M.Sc. PHYSICS SYLLABUS

(UNDER CHOICE BASED CREDIT SYSTEM)

Applicable to the candidates admitted from 2021onwards

OUTCOME - BASED EDUCATION (OBE)

PG & RESEARCH DEPARTMENT OF PHYSICS

BISHOP HEBER COLLEGE (AUTONOMOUS)

AFFILIATED TO BHARATHIDASAN UNIVERSITY

(NATIONALLY REACCREDITED AT THE 'A' GRADE BY NAAC WITH A CGPA OF 3.58 OUT OF 4)

RECOGNIZED BY UGC AS 'COLLEGE WITH POTENTIAL FOR EXCELLENCE'

TIRUCHIRAPPALLI – 620 017

VISION

To ignite the young minds to achieve excellence in physics through whole person education, to provide opportunities to explore the laws of nature and enable them to contribute to nation building.

MISSION

- Impart quality education, endorse scientific temper and create a passion for Physics through competitive curriculum and effective teaching.
- Explore the skills through hands on experiences by providing state of art research facilities.
- Strive for holistic development by imbibing ethical and social values and build scientific, communicative and leadership competencies to face the global challenges.

M.Sc. PHYSICS

PROGRAMME OUTCOMES

On successful completion of the M.Sc. Physics Course, the graduates will be able to

KNOWLEDGE

PO1-Cognizeandexhibitadvancedknowledgeincoreandappliedareas andrealizetheirrelevanceinmodernscienceandtechnology.

PO2-Criticallyandintellectuallyanalyzeandsolvecomplexscientificandrealtimeproblemsand arriveatlogicalconclusions

PO3-Exhibitresearch oriented inquisitive,novelideasbyutilizingappropriatemoderntoolsand techniquestocatertotheneeds

SKILL

PO4-Demonstrateskillinperformingadvancedphysicsexperimentsandprojectsusinglaboratory facilitiesandinstrumentationtechniques,bylogicalplanningandsystematicexecution

PO5-Utilizeappropriateexperiments,interfacingtechniques,mathematicalmodellingmethodsand computationaltools.

PO6-Acquiredata,analyzeandcommunicatetechnicalandscientificfindingseffectivelytotheglobal community.

ATTITUDE

PO7-Demonstrateindependentandlifelonglearning,endowedwithleadershipskillsandcarry outresearchcollaboratingwithrelatedfieldsofPhysics.

ETHICAL AND SOCIAL VALUES

PO8-Practiceindividualconsciousnessandexhibitprofessionalandethicalvaluesinpersonal, socialandscientificresearch

PO9-Providesolutionswithsocialconcerntotheproblemsonenergydemands,environment, healthandsafetyissuesforthewell-beingofthesociety

PROGRAMME SPECIFIC OUTCOMES

On successful completion of the M.Sc. Physics Course, the graduates will be able to

PSO1-ComprehendthephysicalconceptsX,theory,andapplicationsinadvancedcorePhysics domainssuchasMathematicalPhysics,Classical,QuantumandStatisticalPhysics,AtomicandMolecularPhysics,NuclearPhysics,SolidstatePhysicsandElectronics

PSO2-Utilizescientificknowledgeandapplynumericaltechniquesformodelingphysicalsystems forwhichanalyticalmethodsareinappropriateoroflimitedutility.

PSO3-Recognizethelimitationsofphysicalsystembasedonempiricalstudy,minimizecontributing variables,collectdata,analyzeandinterprettheresults.

PSO4-Integratemathematical,physicalandcomputationaltechniquestoaddresstheproblemsand identifytheapplicationsofphysicsinnewinterdisciplinaryareas.

M. Sc. Physics

Structure of the Curriculum (2021)

Parts of the curriculum	No. of Courses	Credits
Core	**10**	**50**
Elective	**5**	**22**
Project	**1**	**4**
VLO	**1**	**2**
Major Practicals	**4**	**12**
Total	**21**	**90**

SYLLABUS STRUCTURE

Sem.	Course	Course Title	Course Code	Hours / week	Credits	Marks		
						CIA	ESE	Total
I	Core I	Mathematical Physics - I	P21PH101	6	5	25	75	100
	Core II	Classical Dynamics	P21PH102	6	5	25	75	100
	Core III	Statistical Mechanics	P21PH103	6	5	25	75	100
	Core Prac. I	Major Practical - I	P21PH1P1	6	3	40	60	100
	Elective I	Analog and Digital Electronics/ Modern Communication System	P21PH1:1/ P21PH1:A	6	5	25	75	100
			Sem.I Credits :		23			
II	Core IV	Mathematical Physics - II	P21PH204	6	5	25	75	100
	Core V	Electromagnetic Theory	P21PH205	6	5	25	75	100
	Core Prac. II	Major Practical - II	P21PH2P2	6	3	40	60	100
	Elective II	Atomic and Molecular Physics/ Solar PV Technology and its Applications	P21PH2:2 P21PH2:A	6	4	25	75	100
	Elective III	Virtual Labs - Physics Experiments	P21PH2:P	4	4	40	60	100
	VLO	RI / MI	P21VL2:1/ P21VL2:2	2	2	25	75	100
			Sem.II Credits :		23			
III	Core VI	Quantum Mechanics - I	P21PH306	6	5	25	75	100
	Core VII	Solid State Physics - I	P21PH307	6	5	25	75	100
	Core VIII	Microprocessor and Microcontroller	P21PH308	6	5	25	75	100
	Core Prac. III	Major Practical - III	P21PH3P3	6	3	40	60	100

	Elective IV	Nuclear Physics / Radiation Physics	P21PH3:4 P21PH3:A	6	5	25	75	100
			Sem.III Credits :		23			
IV	Core IX	Quantum Mechanics - II	P21PH409	6	5	25	75	100
	Core X	Solid State Physics - II	P21PH410	6	5	25	75	100
	Core Prac. IV	Major Practical - IV	P21PH4P4	6	3	40	60	100
	Elective V	Crystal Growth ,Thin Film and Nano Science/ Astrophysics	P21PH4:5/ P21PH4:A	6	4	25	75	100
	Core Project	Project	P21PH4PJ	6	4	--	--	100
			Sem.IV Credits :		21			
			Total Credits :		90			
Core Theory : 10	Core Practical : 4	Core Project : 1	Elective :5	Value Education : 1			Total Courses:	21

CORE - I: MATHEMATICAL PHYSICS I

SEMESTER: I **CODE: P21PH101**

CREDITS: 5 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course, the students will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Explain the basic concepts of vectors, vector differential calculus, vector integral calculus, vector space, matrices, differential equations and numerical techniques.	**K2**	**I, II, III, IV, V**
CO2	Apply Gauss, Stoke's and Green's Theorems for solving vector field related problems and principle of least squares for curve fitting.	**K3**	**I, V**
CO3	Determine the eigenvalues, eigenvectors, rank, inverse, power and exponential of matrices and roots of algebraic and transcendental equations using numerical techniques.	**K5**	**II, V**
CO4	Solve linear ordinary differential equations using elementary methods and partial differential equations using method of separation of variables	**K3**	**III**
CO5	Analyze the properties of Bessel, Legendre, Hermite, Laguerre, beta and gamma functions.	**K4**	**IV**
CO6	Choose the optimal numerical technique for solving integral and differential equations.	**K5**	**V**

2. A. SYLLABUS

Unit-I: Vector Fields and Vector Spaces **(15 hours)**

Gauss theorem, Green's Theorem, Stoke's Theorem and applications – Orthogonal curvilinear coordinates – Expressions for gradient, divergence, curl and Laplacian in cylindrical and spherical co–ordinates.

Definitions – Linear dependence and linear independence of vectors – Bilinear and quadratic forms– change of Basis – Schmidt's orthogonalisation process– Schwartz inequality.

Unit-II: Matrices **(15 hours)**

Introduction to Matrix – Types of matrices and their properties - Rank of a matrix – Cramer's rule - Characteristic equation - Eigen values, Eigen vectors – Adjoint of a matrix – Inverse of a matrix – Diagonalization of Matrices – Cayley Hamilton's theorem - Jacobi method – Sylvester's theorem.

Unit-III: Differential Equations **(15hours)**

Linear ordinary differential equations – Elementary methods – Linear second order differential equations with variable coefficients – Sturm – Liouville differential equation – Linear partial differential equations – Separation of variables – Examples: the wave equation, Laplace equation and diffusion Equation-Fixed points and slope fields.

Unit-IV: Special Functions **(15 hours)**

Bessel, Legendre, Hermite and Laguerre differential equations – series solutions – generating function – orthogonal relations – recursion relations – Rodrigue's formula – gamma and beta functions.

Unit-V: Numerical Methods **(15 hours)**

The method of least squares – curve fitting - straight line - Numerical integration: Trapezoidal rule – Simpson's (1/3) rule - Numerical solution of ordinary differential equations – Taylor's series method–Runge-Kutta (II and IV order) methods. Solution of Algebraic and Transcendental equations: Successive approximation method – Newton–Raphson method – Gauss-Jordan method – Gauss–Seidal method.

B. TOPICS FOR SELF STUDY

1. **Understanding on polar Plot (Polar coordinates)**

   https://www.wolframalpha.com/

2. **Numerical methods and simulation techniques**

   i) https://swayam.gov.in/nd1_noc19_ph11/preview

   ii)https://swayam.gov.in/nd1_noc19_ma21/preview

C. TEXT BOOKS

1. SathyaPrakash, Mathematical Physics 6e, Sultan Chand and Sons, New Delhi, 2014.
2. H.K. Dass, Mathematical Physics, S. Chand and Co. Ltd, New Delhi, 2003
3. A.W.Joshi, Matrices and Tensors in Physics, Wiley Eastern Ltd., New Delhi, 1975.
4. Arfken and H.J Weber, Mathematical Methods for Physicists, Academic Press, 2005.
5. N. Vedamurthy and N.Ch.S.N. Iyengar, Numerical Methods, Vikas Publishing House Pvt. Ltd, New Delhi, 2003.

D. REFERENCE BOOKS

1. E. Kreyszig, Advanced Engineering Mathematics, Wiley, New York, 1999.

2. M.K. Venkatraman, Numerical Methods in Science and Engineering, The National Publishing Company, Madras, 1999.

3. S.S. Sastry, Introductory Numerical Methods, Prentice Hall of India, New Delhi, 2006.

4. R. Bronson, Differential Equations, Schaum's outline series McGraw Hill, New York, 1973.

5. M. W. Hirsch, S. Smale and R.L. Devaney, Differential Equations, Dynamical Systems and Introduction to Chaos, Academic Press, USA, 2013.

