosphere: Photosphere, Model of solar photosphere, Chromosphere, corona

Unit III

Coronal Mass Ejection- Radio Burst – Different types- Detection

Unit IV

Coronal Shock Waves - Determination of location- 2D electron density – Alfven Speed Maps

Unit V

Data collection from Radio spectrometer at Kodaikanal Solar Observatory- Analysis of Spectrum- Estimation of Coronal Shock Speed

Text Books

1. V.B. Bhatia, Textbook of Astronomy and Astrophysics with elements of cosmology, Alpha Science International India, 2000
2. B.W.Carroll & D.A.Ostlie: An Introduction to Modern Astrophysics, 2nd Edn, Cambridge University Press, 2017
3. Shu F, The Physical Universe, University of Science Press,1981
4. K.D.Abhyankar, Astrophysics: Stars and Galaxies- Tata McGraw Hill Publication 2001

Course Code	P21PHV423	ESTIMATION OF CORONAL MAGNETIC FIELD FROM TYPE II RADIO BURST	L	T	P	C
SEMESTER - IV				30		2

Objective:

- To estimate coronal magnetic field using type II radio burst data observed in Kodaikanal Solar Observatory

Unit I
Solar Interior structure (Pressure Density, temperature, generation of energy, radiative and convective zones), Solar Neutrino

Unit II
Solar Atmosphere: Photosphere, Model of solar photosphere, Chromosphere, corona

Unit III
Coronal Mass Ejection- Radio Burst – Different types- Detection

Unit IV
Coronal Magnetic field- Newkirks's density model

Unit V
Data collection from Radio spectrometer at Kodaikanal Solar Observatory- Analysis of Spectrum- Estimation of Coronal magnetic field from type II radio burst

Text Books

1. V.B. Bhatia, Textbook of Astronomy and Astrophysics with elements of cosmology, Alpha Science International India, 2000
2. B.W.Carroll & D.A.Ostlie: An Introduction to Modern Astrophysics, 2nd Edn, Cambridge University Press, 2017
3. Shu F, The Physical Universe, University of Science Press,1981
4. K.D.Abhyankar, Astrophysics: Stars and Galaxies- Tata McGraw Hill Publication 2001

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