E. WEBLINKS

1. Advanced matrix theory: linear transformations

https://nptel.ac.in/ (Lectures)

2. Advanced Partial differential equations and applications

https://ocw.mit.edu/courses/mathematics/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit / Section	Course content	Learning Outcomes	HighestBloom's Taxonomic Levelof Transaction
I	**Vector Fields and Vector Spaces**		
1.1	Gauss theorem, Stoke's Theorem, Greens Theorem, Applications	Evaluate line integral, surface integral and volume integral through these theorems.	**K5**
1.2	Orthogonal curvilinear coordinates	Explain Cartesian and curvilinear coordinates	**K2**
1.3	Expressions for gradient, divergence, curl and Laplacian in cylindrical and spherical co-ordinates	Construct the gradient, divergence, curl and Laplacian in terms of curvilinear coordinates	**K3**
1.4	Vector spaces: Definitions	Extend the concept of vector space	**K2**
1.5	Linear dependence and linear independence of vectors	Identify 1inear dependence and independence of vectors.	**K3**
1.6	Bilinear and quadratic Forms and change of Basis	Outline the concept of basis	**K2**
1.7	Schmidt's orthogonalisation	Construct set of orthonormal vectors	**K3**

	process		
1.8	Schwartz inequality	Interpret Schwartz inequality	**K2**
II	**Matrices**		
2.1	Introduction to Matrix	Relate physical observables in matrix form	**K2**
2.2	Types of matrices and their properties	Classify the types of matrices and elaborate their properties	**K2**
2.3	Rank of a matrix	Deduce the rank of matrix	**K5**
2.4	Cramer's rule	Apply Cramer's rule to find solution of equations	**K3**
2.5	Characteristic equation, Eigen values, Eigen vectors	Formulate characteristic equation to find Eigen values, Eigen vectors	**K5**
2.6	Adjoint of a matrix, Inverse of a matrix	Evaluate Adjoint of a matrix and Inverse of a matrix	**K5**
2.7	Diagonalization of Matrices	Diagonalize the given Matrix	**K5**
2.8	CayleyHamilton's theorem	Determine inverse of the matrix using Cayley Hamilton's theorem	**K5**
2.9	Jacobi method	Solve given simultaneous equations by Jacobi method	**K5**
2.10	Sylvester's theorem	Explain Sylvester's theorem Evaluate power of matrix using Sylvester's theorem	**K2** **K5**
III	**Differential Equations**		
3.1	Linear ordinary differential equations	Categorize the linear ordinary differential equation	**K2**
3.2	Elementary methods	Determine the solution of linear ordinary differential equation using suitable elementary methods.	**K5**
3.3	Linear second order differential equations with constant coefficients	Solve linear second ordinary differential equation with constant coefficients.	**K5**
3.4	Sturm – Liouville differential equation	Explain the Sturm – Liouville differential equation	**K2**
3.5	Linear partial differential equations: Separation of variables	Solve linear partial differential equations by variables Separable method	**K2**
3.6	Examples: the wave equation	Solve wave, Laplace and Diffusion second order partial	

	Laplace equation Diffusion equation	differential equation using method of separation of variables.	**K2**
3.7	Fixed points and slope fields	Explain Fixed points and slope fields.	**K2**
IV	**Special Functions**		
4.1	Bessel, Legendre, Hermite and Laguerre differential equations, series solution generating function, orthogonal relations, recursion relations and Rodrigue's formula	Examine the various special functions, their series solutions, properties. Explain the applications of various special functions.	**K4** **K2**
4.2	Gamma and Beta functions	Relate gamma and beta functions Solve integrals using gamma and beta functions.	**K4** **K2**
V	**Numerical Methods**		
5.1	The method of least squares curve fitting straight line	Determine the value of best fit constants for the given set of values.	**K5**
5.2	Numerical integration: Trapezoidal rule Simpsons (1/3) rule	Evaluate the integral using Trapezoidal and Simpson's (1/3) rule.	**K5**
5.3	Numerical solution of ordinary differential equations: Taylor's series method	Solve the differential equation using Taylor's series method	**K5**
5.4	Runge-Kutta (II and IV order) methods.	Solve the differential equation using R-K methods.	**K5**
5.4	Solution of Algebraic and Transcendental equations : Successive approximation method Newton–Raphson method, Gauss-Jordan method, Gauss–Seidal method	Solve the algebraic and transcendental equations using Successive approximation method Newton–Raphson method, Gauss-Jordan method and Gauss–Seidal method	**K5**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH101	PO									PSO			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PSO1	PSO 2	PSO 3	PSO 4
CO1	H	H	M	L	L	M	M	H	L	H	L	L	H
CO2	H	L	M	L	L	M	L	M	L	H	L	L	M
CO3	H	H	M	L	H	M	H	M	H	H	H	L	H
CO4	H	H	M	L	H	M	H	L	H	H	H	L	H
CO5	H	H	H	L	L	M	H	L	L	H	L	L	M
CO6	H	M	M	L	H	H	M	H	L	H	M	H	M

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

Direct

1. Continuous Assessment Test (Model Exams) I, II
2. Open book test, Assignment, Seminar, Quiz, Problem solving.
3. End Semester Examination

Indirect

1. Course-end survey

Course Co-ordinator: Dr. M. B. Jessie Raj

CORE – II: CLASSICAL DYNAMICS

SEMESTER: I **CODE: P21PH102**

CREDITS: 5 **NO. OF HOURS / WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course, the students will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Explain the symmetries and conservation laws of system of particles and kinematics of rigid body	**K2**	**I,II**
CO2	Solve small oscillation problem and construct canonical transformation as well as to evaluate Poisson bracket structure	**K3**	**II,III**
CO3	Analyse the planetary motion and scattering in the central force field.	**K4**	**I**
CO4	Develop Lagrangian, Hamiltonian, Hamilton-Jacobi, action-angle formulations and analyse various physical systems like simple pendulum, Atwood's machine, Kepler problem, symmetric top, etc.	**K5**	**I, II&III**
CO5	Describe the chaotic behaviour in dynamical systems and develop the methods of soliton theory.	**K6**	**IV**
CO6	Outline the special theory of relativity and examine the invariance of relativistic systems (Ex.: Maxwell's equations) under the Lorentz Transformation.	**K4**	**V**

2. A. SYLLABUS

Unit -I: Fundamental Principles and Lagrangian Formulation **(15 Hours)**

Mechanics of a particle and system of particles – Conservation theorems – Constraints – Generalized co–ordinates – D'Alembert's principle and Lagrange's equation – Derivation of Lagrange's equation using Hamilton's principle – Application to Simple pendulum, Atwood's machine – Conservation laws and symmetry properties – Central force motion: General features – The Kepler problem – Scattering in a central force field.

Unit -II: Rigid body dynamics and theory of small oscillations **(15 Hours)**

a) Rigid Body Dynamics: Coordinates of rigid bodies – Orthogonal transformations (basics) - The Euler angles – connection between rate change of a vector in body set of axes and in space set of axes - Moments and products of inertia – Euler's equations of motion – The heavy Symmetrical top with one point fixed.

b) Small oscillations: Theory - Normal modes and normal frequencies – application to linear triatomic molecule.

Unit -III: Hamilton's Formulation **(15 Hours)**

Hamilton's canonical equations from variational principle – Principle of Least action – Cyclic coordinates - Canonical transformations – Poisson bracket – Hamilton–Jacobi equation – Hamilton's principal function – Linear Harmonic oscillator – Hamilton's characteristic function - action - angle variables – Application to Kepler's problem.

Unit -IV: Nonlinear Dynamics **(15 Hours)**

Linear and nonlinear forces – Introduction to nonlinear oscillators – Duffing oscillator – jump phenomenon - Classification of Fixed points – Phase portrait - Period doubling phenomena and chaos in MLC circuit.

Linear and nonlinear waves – Solitary waves - Fermi – Pasta - Ulam experiment - Numerical experiment of Kruskal and Zabusky – Solitons- KdV equation (no derivation) - one soliton solution by Hirota'sbilinearization method.

Unit -V: Relativistic Mechanics **(15 Hours)**

Fundamentals of special theory of relativity - Minkowski's four dimensional space – Four vectors – Energy and momentum four vectors – Lorentz transformation (LT) equations – LT as rotation in Minkowski's space – Invariance of Maxwell's equations under LT.

B. TOPICS FOR SELF STUDY

1. **Newtonian Mechanics**

https://youtu.be/8X1x9RL

2. **Analysis of linear dynamical systems in phase-space**

https://youtu.bp/QZo93VDYacE

https://www.youtube.com/watch?v=ucG_Ft36XOo

https://www.youtube.com/watch?v=Vmj54LvrLOA

C. TEXT BOOKS

1. H. Goldstein, J. Safko and C. Poole, Classical Mechanics, Addison Wesley, New Delhi, 2002.

2. M. Lakshmanan and S. Rajasekar, Nonlinear Dynamics: Integrability Chaos and Pattern, Springer Verlag, Berlin, 2003.

D.REFERENCE BOOKS

1. T.W.B. Kibble and F.H. Berkshire, Classical Mechanics, Cambridge University Press, New Delhi, 2010.
2. N. C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1991.

3. R. Douglas Gregory, Classical Mechanics, Cambridge University Press, New Delhi, 2018.
4. L.D. Landau and E.M. Lifshitz, Mechanics, Pergmon Press, India, 2005.
5. P.G. Drazin and R.S. Johnson, Solitons: An Introduction, Cambridge University Press, New York, 1989.
6. M. Lakshmanan and K. Murali, Chaos in Nonlinear Oscillators, World Scientific Co., Singapore, 1996.
7. K.N. SrinivasaRao, Classical Mechanics, University Press, Hyderabad, India, 2003.
8. P.C. Deshmukh, Foundations of Classical Mechanics, Cambridge University Press , U.K., 2019.

E. WEBLINKS

1. https://nptel.ac.in/courses/115105098/
2. https://ocw.mit.edu/courses/physics/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	CourseContent	LearningOutcomes	HighestBloom'sTaxonomiclevelof transaction
I	**Fundamental Principles and Lagrangian Formulation**		
1.1	Mechanics of a particle and system of particles, Conservation Theorem	Discuss the properties of single particle and system of particles	**K2**
1.2	Constraints-Generalized co–ordinates	Explain generalized co-ordinates	**K2**
1.3	D'Alembert's principle and Lagrange's equation	Deduce Lagrange's equation	**K3**
1.4	Derivation of Lagrange's equation using Hamilton's principle	Deduce Lagrange's equation using Hamilton's principle	**K3**
1.5	Application to Simple pendulum, Atwood's machine	Apply Lagrange's formalism to simple dynamical systems	**K5**
1.6	Conservation laws and symmetry properties	Explain the role of symmetries in conservation laws.	**K2**
1.7	Central force motion: General features	Discuss the central force motion	**K2**
1.8	The Kepler problem	Formulate the first integral approach to discuss the Kepler problem	**K5**
1.9	Scattering in a central force field	Analyse scattering of particles and deduce Rutherford's scattering formula	**K4**

II	**Rigid body dynamics and theory of small oscillations**		
2.1	Coordinates of rigid bodies-Orthogonal transformations (basics)-The Euler angles	Describe the kinematics of rigid body	**K2**
2.2	Connection between rate change of a vector in body set of axes(BSA) and in space set of axes (SSA)	Identify the connection between BSA and SSA for a change in a vector	**K2**
2.3	Moments and products of inertia	Define and explain moments of inertia	**K2**
2.4	Euler's equations of motion	Deduce Euler's equations of motion	**K5**
2.5	The heavy symmetrical top with one point fixed	Apply Lagrange's formalism to symmetric top and analyse its dynamics	**K5**
2.6	Small oscillations: Theory	Definition of normal modes and frequencies and building the theory to calculate	**K2**
2.7	Normal modes and normal frequencies	Determine normal modes of LTO	**K3**
2.8	application to linear triatomic molecule (LTO)	Determine normal modes of LTO	**K5**
III	**Hamilton's Formulation**		
3.1	Hamilton's canonical equations from variational principle	Deduce Hamilton's equations of motion	**K3**
3.2	Principle of Least action	Explain least action principle and employ it to deduce Hamilton's equations of motion	**K3**
3.3	Cyclic coordinates	Define Cyclic coordinates.	**K1**
3.4	Canonical transformations (CT)	Compute the generating functions for canonical transformations and explain the nature of transformation	**K3**
3.5	Poisson bracket (PB)	Define PB and list downs their properties	**K2**
3.6	Hamilton–Jacobi (HJ) equation, Hamilton's principal function	Develop HJ theory	**K5**
3.7	Linear Harmonic oscillator (LHO)	Apply the HJ theory to LHO	**K5**
3.8	Hamilton's characteristic function – action angle variables	Discuss the action-angle variable theory	**K2**

3.9	Application to Kepler's problem	Develop action and angle variable theory for the Kepler problem	**K5**
IV	**Nonlinear Dynamics**		
4.1	Linear and nonlinear forces	Distinguish between linear and nonlinear forces	**K4**
4.2	Introduction to nonlinear oscillators	Explain nonlinear oscillators	**K2**
4.3	Duffing oscillator (DO) jump phenomenon	Describe the jump phenomenon in DO	**K6**
4.4	Classification of Fixed points Phase portrait	Classify fixed points of 2D dynamical system	**K2**
4.5	Period doubling phenomena and chaos in MLC circuit	Analyze the chaotic behavior in MLC Circuit by applying the theory of period doubling phenomenon, A	**K6**
4.6	Linear and nonlinear waves	Distinguish between linear and nonlinear waves	**K4**
4.7	Solitary waves	Outline the historical development of solitons	**K2**
4.8	Fermi – Pasta - Ulam (FPU) experiment	Explain Recurrence phenomenon in nonlinear lattices	**K2**
4.9	Numerical experiment of Kruskal and Zabusky (KZ), Solitons	Explain KZ experiment and give its importance; Definition of solitons	**K2**
4.10	KdV equation, one soliton solution by Hirota'sbilinearization method	Solve KdV type equations by the Hirota's method and study the propagation of solitons	**K4**
V	**Relativistic Mechanics**		
5.1	Fundamentals of special theory of relativity	Recall the fundamental postulates of special theory of relativity	**K2**
5.2	Minkowski's four dimensional space, Four vectors – Energy and momentum four vectors	Construct the energy and momentum four vectors in relativistic systems using fundamental definitions of four vectors.	**K3**
5.3	Lorentz transformation (LT) equations, LT as rotation in	Construct LT equations and analyse the properties of LT	**K4**

	Minkowski's space		
5.4	Invariance of Maxwell's equations under Lorentz Transformations	Prove that Maxwell's equations are invariant under Lorentz Transformation	**K4**

4. MAPPING SCHEME (PO, PSO& CO)

P21PH 102	**PO**									**PSO**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	L	M	L	L	L	L	L	L	L	H	H	M	L
CO2	H	H	M	M	L	L	L	L	L	H	H	M	M
CO3	H	H	H	H	H	L	L	L	L	H	H	M	H
CO4	H	H	H	H	M	L	H	L	L	H	H	M	H
CO5	H	H	H	H	M	M	H	L	L	H	H	H	H
CO6	M	M	L	L	M	L	L	L	L	H	M	H	M

L-Low, M-Moderate, H-High

5. COURSEASSESSMENTMETHODS

Direct

1. Continuous assessment tests I & II
2. Openbooktest;cooperativelearningreport,assignment;journalpaperreview,group presentation, project report, poster preparation, prototype or product demonstration etc. (asapplicable)
3. Endsemester examination

Indirect

1. Course-endsurvey

Course Co- ordinator: Dr. T. Kanna

CORE -III - STATISTICAL MECHANICS

SEMESTER: I **CODE:P21PH103**

CREDITS: 5 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course, the students will be able to:

CO.NO.	Course Outcomes	Level	Unit Covered
CO1	Analyze the consequences of the laws of thermodynamics under varied external conditions	**K4**	**I**
CO2	Enumerate the role of statistics applied to the microscopic world and establish the link between thermodynamics and statistical mechanics	**K4**	**II, III**
CO3	Construct different ensembles and deduce Maxwell Boltzmann (Classical particles), Bose Einstein and Fermi Dirac (Quantum particles) statistical distribution functions.	**K5**	**II, III**
CO4	Interpret thermodynamical quantities in terms of partition function and derive the specific heat capacities of solids	**K5**	**II, III**
CO5	Assess the behavior of ideal gas, black body, liquid helium and electron gas systems in the light of classical and quantum statistical mechanics	**K5**	**IV**
CO6	Interpret phase transitions and phase diagrams under thermodynamical equilibrium for binary systems.	**K5**	**V**

2. A. SYLLABUS

Unit -I: Laws of Thermodynamics and their Consequences **(15 hours)**

Consequences of first law – T and V independent, T and P independent, P and V independent - Entropy and consequences of second law of thermodynamics – consequences of combined first and second law - T and V independent, T and P independent, P and V independent TdS equations – Thermodynamic potential and the reciprocity relations – Clausius – Clapeyron equation – Gibb's – Helmholtz relations – Thermodynamic equilibria – Nernst heat theorem – Consequences of third law – chemical potential.

Unit -II: Classical Statistical Mechanics **(15 hours)**

Macro and micro states– Phase space - Volume of the phase space - Liouville's theorem – Statistical equilibrium - Ensembles – Micro canonical, Canonical and Grand canonical –– Maxwell Boltzmann distribution law – Distribution of energy and velocity – Principles of equipartition of energy – Partition function – Relation between partition function and thermodynamic quantities.

Unit -III: Quantum Statistical Mechanics **(15 hours)**

Basic concepts – Quantum ideal gas – Bose Einstein and Fermi–Dirac statistics – Distribution laws – Partition function for a harmonic oscillator – Specific heat of solids – Einstein's theory – Debye's theory.

Unit -IV: Applications of Statistical Mechanics **(15 hours)**

Ideal gas (Micro canonical) - Black body and Planck radiation law – Ideal Bose gas: Energy, pressure and thermal properties – Bose Einstein condensation – Liquid Helium and its properties. Ideal Fermi gas: Properties – Degeneracy – Electron gas.

Unit -V: Phase Transitions and Phase Diagrams **(15 hours)**

Phase equilibria – first and second-order phase transitions –differences and examples – Binary phase diagram – Types - Phase rule – Lever rule – Iron – Carbon phase diagram

Ising model (Bragg William approximation)–diffusion equation – random walk and Brownian motion – Introduction to non equilibrium processes.

B. TOPICS FOR SELF STUDY

1.**Classical Statistical Mechanics**

https://www.youtube.com/watch?v=D1RzvXDXyqA

https://www.youtube.com/watch?v=XIXQ38JnF0k

2.**Ideal gas – Interpretation of behavior of ideal gas using microcanonical, canonical and grand canonical ensembles**

https://www.youtube.com/watch?v=zUp0D5Xcigs (microcanonical)

https://www.youtube.com/watch?v=3KM-IBkBKFQ (canonical)

https://www.youtube.com/watch?v=OWZVL1vU_WM (grand canonical)

3.**Phase Transitions and Phase diagrams**

https://www.youtube.com/watch?v=kKZsqO_xqNQ (Part I)

https://www.youtube.com/watch?v=kl0lqRnfUWg (Part II)

C. TEXT BOOKS

1. B.R. Agarwal and N. Eisner, Statistical Mechanics, New Age International Pvt. Ltd., New Delhi, 2005.

2. N. Sears and L. Salinger, Thermodynamics Kinetic Theory and Statistical Mechanics, Narosa Publishing House, New Delhi. 1998.

3. S.I. Gupta and V. Kumar, Statistial Mechanics 24e, PragatiPrakashan Publishing Ltd., Meerut, 2011.

4. V. Raghavan, Physical Metallurgy: Principles and Practice, Prentice Hall of India, New Delhi, 2006.

D. REFERENCE BOOKS

1. F. Reif, Statistical and Thermal Physics, McGraw Hill, Singapore, 1979.
2. R. Huang, Statistical Mechanics, Wiley Eastern Ltd., New Delhi, 2009.
3. SathyaPrakash and Agarwal, Statistical Mechanics, KedarNath Ram Nath and Co., Meerut, 2003.
4. R.K. Pathria and P.D. Beale, Statistical Mechanics 3e, Academic Press, 2011.
5. PJ Haines, Principles of Thermal Analysis and Calorimetry, Springer (2002).

E. WEB LINKS

1. https://nptel.ac.in/courses/115/103/115103113/

2.https://nptel.ac.in/courses/115/103/115103028/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit / Section	**Content**	**Learning Outcomes**	**HighestBloom'sTaxonomic Levelof Transaction**
I	**Laws of Thermodynamics and their Consequences**		
1.1	Consequences of first law T and V independent, T and P independent, P and V independent	Recall the first law of thermodynamics Relate the energy equation through extensive and intensive variables Construct T-V, T-P and P-V relations by applying the first law Analyze the relations for isothermal, isobaric and isochoric processes	**K4**
1.2	Entropy and consequences of second law of thermodynamics	Define entropy in terms of second law of thermodynamics Compare the thermodynamic processes by including entropy term Build entropy relation for reversible processes	**K3**
1.3	Consequences of combined first and second law- T and V independent, T and P independent, P and V independent	Construct the combined form of first and second law of thermodynamics. Classify coefficients of volume expansion, isothermal compressibility and specific heat capacity based on the partial derivatives Develop equations for T-V, T-P and P-V independent conditions using the combined I and II laws.	**K3**
1.4	TdS equations	Recall TdS equations Summarize the TdS equations Utilize TdS relations for liquid helium system	**K3**

1.5	Thermodynamic potential and the reciprocity relations	Define quantities such as Helmholtz function (F) and Gibb's free energy (G) - Illustrate the reciprocity relations in terms of F and G Correlate the thermodynamic relations and interpret its variation with external conditions	**K4**
1.6	Clausius – Clapeyron equation	Analyze the variation of pressure with respect to temperature for a system consisting of multiple phases Explain the triple point temperature for water. Identify the ice point temperature from phase diagram	**K4**
1.7	Gibb's – Helmholtz relations	Relate Gibb's and Helmholtz functions Apply G-H relation to calculate internal energy of voltaic cell	**K3**
1.8	Thermodynamic equilibria	Outline thermodynamic equilibria Prove that systems in thermodynamic equilibrium are in thermal, mechanical and chemicalequilibria	**K4**
1.9	Nernst heat theorem– Consequences of third law	State and explain Nernst heat theorem Analyze, how the internal equilibrium of the system behaves at absolute zero	**K4**
1.10	Chemical Potential	Outline chemical potential Apply thermodynamic potentials to calculate chemical potential	**K3**
II	**Classical Statistical Mechanics**		
2.1	Macro and micro states	Explain the fundamental postulates of statistical mechanics Differentiate macro and micro states Illustrate macro and micro states with suitable example	**K4**
2.2	Phase Space	Explain the concept of phase space Account on Γ and μ space	**K2**
	Volume of the Phase space	Evaluate the volume of the phase space	**K5**
2.3	Liouville's theorem	State and explain Liouville's theorem Illustrate that the density of phase points is conserved	**K5**
2.4	Statistical equilibrium	Explain statistical equilibrium	**K2**
2.5	Ensembles Micro Canonical, Canonical and Grand Canonical ensemble	Outline the need for defining an ensemble Summarize on micro canonical, canonical and grand canonical ensembles Enumerate the differences between the three ensembles	**K4**

2.7	Maxwell Boltzmann distribution law	Outline the properties of classical particles Deduce Maxwell Boltzmann distribution law of molecules in a gas	**K5**
2.8	Distribution of energy and velocity	Deduce and interpret the relation for most probable energy and velocity of a gas molecule Obtain the expressions for mean, mean square and root mean square velocity of a gas molecule	**K5**
2.9	Principles of equipartition of energy	Explain the principles of equipartition of energy Evaluate the energy shared by a molecule per degree of freedom	**K5**
2.10	Partition function	Define partition function Derive an expression for the partition function for a system of classical particles	**K5**
2.11	Relation between partition function and thermodynamic quantities	Relate partition function and thermodynamic quantities Interpret thermodynamical quantities in terms of partition function	**K5**
III	**Quantum Statistical Mechanics**		
3.1	Basic concepts	List the fundamental postulates of quantum mechanics Explain the need for quantum statistical mechanics	**K2**
3.2	Quantum ideal gas	List the properties of quantum ideal gas.	**K2**
3.3	Bose Einstein and Fermi–Dirac statistics Distribution laws	Obtain distribution functions for Fermions and Bosons	**K5**
3.4	Partition function for a harmonic oscillator	Arrive at the vibrational partition function for a harmonic oscillator and analyze its characteristics	**K4**
3.5	Specific heat of solids – Einstein's theory & Debye's theory.	Analyze the specific heat capacity variation with temperatures with examples Explain Debye T^3 law Determine the specific heat capacity of solids according to Einstein's/Debye's theory on the basis of atomic vibrations Discuss the merits and limitations of Einstein's/Debye's theory of specific heat	**K5**
IV	**Applications of Statistical Mechanics**		
4.1	Ideal gas (Micro canonical)	Analyze the behavior of ideal gas by considering the system as microcanonical ensemble.	**K4**

4.2	Black body and Planck radiation law	Explain the concept of energy quantization in black body radiation. Apply Bose-Einstein statistics to explain the spectral distribution of black body	**K3**
4.3	Ideal Bose gas: Energy, pressure and thermal properties	Outline the properties of bosons and spin degeneracy factor Deduce the relation for energy, pressure and thermal properties of a boson gas	**K5**
4.4	Bose Einstein condensation Liquid Helium and its properties	Summarize the properties of liquid helium Examine the critical temperature of liquid helium using Bose-Einstein condensate.	**K4**
4.5	Ideal Fermi gas: Properties – Degeneracy	Deduce energy, pressure and thermal properties of fermi gas	**K5**
4.6	Electron gas	Apply the statistical distribution to calculate fermi energy, temperature of an electron gas	**K3**
V	**Phase Transitions and Phase Diagrams**		
5.1	Phase equilibria	Explain phase equilibria Recall triple point	**K2**
5.2	First and second-order phase transitions differences and examples	Differentiate first and second order phase transitions with suitable examples	**K4**
5.3	Binary Phase Diagrams – Types	Explain binary Phase Diagram Classify the types of reactions in binary phase diagrams	**K2**
5.4	Phase rule – Lever Rule	Explain Phase rule and lever rule Calculate the number of phases available in a binary phase diagram Calculate the composition of two elements in a given binary phase diagram using lever rule	**K5**
5.5	Iron-Carbon Phase diagram	Evaluate the phases and types of phase transitions in an Iron – Carbon System	**K3**
5.6	Ising model (Bragg William approximation)	Explain Ising model Investigate the magnetic phase transitions using Bragg William approximation	**K5**
5.7	Diffusion equation	State Fick's law Explain the factors influencing the mechanism of diffusion Apply diffusion equation to address heat flow in materials	**K3**

5.8	Random walk and Brownian motion	Derive the probability function for one dimensional random walk Explain kinetic theory and Brownian motion	**K5**
5.9	Introduction to non-equilibrium processes	Explain non equilibrium processes in thermodynamical systems Distinguish between equilibrium and non-equilibrium process	**K2**

4. MAPPING SCHEME (PO, PSO& CO)

P21PH 103	**PO**									**PSO**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	H	M	L	L	M	L	L	L	L	H	M	H	H
CO2	H	M	L	L	L	L	M	L	L	H	M	M	M
CO3	H	M	L	L	M	L	M	L	L	H	M	M	L
CO4	H	M	M	M	L	L	M	L	L	H	L	M	L
CO5	H	M	M	L	M	L	M	L	L	H	M	M	L
CO6	H	M	M	M	M	M	H	L	L	H	M	M	M

L-Low M-Moderate H-High

5. COURSE ASSESSMENT METHODS

Direct

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Assignment, Group Discussion, Seminar, Quiz (written)
3. Pre-Semester & End Semester Theory Examination

Indirect

1.Course end survey (Feedback)

Course Co-ordinator: Dr. A. Josephine Prabha

ELECTIVE- I: ANALOG AND DIGITAL ELECTRONICS

SEMESTER: I **CODE: P21PH1:1**

CREDITS: 5 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After successful completion of this course the student will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Summarize the characteristics and applications of thyristor family and MOSFET	**K4**	**I**
CO2	Examine the working of optoelectronics devices and special diodes.	**K4**	**II**
CO3	Examine the function of OPAMP as an active filter, log amplifier, clipper, clamper and 555 timer	**K4**	**III**

	as Astablemultivibrator		
CO4	Analyse the function of different mode of shift register.	**K4**	**IV**
CO5	Develop synchronous sequential circuits.	**K3**	**IV**
CO6	Analyze the factors affecting Fiber optic communication and functioning of Microwave Devices	**K5**	**V**

2. A. SYLLABUS

Unit – I: Semiconductor Devices and Thyristor (12 Hours)

MOSFET – Depletion mode MOSFET – Enhancement mode MOSFET - SCR operation – SCR characteristics – Parameters - 90˚ phase control -DIAC – TRIAC operation and Characteristics – TRIAC Phase control circuit –UJT operation – UJT characteristics – Parameters – Relaxation Oscillator – PUJT.

Unit – II: Optoelectronic Devices and Special diodes (12 Hours)

LED –Organic LED (OLED) - Photo conductive cells – Photo diodes– Photo transistors –Photo multiplier tube - Optocouplers – solar cells – varactor diodes- Thermistors – Tunnel diodes – Schottky, PIN and Current regulator diode - Chua's diode – MLC.

Unit – III: Analog Electronics (12 Hours)

Op-Amp parameters - Precision rectifiers – logarithmic – Antilogarithmic amplifiers – Clippers – clampers.

Active filters: Low pass – High pass – band pass -- Solution to simultaneous equations – Op-amp negative impedance converter – IC 555 timer block diagram – Astablemultivibrator and Schmitt trigger.

Unit - IV: Digital Electronics (12 Hours)

JK Flip Flop - D flip-flop – T Flip flop- Registers: Serial in Serial out - Serial in Parallel out - Parallel in Serial out - Parallel in Parallel out - Universal shift registers - Design of synchronous sequential circuit: Model Selection – State synthesis table – Designs equations and circuit diagram

Unit – V: Fiber Optical Communication and Microwave Devices (12 Hours)

Optical fiber cables – types - losses in fiber - measurements of fiber characteristics - analog and digital modulation schemes - fiber optical communication systems.

Reflex Klystron: Introduction- Basic Theory of Operation- Transit time and mode number –Gunn Oscillator: Gunn Oscillator. Waveguide E-And H-plane Tees – Attenuators – Attenuator Characteristics.

B. TOPICS FOR SELF STUDY

1. **Semiconductors devices**

https://www.youtube.com/watch?v=djbJm-xWo2w&list=PLgwJf8NK-2e4B9bchhZBBvsoEEhCQfQ4k

2. **Organic LED**

https://www.youtube.com/watch?v=uwmQ3oXVV2w

3. **Digital Electronics**

https://www.youtube.com/watch?v=M0mx8S05v60&list=PLBlnK6fEyqRjMH3mWf6kwqiTbT798eAOm

C. TEXT BOOKS

1. L. Floyd, Electronic Devices, Pearson Education, New York, 2004.

2. David A. Bell, Operational Amplifiers & Linear ICs,Oxford University Press, New Delhi, 2011.

3. L. Floyd, Digital Fundamentals 10e, Pearson Education, New York, 2004.

4. M.L. Sisodia and G.S. Raghuvanshi, Basic Microwave Techniques and Laboratory Manual, New Age International (P) Limited, New Delhi, 2009.

5. T. F. Schubert and E.M. Kim, Active and Nonlinear Electronics, John Wiley, New York, 1996.

6. Subirkumarsarkar, Optical fiber and fiber optic communication system S.chand (4e) 2010.

7. Donald P Leach, Albert Paul Malvino – GouamSaha – Digital Principles and Applications (8e), McGraw Hill,2016

D. REFERENCE BOOKS

1. J. Millman and C. Halkias, Integrated Electronics, Tata McGraw Hill Ltd., New Delhi, 1987.

2. A. Malvino, Electronic Principles, Tata McGraw Hill Ltd., New Delhi, 1985.

3. David A. Bell, Electronic Devices and Circuits, Oxford University Press, New Delhi, 2008.

E. WEBLINKS

1. www.electrical4u.com
2. www.electronics-tutorials.ws

3.SPECIFIC LEARNING OUTCOME

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Semiconductor Devices and Thyristor**		
1.1	MOSFET	Define MOSFET	**K1**

1.2	Depletion mode of MOSFET	Explain the Structure of MOSFET	**K2**
1.3	Enhancement Mode MOSFET	Outline the enhanced mode of MOSFET	**K2**
1.4	SCR Operation	Analyze the operation of SCR	**K4**
1.5	SCR Characteristics and Parameters	Examine the SCR characteristics and Evaluate SCR parameters	**K5**
1.6	90˚ phase control	Analyze phase control of SCR	**K4**
1.7	DIAC operation and Characteristics	Explain the working of DIAC operation and characteristics	**K4**
1.8	TRIAC operation and Characteristics	Explain the working of DIAC operation and characteristics	**K4**
1.9	TRIAC Phase control circuit	Analyze phase control of TRIAC	**K4**
1.10	UJT Operation	Analyze the operation of UJT	**K4**
1.11	UJT characteristics, Parameters	Examine the UJT characteristics and parameters	**K4**
1.12	Relaxation Oscillator	Analyze the UJT relaxation oscillator	**K3**
1.13	PUJT	Sketch basic structure and operation of PUJT	**K3**
II	**Optoelectronic Devices and Special diodes**		
2.1	LED	Analyze the operation of LED	**K2**
2.2	OLED (Organic LED)	Explain the working of OLED	**K2**
2.3	Photo conductive cells	Explain the Photo conductive cells	**K2**
2.4	Photo diodes	Outline the structure of Photo diodes	**K2**
2.5	Photo transistors	Explain the working of Photo transistor	**K2**
2.6	Photo multiplier tube	Analyze the working of photo multiplier tube	**K4**
2.7	Optocouplers	Explain the principle of Optocouplers	**K3**
2.8	Solar cells	Explain the Construction and working of solar cell	**K3**

2.9	Voltage variable capacitor diodes	Construction and working of voltage variable capacitor diodes	**K3**
2.10	Thermistors	Analyze thermistors	**K2**
2.11	Tunnel diodes	Analyze the Construction and working of Tunnel diode	**K4**
2.12	Schottky diode	Analyze the Construction and working of Schottky diode	**K4**
2.13	PIN diode	Analyze the Construction and working of PIN diode	**K4**
2.14	Current limiting diodes	Analyze the Construction and working of current limiting diode	**K4**
2.15	Chua’s diode	Explain the working of Chua’s diode	**K2**
2.16	MLC circuit	Analyze the working of MLC	**K4**
III	**Analog Electronics**		
3.1	Op-Amp parameters	Explain the parameters of OPAMP	**K2**
3.2	Precision rectifiers	Analyze the operation of precision rectifier	**K4**
3.3	Logarithmic amplifier	Analyze the working of log amplifier	**K4**
3.4	Antilogarithmic amplifier	Analyze the working of antilog amplifier	**K4**
3.5	Clippers	Analyze the operation of Clippers	**K4**
3.6	Clampers	Analyze the operation of clampers	**K4**
3.7	Active filters: Low pass and High pass	Analyze the operation of low pass and High pass filter	**K4**
3.8	Active filters: Band Pass and Band stop	Analyze Band Pass and Band stop filter	**K4**
3.9	Solution to simultaneous equations	Construct a circuit to solve simultaneous equations using OPAMP	**K4**
3.10	Op-amp negative impedance converter	Define opamp negative impedance converter	**K1**
3.11	IC 555 timer block diagram	Analyze the working of 555 timer	**K4**
3.12	Astablemultivibrator	Analyze the working of astablemultivirator	**K4**

3.13	Schmitt trigger	Examine the working of Schmitt trigger	**K4**
IV	**Digital Electronics**		
4.1	Introduction to sequential circuits	Recall the principle of sequential circuit	**K1**
4.2	SR FF	Examine the operation of SR FF	**K3**
4.3	JK latch	Examine the operation of JK latch	**K3**
4.4	Master slave latch	Examine the operation of Master slave FF	**K3**
4.5	Delay Flip Flop	Examine the operation of D-FF	**K3**
4.6	T Flip Flop	Examine the operation of T-FF	**K3**
4.7	Registers	Discuss the principle of Register	**K2**
4.8	Serial load shift registers	Examine the operation of serial load shift register	**K4**
4.9	Parallel load shift register	Examine the operation of parallel load shift register	**K4**
4.10	Parallel to serial conversion	Examine the operation of parallel to serial shift register	**K4**
4.11	Universal shift registers	Examine the operation of universal shift register	**K3**
4.12	Design of synchronous sequential circuit: Model Selection	Classify different type of models	**K4**
4.13	State synthesis table	Develop the sate synthesis table for the given model	**K4**
4.14	Designs equations and circuit diagram	Analyze the operation of designs equation and circuit diagram	**K4**
V	**Fiber Optic communication and Microwave Devices**		
5.1	Optical fiber cables and types	Classify fiber cables and types	**K1**
5.2	losses in fibers	Estimate the losses in fiber	**K5**
5.3	Measurements of fiber characteristics	Analyze the operation measurement of fiber characteristics	**K4**
5.4	Analog and digital modulation schemes, fiber optical communication system	Explain the working of analog and digital modulation schemes	**K4**

5.5	Reflex Klystron: Introduction	Define Reflex klystron	**K1**
5.6	Basic Theory of Operation	Explain the working of Klystron	**K5**
5.7	Transit time and mode number	Estimate transit time and mode number	**K4**
5.8	Gunn Oscillator	Analyze the working of Gunn Oscillator	**K4**
5.9	Waveguide H-Plane Tee	Analyze the operation of plane	**K4**
5.10	Waveguide E-Plane Tee	Analyze the operation of E-plane	**K4**
5.11	Attenuators	Explain the working of attenuator	**K2**
5.12	Attenuator Characteristics	Analyze the characteristics of attenuator	**K4**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH1:1	**PO**									**PSO**			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	M	L	L	H	M	-	M	L	L	M	L	L	-
CO2	H	M	L	M	M	L	M	L	L	M	L	L	-
CO3	H	M	L	M	L	L	L	-	-	M	L	M	M
CO4	M	M	M	H	L	L	L	-	-	M	M	L	L
CO5	M	H	L	M	M	L	M	-	L	L	L	M	L
CO6	H	M	M	L	-	-	M	-	L	L	M	M	L

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

Direct:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book

2. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, project Report, Field Visit Report, Poster Presentation, Seminar, Quiz (written)
3. Pre/Post Experiment Test, Viva, Experimental Report for each Experiment (Lab Component)
4. Lab Model Examination & End Semester Practical Examination
5. Pre-Semester & End Semester Theory Examination

Indirect:

1.Course end survey (Feedback)

Course Co – ordinator: Dr. M. Maria Sylvester

ELECTIVE-I: MODERN COMMUNICATION SYSTEM

SEMESTER: I **CODE: P21PH1:A**

CREDITS:5 **NO. OF HOURS/WEEK :6**

1. COURSE OUTCOMES (CO)

After the completion of this course the student will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Outline the basics of noise in communication	**K2**	**I**
CO2	Classify the modulations on the basis of frequency	**K3**	**II**
CO3	Apply the concept of different type of pulse modulation in communication	**K3**	**III**
CO4	Analyze the network and controls in data communication	**K4**	**IV**
CO5	Utilize the analog and digital modulation schemes in fiber optical communication	**K3**	**V**

CO6	Explain the emitter design and detector design in fiber optical communication	**K4**	**V**

2. A. SYLLABUS

Unit -I: Basics of Communication (15 hours)

Communication systems – modulation - need for modulation - bandwidth requirements- noise - thermal noise - noise calculations - signal to noise Ratio - noise figure - calculation of noise figure - measurement of noise figure.

Unit -II: Analog Communication (15 hours)

Amplitude modulation - frequency spectrum of AM wave - power relations in the AM wave - frequency modulation - mathematical representation of FM - frequency spectrum - phase modulation - comparisons: frequency and phase modulation, frequency and amplitude modulations.

Unit -III: Pulse Communication (15 hours)

Importance of pulses in Digital communication – Pulse communication – pulse modulation types: pulse amplitude modulation – pulse width modulation – pulse position modulation – pulse code modulation – telegraphy - telemetry.

Unit -IV: Data Communication (15 hours)

Data communication systems - data transmission circuits - error detection and correction - interconnection requirements - modern classification- network and control considerations.

Unit -V: Fiber Optical Communication (15 hours)

Optical fiber cables – types - losses in fibers - measurements of fiber characteristics - analog and digital modulation schemes - fiber optical communication systems - operating wavelength - emitter design - detector design - fiber choice.

B. TOPICS FOR SELF STUDY

1.**Fibre optic communication system – Techniques - Telecommunication**

https://nptel.ac.in/courses/108/104/108104113/

2.**Digital modulation – frequency - correction** https://nptel.ac.in/courses/117/101/117101051/

C. TEXT BOOK

1. George Kennedy, Electronic Communication System, McGraw-Hill International Editions, 1987.
2. G. Jose Robin and A. Ubald Raj, Communication Electronics, Indira Publications, Martandam, 2002.

D. REFERENCES BOOKS

1. John Gowar, Optical Communication Systems, Prentice Hall India, New Delhi, 1993.
2. Gerd Keiser, Optical Fiber Communications, McGraw Hill, Singapore, 2000.
3. Joseph C. Palais, Fiber Optic Communications, Prentice Hall International, USA, 2001.
4. B. P. Lathi, Communication systems, Wiley Eastern Ltd, New Delhi, 1968.
5. J.F.B. Hawkes, Optoelectronics: An Introduction, J. Wilson, Prentice Hall of India, 1992.

E. WEBLINKS

1.https://www.tutorialspoint.com/principles_of_communication/principles_of_optical_fiber_communications.htm

2.https://www.tutorialspoint.com/principles_of_communication/principles_of_communication_pulse_modulation.htm

3. https://byjus.com/jee/communication-systems/

4.https://www.tutorialspoint.com/data_communication_computer_network/data_communication_computer_network_tutorial.pdf

5. https://en.wikipedia.org/wiki/Fiber-optic_cable

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
I	**Basics of Communication**		
1.1	Communication systems - modulation	Define modulation	**K2**
1.2	Bandwidth requirements	Utilize the concept of modulation	**K3**
1.3	Noise - Thermal noise	Describe thermal noise	**K3**
1.4	Noise calculation	Explain noise calculation	**K4**

1.5	Signal to noise ratio	Analyze the signal to noise ratio	**K4**
1.6	Calculation of noise figure	Analyze the calculation of noise figure	**K4**
1.7	Measurement of noise figure	Outline measurement of noise figure	**K3**
II	**Analog Communication**		
2.1	Amplitude modulation - frequency spectrum of AM wave	Illustrate amplitude modulation. Outline frequency spectrum of AM wave.	**K2** **K2**
2.2	Power relations in the AM wave	Construct the power relations in AM wave	**K3**
2.3	frequency modulation - mathematical representation of FM	Analyze the importance of frequency modulation and mathematical representation of FM	**K4**
2.4	frequency spectrum	Analyze the frequency spectrum in analog communication	**K4**
2.5	phase modulation	Describe phase modulation in analog communication	**K3**
III	**Pulse Communication**		
3.1	Importance of pulses in Digital communication	Analyze the importance of pulses in digital communication.	**K4**
3.2	Pulse communication	Analyze pulse communication	**K4**
3.3	pulse modulation types:pulseamplitude modulation	Examine the types of pulse modulation Outline pulseamplitude modulation	**K4** **K2**
3.4	Pulse width modulation	Compare pulse width modulation and pulseamplitude modulation	**K3**
3.5	Pulse position modulation	Utilize the pulse position modulation in pulse communication	**K3**
3.6	pulse code modulation	Summarize the pulse code modulation	**K2**
3.7	telegraphy	Describe telegraphy in pulse communication	**K2**
3.8	telemetry	Illustrate telemetry	**K2**
IV	**Data Communication**		
4.1	Data communication system	Explain the data communication system	**K2**

4.2	Data transmission circuits	Outline the data transmission circuits	**K2**
4.3	error detection and correction	Categorize the error detection and correction in data communication	**K4**
4.4	Interconnection	Describe interconnection in data communication	**K3**
4.5	modern classification network	Categorize the modern classification network	**K4**
4.6	control considerations	Outline the control system in data communication	**K4**
V	**Fiber Optical Communication**		
5.1	Optical fiber cables – types	Classify the types of optical fiber cables	**K2**
5.2	losses in fibers	Outline the loses in fibers	**K2**
5.3	measurements of fiber characteristics	Describe the measurements of fiber characteristics	**K3**
5.4	analog and digital modulation schemes	Analyze the analog and digital modulation schemes	**K4**
5.5	fiber optical communication systems	Explain the fiber optical communication systems	**K2**
5.6	operating wavelength	Discuss the operating wavelength in fiber optical communication	**K3**
5.7	emitter design - detector design	Analyze the emitter design and detector design	**K4**
5.8	fiber choice	Summarize fiber choice in fiber optical communication	**K2**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH1: A	**PO**									**PSO**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO4**
CO1	M	H	H	H	H	M	M	L	L	M	H	H	H
CO2	M	H	H	H	M	M	M	L	L	M	M	M	M
CO3	M	M	M	M	M	M	L	L	L	L	M	M	L
CO4	M	L	M	M	M	L	L	L	L	M	M	M	L
CO5	M	M	L	M	M	M	L	M	L	M	M	H	L
CO6	L	M	L	L	L	M	L	L	L	L	L	L	M

L-Low M-Moderate H- High

5. COURSEASSESSMENTMETHODS

Direct

1. ContinuousAssessmentTest(ModelExams) I, II
2. Openbooktest;Cooperativelearningreport,Assignment,Seminar,GroupPresentation, etc.
3. EndSemesterExamination

Indirect

1.Course-endsurvey

Course Co-ordinator: Dr. C. Indumathi

CORE IV: MATHEMATICAL PHYSICS – II

SEMESTER : II **CODE: P21PH204**

CREDITS: 5 **NO. OFHOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course, the students will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Apply Cauchy-Riemann conditions to test analyticity of complex function	**K3**	**I**
CO2	Evaluate the integral of complex function using Cauchy's integral theorem, Cauchy's integral formula, Cauchy's residue theorem and the solution of wave and diffusion equations using Greens function	**K5**	**I, III**
CO3	Extend the complex function using Taylor, Laurent's series and periodic function using the Fourier series and Fourier integral.	**K3**	**I, II**
CO4	Outline the types, algebra and role of tensors in physics.	**K2**	**IV**
CO5	Analyze point groups and space groups in molecular structure.	**K4**	**V**
CO6	Construct a function of a complex variable (frequency) from a function of a real variable (time) using Fourier, Laplace transforms and character tables.	**K3**	**II, III, V**

2. A. SYLLABUS

Unit-I: Complex Variables **(15 hours)**

Functions of complex variables – Differentiability – Cauchy – Riemann conditions – Integrals of complex functions – Cauchy's integral theorem and integral formula – Taylor's and Laurent's series – Residues and singularities – Cauchy's residue theorem – Liouville's theorem – Evaluation of definite integrals – Integration of trigonometric functions around a unit circle.

Unit-II: Fourier series and Transforms (15 hours)

Definition of Fourier series (odd and even functions) – Dirichlet's theorem – complex form of Fourier series – properties of Fourier series – Fourier integral (odd and even functions) – complex form of Fourier integral - Fourier transform –infinite and finite Fourier sine and cosine transforms - properties – Applications (Square, Triangular and Sawtooth waves) - solving linear partial differential equations.

Unit-III: Laplace Transform and Green's Functions (15 hours)

Laplace transform – properties of Laplace transforms – solution of second order ordinary differential equations – convolution theorem – Green's functions – properties – methods of solutions in one dimension – applications.

Unit-IV: Tensors (15 hours)

Occurrence of tensors in physics – Notation and conventions – Contravariant vector – Covariant vector – Tensors of second rank – Equality and null tensor –Addition and Subtraction – Outer Product of tensors – Inner product of tensors –Contraction of a tensor – Symmetric and antisymmetric Tensors – The Kronecker Delta – The Fully antisymmetric tensor – Quotient law – Examples of quotient law – Conjugate symmetric tensors of second rank – The Metric tensor – Associated tensor.

Unit-V: Group Theory (15 hours)

Basic definitions – multiplication table – sub–groups, co–sets and classes – direct product groups – point groups and space groups - elementary ideas of rotation group – Representation theory – homomorphism and isomorphism – reducible and irreducible representations - Schur's lemma – the great orthogonality theorem – character tables – c_{2v} ,c_{3v}.

B. TOPICS FOR SELF STUDY

1. **Complex Analysis – Problems with solutions**

https://www.researchgate.net/publication/280722238_Complex_Analysis_Problems_with_solutions

2. **Astronomy and the fourier transform**

http://w.astro.berkeley.edu/~jrg/ngst/fft/astronmy.html

3. **Laplace transform and its applications to real life**

https://www.academia.edu/37710981/Laplace_Transform_and_its_application_to_real_life_problems

4. **Foundations of Mathematical Physics: Vectors, Tensors and Fields**

https://www.roe.ac.uk/japwww/teaching/vtf_0910/vtf_0910.pdf

5. **Group theory applied to Crystallography**

https://www.researchgate.net/publication/255618156_Group_theory_applied_to_crystallography

C. TEXT BOOKS

1. SathyaPrakash, Mathematical Physics 6e, Sultan Chand and Sons, New Delhi, 2014.
2. H.K. Dass, Mathematical Physics, S. Chand and Co. Ltd, New Delhi, 2003.
3. A.W. Joshi, Matrices and Tensors in Physics, Wiley Eastern Ltd., New Delhi, 1975.
4. A.W. Joshi, Elements of Group Theory For Physicists, New Age International Pvt. Ltd, New Delhi, 2005.
5. G. Arfken and H.J Weber, Mathematical Methods for Physicists, Academic Press, 2005.

D. REFERENCE BOOKS

1. L.A. Pipes and L.R. Harvill, Applied Mathematics for Engineers and Physicists, Mcgraw Hill, Singapore, 1985.
2. A.K. Ghatak, I.C. Goyal and A.J. Ghua, Mathematical Physics, Macmillan, New Delhi, 1995.
3. E. Kreyszig, Advanced Engineering Mathematics, John Wiley, New York, 1999.

E. WEBLINKS

1. https://nptel.ac.in/courses/115/106/115106086/#
2. https://nptel.ac.in/courses/115/103/115103036/#

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/Section	CourseContent	LearningOutcomes	Highest BloomsTaxonomicLevelof Transaction
I	**Complex Variables**		
1.1	Functions of complex variables, Differentiability	Explain complex numbers, relate them with their functions and differentiability	**K2**
1.2	Cauchy-Reimann conditions & related problems	Apply Cauchy - Reimann conditions to test the analyticity of a given function	**K3**
1.3	Cauchy's integral theorem and integral formula	Evaluate related integrals	**K5**
1.4	Taylor's and Laurent's series, Cauchy's residue theorem, Liouville's theorem	Explain singularities, residues and related residue theorems	**K2**
1.5	Integration of trigonometric functions around a unit circle	Solve integrals using above residue theorems	**K3**
II	**Fourier Series And Transforms**		
2.1	Definition of Fourier series (odd and even functions)	Define fourier series, odd and even functions	**K1**
2.2	Dirichlet's theorem, complex form of Fourier series, properties of Fourier series	Extend a non-sinusoidal periodic function into a fundamental and its harmonics	**K3**
2.3	Fourier integral (odd and even functions), complex form of Fourier integral	Define and list various integral transforms	**K1**
2.4	Fourier transform, infinite and finite Fourier sine and cosine transforms, properties	Explain the fourier transforms of different functions	**K2**

2.5	Applications (Square, Triangular and Sawtooth waves) - solving linear partial differential equations	Solve partial differential equations in practical applications	**K3**
III	**Laplace Transform And Green's Functions**		
3.1	Laplace transform, properties of Laplace transforms, Convolution theorem	Construct a function of a complex variable (frequency) from a function of a real variable (time) using Laplace transform	**K5**
3.2	Solution of second order ordinary differential equations	Solve differential equations with boundary values without finding the general solution and values of arbitrary constants	**K3**
3.3	Green's function, properties	Define Green's function and list its properties	**K1**
3.4	Methods of solutions in one dimension - applications	Solve related problems using Green's function	**K3**
IV	**Tensors**		
4.1	Occurrence of tensors in physics	Describe physical observables in different frames of reference.	**K2**
4.2	Notation and conventions	Explain the concept of summation convention.	**K2**
4.3	Contravariant vector , Covariant vector, Tensors of second rank	Identify the rank of given tensors	**K2**
4.4	Equality and null tensor, Addition and Subtraction, Outer Product of tensors, Inner product of tensors	Discuss the basic algebraic operations of tensors	**K2**
4.5	Contraction of a tensor	Describe the method to reduce the rank of mixed tensors.	**K2**

4.6	Symmetric and anti-symmetric Tensors	Discuss the invariance of symmetric and anti-symmetric properties of tensors.	**K2**
4.7	The Kronecker Delta, The Fully antisymmetric tensor	Define the Kronecker delta function and explain the fully anti-symmetric tensor	**K2**
4.8	Quotient law, Examples of quotient law	Explain quotient law	**K2**
4.9	Conjugate symmetric tensors of second rank, The Metric tensor, Associate tensor	Explain the conjugate symmetric tensor and fundamental tensors.	**K2**
V	**Group Theory**		
5.1	Basic definitions - Group, Multiplication table, Sub–groups, Co–sets and classes, Point groups and space groups, Elementary ideas of rotation group	Analyze various point groups and space groups	**K4**
5.2	Homomorphism and Isomorphism Reducible and irreducible representations Schur's lemma – The great orthogonality theorem Character tables - c_{2v} c_{3v}.	Construct multiplication table and character table for different point groups	**K3**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH204	PO									PSO			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	H	M	M	M	M	M	M	L	L	H	H	H	H
CO2	H	M	M	M	M	M	M	L	L	H	H	H	H

CO3	H	M	M	M	M	M	M	L	L	H	H	H	H
CO4	H	M	M	M	M	M	M	L	L	H	H	H	H
CO5	H	M	M	M	M	M	M	L	L	H	H	H	H
CO6	H	M	M	M	M	M	M	L	L	H	H	H	H

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

Direct

1. Continuous Assessment Test (Model Exams) I,II
2. Open book test; Assignment, Seminar, Problem solving
3. End Semester Examination

Indirect

1. Course-end survey

Course Co- ordinator: Dr. D. Gopalakrishna

CORE-V: ELECTROMAGNETIC THEORY

SEMESTER : II **CODE: P21PH205**

CREDITS: 5 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course the students will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Explain the fundamental laws of Electrostatics, Magnetostatics and electromagnetism and rephrase them in vectoral form.	**K2**	**I, II, III**
CO2	Classify magnetic materials based on their susceptibility and organize experiments to determine the magnetic properties of magnetic materials.	**K3**	**II**
CO3	Apply various mathematical techniques to solve equations related electrostatic, magnetostatic and electromagnetic scalar and vector potentials.	**K3**	**I,II, III**
CO4	Analyze the propagation of electromagnetic waves in various medium and examine its behavior at the interface between two different media.	**K4**	**IV,V**
CO5	Design basic structures of waveguides and antennas as per the requirements.	**K6**	**V**
CO6	Evaluate the electric, magnetic and electromagnetic fields due to simple and complex structures and the energy stored in these fields.	**K5**	**I-V**

2. A. SYLLABUS

UNIT-I: ELECTROSTATICS **(15 hours)**

Coloumb's law – The electric field – Continuous charge distribution – Gauss's law – Differential form – Proof – The curl of E – The electrical potential – Electrostatic boundary conditions – Multipole expansion – Energy density of an electrostatic field - Method of images– Applications – Point charge near a grounded conducting plane – A conducting sphere when it is grounded, insulated, insulated and has a total charge Q and when the sphere is maintained at a constant potential.

UNIT-II: MAGNETOSTATICS (15 hours)

Magnetic fields – Magnetic forces – Biot–Savart law: The magnetic field due to steady straight current – The Divergence and Curl of B – Application of Ampere's Force law – Magnetic Vector Potential – Magneto statics boundary conditions – Multipole expansion of vector potential – Magnetisation – Magnetic Materials – Magnetic susceptibility and permeability – Measurement of susceptibility – Quincke's Method – Gouy's Method.

UNIT-III: ELECTROMAGNETISM (15 hours)

Faraday's law of electromagnetic induction – Energy in the magnetic field – Maxwell's displacement current – Derivation of Maxwell's Equations - Vector and Scalar potentials – Gauge transformations – Lorentz gauge – Coulomb gauge – Green function for the wave function – Poynting's theorem – Conservation of energy and momentum for a system of charged particles and electromagnetic fields.

UNIT-IV: PLANE ELECTROMAGNETIC WAVES AND WAVE PROPAGATION (15 Hours)

Plane electromagnetic waves in free space, isotropic and anisotropic non conducting media – Conducting Medium (dissipative medium) – Boundary conditions at the surface of discontinuity - Reflection and refraction of electromagnetic waves at a plane interface between dielectrics – Polarization by reflection and total internal reflection – Super position of waves – Polarization - Stokes Parameters.

UNIT-V: WAVE GUIDES AND SIMPLE RADIATING SYSTEMS (15 Hours)

Wave guides – TE waves in a rectangular wave guide – the coaxial transmission lines - Retarded potentials – Radiation and fields due to an oscillating dipole – Electric dipole and quadrupole radiation and Fields - Centre fed linear antenna – Fields and Radiation from a linear half wave antenna.

B. TOPICS FOR SELF-STUDY

1. **Method of images for problems involving dielectric**
https://nptel.ac.in/courses/115/101/115101005/

2. **Electromagnetic properties of superconductors**

https://courses.physics.ucsd.edu/2014/Spring/physics239/LECTURES/SUPERCONDUCTIVITY.pdf

3. Spherical waves
https://nptel.ac.in/courses/115/106/115106124/

4. **Scalar diffraction theory**
https://www.iue.tuwien.ac.at/phd/kirchauer/node50.html

C. TEXT BOOKS

1. David J. Griffiths, Introduction to Electrodynamics, Pearson Education Ltd., New Delhi, 2015.
2. J.D. Jackson, Classical Electrodynamics, Wiley India, New Delhi, 2007.
3. K. Chopra and G. Agarwal, Electromagnetic Theory, Kadernath and Ramnath& Co., Meerut.
4.SathyaPrakash, Electromagnetic Theory and Electrodynamics, Kadernath and Ramnath& Co., Meerut, 2007.

D. REFERENCE BOOKS

1. B. B. Laud, Electromagnetics, New Age International, New Delhi, 2005.
2. K.G. Balmain, Electromagnetic Waves and Radiating System, Prentice Hall of India, 1995.
3. John R. Reitz, Fredric, J. Milford and Robert W. Christy, Foundations of electromagnetic Theory, Addison Wesley, 2008.
4. Paul Lorrain, Dale R. Corson and Francois Lorrain, Electromagnetic Fields and Waves, CBS Publishers.

E. WEBLINKS

1. https://nptel.ac.in/courses/115/101/115101005/
2. https://onlinecourses.nptel.ac.in/noc21_ee83/preview
3. https://ocw.mit.edu/courses/physics/
4. https://www.coursera.org/lecture/electrodynamics-introduction/1-1-introduction-to electromagnetism-qiIQb

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit	**Course content**	**Learning outcomes**	**Highest bloom's taxonomic level of transaction**
1	**Electrostatics**		
1.1	Coloumb's law	Define Coulomb's law for charge distribution.	**K1**
1.2	The electric field	Explain electric lines of force and	**K2**

		electric field.	
1.3	Continuous charge distribution	Recall types of charge distribution.	**K1**
1.4	Gauss's law – Differential form – Proof	Rephrase Gauss law in differential form.	**K2**
1.5	The curl of **E**	Show that **E** is irrotational.	**K2**
1.6	The electric potential	Relate electric field and potential.	**K2**
1.7	Electrostatic boundary conditions	Analyse electrostatic boundary conditions.	**K4**
1.8	Multipole expansion electric potential	Interpret the association of terms in expansion with various charge configuration.	**K5**
1.9	Energy density of an electrostatic field	Estimate the Energy density of an electrostatic field.	**K5**
1.10	Method of electrical images.	Identify the image charge for a given potential using method of electrical images.	**K2**
1.11	Applications – Point charge near a grounded conducting plane Grounded conducting sphere, insulated sphere charged insulated sphere and sphere kept in a constant potential	Evaluate the fields due to these structures using the method of images.	**K5**
2	**Magnetostatics**		
2.1	Magnetic fields – Magnetic forces	Explain magnetic forces due to current carrying conductors and magnetic fields.(Ampere's Force Law)	**K2**
2.2	Biot-Savart law	Summarize the origin of Biot -Savart Law	**K2**
2.3	The magnetic field due to steady straight current	Apply Biot-Savart law to Magnetic induction due to steady straight current.	**K3**
2.4	The Divergence of B	Show that magnetic field is	**K2**

		solenoidal.	
2.5	Curl of B	Show that magnetic field is rotational.	**K2**
2.6	Ampere's circuital law	Summarize the origin of Ampere's Law	**K2**
2.7	Applications of Ampere's circuital law	Evaluate the magnetic field due to different current configuration using Ampere's law.	**K5**
2.8	Magnetic Vector Potential	Deduce an expression for magnetic vector potential due to current distribution.	**K5**
2.9	Magneto static boundary conditions	Analyzemagnetostatic boundary conditions.	**K4**
2.10	Multipole expansion of vector potential	Interpret the association of terms in expansion with various current configuration.	**K5**
2.11	Magnetisation	Define Magnetization	**K1**
2.12	Magnetic Materials	List The Properties Of Magnetic Materials.	**K1**
2.13	Magnetic susceptibility and permeability	Obtain the relationship between susceptibility and permeability.	**K4**
2.14	Measurement of susceptibility – Quincke's Method	Organize an experiment to determine susceptibility of magnetic material.	**K3**
2.15	Gouy's Method	Organize an experiment to determine susceptibility of magnetic material.	**K3**
3	**Electromagnetism**		
3.1	Faraday's law of electromagnetic induction	Explain Laws of electromagnetic induction	**K2**
3.2	Energy in the magnetic field	Estimate the Energy stored in magnetic field.	**K5**
3.3	Maxwell's displacement current	Modify Ampere's circuital law for time varying fields and estimate the displacement current	**K5**

3.4	Derivation of Maxwell's Equations	Construct Maxwell's electromagnetic equations.	**K3**
3.5	Vector and Scalar potentials	Relate vector and scalar potential to fields.	**K2**
3.6	Gauge transformations - Lorentz gauge- Coulomb gauge	Illustrate the method of solving electromagnetic wave equations by Gauge transformations.	**K2**
3.7	Green function for the wave function	Solve electromagnetic wave equations using Green function technique.	**K6**
3.8	Poynting's theorem	Prove energy is conserved in electromagnetic fields.	**K5**
3.9	Conservation of energy and momentum for a system of charged particles and electromagnetic fields.	Prove conservation of momentum for a system of charged particles and electromagnetic fields.	**K5**
4	**Electromagnetic wave propagation**		
4.1	Plane electromagnetic waves in (i) free space (ii)isotropic and anisotropic non conducting media (iii) Conducting Medium (dissipative medium)	Analyze the nature of propagation of electromagnetic waves in these media.	**K4**
4.2	Boundary conditions at the surface of discontinuity	Analyze the behavior of the fields of EM waves at the interface between two media.	**K4**
4.3	Reflection and refraction of electromagnetic waves at a plane interface between dielectrics	Evaluate the changes in dynamic properties of EM waves after reflection and refraction.	**K6**
4.4	Polarization by reflection	Deduce the condition for plane polarization of EM waves after reflection.	**K5**
4.5	Total internal reflection	Deduce the condition for a wave to be totally internally reflected.	**K5**

4.6	Super position of waves - Polarization	Apply the principle of superposition to produce various kinds of polarization of EM waves.	**K3**
4.7	Stokes Parameters.	Illustrate how different polarization can be represented by stokes parameters.	**K2**
5	**Wave guides and antenna**		
5.1	Wave guides	Explain the structure of wave guides.	**K2**
5.2	TE waves in a rectangular wave guide	Analyze the TE mode of propagation of EM waves in rectangular wave guide	**K4**
5.3	TE waves in the coaxial transmission lines	Analyze the TE mode of propagation of EM waves in coaxial transmission lines	**K4**
5.4	Retarded potentials	Explain the concept of retarded potentials.	**K2**
5.5	Radiation and fields due to an oscillating dipole,quadrupole	Estimate the fields and power radiated by oscillating dipole and quadrupole.	**K6**
5.6	Radiation and fields due to a centre fed linear antenna, Linear half wave antenna	Evaluate the fields and power radiated by these antennas.	**K6**

4. MAPPING SCHEME (PO, PSO& CO)

P21PH205	**PO**									**PSO**			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	-	H	-	M	H	-	M	-	M	H	M	M	M
CO2	M	-	L	H	M	M	L	L	H	M	-	L	H
CO3	M	H	M	-	H	M	M	L	M	H	-	-	M
CO4	-	H	-	-	-	H	M	-	H	M	-	-	M
CO5	-	-	M	-	-	L	M	-	M	M	L	L	M
CO6	-	H	-	-	-	M	M	L	M	M	-	-	M

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

Direct

1. Continuous Assessment Test (Model Exams) I, II
2. Open book test; Cooperative learning report, Assignment, Seminar, Group Presentation, Project report, Poster preparation, Problem solving etc.
3. End Semester Examination

Indirect

1. Course-end survey

Course Co-ordinator: Mr. S. P. Godwin Rajadoss

ELECTIVE- II: ATOMIC AND MOLECULAR PHYSICS

SEMESTER: II **CODE: P21PH2:2**

CREDITS: 4 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course the students will be able to:

CO. NO	Course Outcomes	Level	Unit Covered
CO1	Analyze the electronic states in many electron systems and atomic spectra due to electric and magnetic field.	**K4**	**I**
CO2	Apply LCAO, Born Oppenheimer and Huckel's approximations to molecular systems.	**K3**	**II**
CO3	Examine the rotational and vibrational spectra of molecules by Microwave and Infrared spectroscopy.	**K5**	**III**
CO4	Analyze the Raman spectra of molecules using polarizability theory and Electronic spectra using Franck Condon principle.	**K5**	**IV**
CO5	Examine the nuclear interactions and relaxation effectsdue to Nuclear Magnetic Resonance and Electron Spin Resonance.	**K4**	**V**
CO6	Explain the principle and instrumentation of Microwave, Infrared, Raman, NMR and ESR spectroscopy.	**K2**	**III,IV,V**

2. A. SYLLABUS

Unit 1: Atomic Spectra **(12 hours)**

Quantum states of electrons in atoms – Electron spin – Stern and Gerlach experiment – results – spin orbit interaction – LS-JJ coupling schemes – Fine structure – spectroscopic terms and selection rules – Hyperfine structure – Pauli's exclusion principle – Alkali type spectra – Equivalent electrons – Hund's rule - Quantum theory of Zeeman effect, Paschen Back effect of one and two electron system – Linear Stark effect.

Unit 2: Quantum Theory of Molecules **(12 hours)**

Born – Oppenheimer approximation – LCAO approximation – Molecular Orbital theory – Hydrogen Molecule ion – Bonding and antibonding Molecular Orbital – Valence Bond method – Hydrogen Molecule – Directed Valance – Hybridization – Huckel's molecular approximation – Application to Butadiene.

Unit 3: Microwave and IR Spectroscopy **(12 hours)**

Rotational spectra of diatomic molecules – intensity of spectral lines – Effect of isotopic substitution – The non– rigid rotator – Rotational spectra of poly–atomic molecules – Linear, symmetric top and asymmetric top molecules – experimental techniques – Vibrating diatomic molecule – Diatomic vibrating rotator – linear and symmetric top molecule – Analysis by infrared techniques – Characteristic and group frequencies.

Unit 4: Raman Spectroscopy and Electronic Spectroscopy of Molecules **(12 hours)**

Raman effect – Polarizability theory – Pure rotational Raman spectrum – Vibrational Raman spectrum of diatomic molecules – structure determination from Raman and IR spectroscopy – Experimental techniques – Electronic spectra of diatomic molecules – intensity of spectral lines – the Frank Condon principle – Dissociation energy and dissociation products – Rotational fine structure of electronic vibration transitions – pre dissociation.

Unit 5: Resonance Spectroscopy **(12 hours)**

Larmor's precision –NMR – Basic Principles – Classical and quantum mechanical description – Spin – Spin and spin lattice relaxation time – NMR – chemical shift – coupling constant – coupling between nucleus – chemical analysis by NMR – NMR instrumentation – high resolution method – ESR spectroscopy – ESR – Basic Principles – ESR spectrometer – Nuclear interaction and hyperfine structure – Relaxation effects – g factor – radical studies.

B. TOPICS FOR SELF-STUDY

1 **Quantum Chemistry: Introduction**
https://www.youtube.com/watch?v=HC81oYe43DI

2 **Orbitals Basics**
https://www.youtube.com/watch?v=Ewf7RlVNBSA

3 **Fourier Transform**
https://www.youtube.com/watch?v=spUNpyF58BY

4 **Hybrid Orbitals**
https://www.youtube.com/watch?v=vHXViZTxLXo
https://www.youtube.com/watch?v=wPw_LCmyjnI

C. TEXT BOOKS

1. G. Aruldhas, Molecular Structure and Spectroscopy 2e, Prentice Hall of India, New Delhi, 2007.
2. A.K. Chandra, Introductory Quantum Chemistry 4e, Tata McGraw Hill Co., New Delhi, 2008.
3. C. N. Banwell, Fundamentals of Molecular Spectroscopy 4e, McGraw Hill, New Delhi, 008.

D. REFERENCE BOOKS

1. B. P. Straughan and S. Walker, Spectroscopy Vol.III, Chapman and Hall, London, 1976.
2. R. P. Feynman, The Feynman Lectures on Physics Vol. III, Narosa Publishing House, New Delhi, 2008.
3. H. S. Mani and G. K. Mehta, Introduction to Modern Physics, Affiliated East West Pvt. Ltd., New Delhi, 2000.
4. Ira N. Levine, Quantum Chemistry 5e, Prentice-Hall of India, New Delhi, 2006.
5. Hobart Hurd Willard, Instrumental Methods of Analysis, Van Nostrand, 1981.
6. ManasChanda, Atomic Structure and Chemical Bond, Tata McGraw Hill, New Delhi, 1991.

E. WEBLINKS

1. https://nptel.ac.in/courses/115/101/115101003/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit / section	Course content	Learning outcomes	Highest bloom's taxonomic levels of transaction
I	**Atomic spectra**		
1.1	Brief introduction to quantum states of electron in atom	Describe the quantum states of electron in atom	**K2**
1.2	Stern - Gerlach experiment and its results	Explain Stern and Gerlach experiment Interpret the outcomes of Stern and Gerlach experiment	**K5**

1.3	Spin – orbit interaction	Define spin- orbit interaction	**K1**
1.4	LS-JJ coupling schemes	Compare LS and JJ coupling schemes Evaluate J for an atom	**K5**
1.5	Fine structure - Hyperfine structure	Compare fine and Hyperfine structure	**K2**
1.6	Selection rules Spectroscopic terms	Outline selection rules Evaluate the spectroscopic terms for an atom	**K2**
1.7	Pauli's exclusion principle	Explain Pauli exclusion principle	**K2**
1.8	Alkali type spectra, Equivalent electrons	Analyze the main feature of alkali spectra Outline equivalent electrons	**K4**
1.9	Hund's rule	State Hund's rule	**K1**
1.10	Zeeman effect Quantum theory of Zeeman effect	Define Zeeman effect Explain the quantum theory of Zeeman effect	**K5**
1.11	Paschen -Back effect	Outline Paschen –Back effect	**K2**
1.12	Linear stark effect	Explain the linear stark effect in hydrogen atom	**K5**
2.	**Quantum theory of molecules**		
2.1	Born - oppenheimer approximation	Analyze the electronic energy of hydrogen molecule using Born –oppenheimer approximation	**K4**
2.2	LCAO approximation	Estimate the energies and wavefunctions for hydrogen molecule ion on the basis of LCAO treatment	**K5**
2.3	Molecular orbital theory - hydrogen molecule	Estimate the energy of hydrogen molecule by Molecular orbital theory	**K5**
2.4	Bonding and antibonding molecular orbital	Compare bonding and antibonding molecular orbital	**K2**
2.5	Valence – Bond (VB) method-hydrogen molecule	Apply VB theory to calculate the energy of hydrogen molecule	**K3**
2.6	Directed valence	Recall Directed valence	**K1**
2.7	Hybridization	Classify hybridization	**K2**

2.8	Huckle's molecular approximation	Evaluate the molecular orbital energy based on Huckle's molecular approximation	**K5**
2.9	Application to Butadiene	Apply Huckle's molecular approximation to Butadiene	**K3**
3	**Microwave and IR spectroscopy**		
3.1	Rotational spectra of Diatomic molecules -Intensity of spectral lines	Explain the rotational spectra of diatomic molecules Interpret on the intensity of spectral lines	**K2**
3.2	Effect of isotopic substitution	Outline the effect of isotopic substitution on the rotational spectra of diatomic molecules	**K5**
3.3	The non-rigid rotator of diatomic molecules	Analyze the rotational spectra of diatomic non –rigid rotator	**K4**
3.4	Rotational spectra of polyatomic molecules	Interpret the spectra of polyatomic molecule	**K2**
3.5	Linear, Symmetric top and Asymmetric top molecules	Explain the rotational spectra of linear symmetric top molecules Analyze the spectra of Asymmetric top molecules	**K5** **K4**
3.6	Experimental techniques	Elaborate on the experimental techniques of microwave spectroscopy	**K5**
3.7	Vibrating diatomic molecule Diatomic vibrating rotator Linear, and symmetric top molecules	Explain the vibration-rotation effect to a linear diatomic molecule Explain the vibration rotation spectra of symmetric top molecules	**K2** **K5**
3.8	Analysis by IR techniques characteristic and group frequencies	Analyze molecules by IR techniques Interpret on the characteristic and group frequencies of an IR spectra	**K4** **K2**
4	**Raman spectroscopy and Electronic spectroscopy of molecules**		
4.1	Raman effect - Polarizability theory	Explain Raman effect using polarizability theory Illustrate the variation of polarizability in molecules	**K5**

4.2	Pure rotational Raman Spectrum	Construct the energy and frequency equation for the rotational Raman spectrum of linear molecule Compose the energy and frequency equation for the rotational Raman spectrum of symmetric top molecule	**K3** **K6**
4.3	Vibrational Raman spectrum of diatomic molecules	Illustrate the vibrational Raman spectrum of diatomic molecule	**K4**
4.4	Structural determination from Raman and IR spectroscopy Experimental techniques	Predict the structure of different types of molecules using Raman and IR spectroscopy Elaborate on the experimental techniques of Raman and IR spectroscopy	**K6** **K5**
4.5	Electronic spectra of diatomic molecules Intensity of spectral lines	Outline on the electronicspectra of diatomic molecule Interpret on the intensity variation of spectral lines	**K2**
4.6	Frank Condon principle	Apply Frank Condon principle to account for the intensity of vibrational electronic spectra	**K5**
4.7	Dissociation energy Dissociation products	Construct equation for the dissociation energy of a diatomic molecule Relate dissociation energy with dissociation products	**K3** **K1**
4.8	Rotational fine structure of electronic vibration transition Predissociation	Analyze the rotational fine structure of electronic vibration transition Illustrate the representation of predissociation	**K4** **K2**
5	**Resonance Spectroscopy**		
5.1	Larmor’sprecession	Recall Larmor’s precession	**K1**
5.2	NMR Basic principle - classical and quantum mechanical description	Explain the principles of NMR giving classical and quantum mechanical description	**K2**
5.3	Spin-lattice - Spin-spin relaxation time	Define relaxation time Distinguish spin-lattice and spin-spin relaxationmechanism in NMR spectroscopy	**K1** **K4**
5.4	NMR Chemical shift	Analyze the effect of magnetic field on the chemical shift of NMR absorption peak	**K4**
5.5	Coupling constant- Coupling between nucleus	Outline coupling constant Inspect various factors which affect the coupling between nucleus	**K2** **K4**

5.6 5.7	Chemical analysis by NMR NMR instrumentation-high resolution method	Describe the chemical analysis by NMR Explain NMR instrumentation high resolution method	**K1** **K2**
5.8	ESR Spectroscopy- basic principles	Describe the basic principle behind ESR spectroscopy	**K2**
5.9	ESR spectrometer	Discuss the instrumentation of ESR spectrometer	**K2**
5.10	Nuclear Interaction and hyperfine structure	Construct the energy levels for the interaction of electron with nucleus of hydrogen atom	**K3**
5.11	Relaxation effects - g-factor	Interpret the hyperfine structure, relaxation effects and g factor of ESR spectral lines for hydrogen atom	**K5**
5.12	Radical studies	Apply ESR techniques to study electron distribution and structure of radicals	**K3**

4. MAPPING SCHEME (PO, PSO& CO)

P21PH2:2	PO									PSO			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO 1	PSO 2	PSO 3	PSO 4
CO1	H	M	H	L	L	L	L	L	L	L	M	M	H
CO2	H	M	M	L	M	M	H	L	L	L	M	M	M
CO3	M	L	H	L	M	M	M	L	L	H	M	M	M
CO4	H	M	M	L	M	H	M	L	L	M	M	M	L
CO5	H	M	L	M	M	L	M	L	L	M	M	M	L
CO6	L	M	M	M	M	M	L	L	L	M	L	M	H

L - Low M – MediumH - High

5. COURSE ASSESSMENT METHOD

Direct

1. Continuous Assessment Test (Model Exams) I, II
2. Open book test, Quizzes, Assignment, Seminar, Problem Solving, Slip test, Surprise test etc.
3. End Semester Examination

Indirect

1. Course-end survey/Feedback

Course Co -ordinator: Dr. K. Vijayalakshmi

ELECTIVE-II: SOLAR PV TECHNOLOGY AND ITS APPLICATION

SEMESTER: II **CODE: P21PH2:A**

CREDITS: 4 **NO. OF HOURS / WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course, the students will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Discuss the importance of renewable energy resources	**K2**	**I**
CO2	Explain the importance of Solar energy and Solar Photovoltaic system	**K2**	**I**
CO3	Apply the principles of electricity in design of solar cells	**K3**	**II**
CO4	Outline the different types of Solar Photovoltaic system, power generation, distribution and storage in solar PV systems.	**K2**	**III**
CO5	Design a solar Photovoltaic system	**K5**	**IV**
CO6	Analyse the applications and installation of a solar Photovoltaic system	**K4**	**V**

2. A. SYLLABUS

Unit-I: Energy resources and basics on solar energy(12 hours)

Energy Scenario-Environmental aspects of energy Utilization-Renewable energy resources and their Importance-Energy balance of the Earth-Basics of Solar Energy-Global SolarResources-Solar spectrum-Electromagnetic spectrum-Earth-Sun angles-Solar angles-Sun path diagram-Solar radiation on the earth surface-Measurement of Solar Radiation-Global, diffused and direct measuring devices -Conversion of Solar Energy-Solar Thermal system-Solar Photovoltaic system.

Unit-II: Photovoltaic basics and balance of system(12 hours)

Basics of electricity – Measurement of electrical Quantities-Electronic Devices-Solar photovoltaic energy conversion – Principles-photovoltaic effect-solar cells- Structure and working of Solar Cells – Types-Electrical properties and Behavior of Solar Cells-Cell properties and design-short- and open-circuit properties, fill factor, and parasitic resistances, Solar cell energy conversion Efficiency, I-V characteristics-PV Cell Interconnection and Module Fabrication.

Unit-III: Types of solar system and its components (12 hours)

Classification of solar PV power systems- Standalone PV system, grid Interactive PV System, hybrid solar PV system-System Components - PV arrays, inverters, batteries, charge controls, net meter, Combiner box, Distribution board, etc., Types of Solar Inverter/PCU- Off grid Inverter, Grid Tie Inverter-Losses & Loading of Inverter (Determination of connected load)Types of Batteries-Series & Parallel combination of batteries-Operation & Maintenance of batteries.

Unit-IV: Design of solar PV system (12 hours)

Single line diagram-Load Estimation-System Sizing-PV module, Inverter, Battery sizing - Determination of Cable sizing both AC,DC cable-Balancing of system-Factors involved in SPV Systems such as Plant load factor, Capacity Utilization factor, Grid Availability factor and Fill factor-Performance ratio-Design of System Components for different PV Applications - Sizing and Reliability - Simple Case Studies- Cost evaluation and savings.

Unit-V: PV system applications and installation(12 hours)

Installation methods of solar PV power system-site survey, shadow analysis, tilt angle importance-Pre and post installation follow ups-Maintenance & Service -Trouble shooting & Electrical safety in SPV System -Home lighting and street lighting appliances, PV lantern, solar water pumping systems- small appliances based on solar energy.

B.TOPICS FOR SELF STUDY

1.Solar radiation

http://ecgllp.com/files/3514/0200/1304/2-Solar-Radiation.pdf

2. Types of Photovoltaic systems

https://www.bca.gov.sg/publications/others/handbook_for_solar_pv_systems.pdf

3. Solar Photovoltaics

https://www.uprm.edu/aret/docs/Ch_5_PV_systems.pdf

C. TEXT BOOKS

1. Chetan Singh Solanki., Solar Photovoltaic: “Fundamentals, Technologies and Application”, PHI Learning Pvt., Ltd., 2009.

2. Martin A. Green, Solar Cells Operating Principles, Technology, and System Applications Prentice- Hall, 2008

3. John R. Balfour, Michael L. Shaw, SharlaveJarosek., “Introduction to Photovoltaics”, Jones & Bartlett Publishers, Burlington, 2011.

D. REFERENCE BOOKS

1. S.P. Sukhatme, J.K.Nayak., “Solar Energy”, Tata McGraw Hill Education Private Limited, New Delhi, 2010. 5. Michael Boxwell, The Solar Electricity Handbook, Code Green Publishing, UK, 2009.

2. Photovoltaics: Design and Installation Manual, Published by Solar Energy International.

E. WEBLINKS

https://nptel.ac.in/courses/112/105/112105050/#

https://nptel.ac.in/courses/112/105/112105051/#

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/Section	Course Content	LearningOutcomes	Highest BloomsTaxonomicLevelof Transaction
I	**Energy resources and basics on solar energy**		
1.1	Energy scenario	Explain the need for energy in different areas of science	**K1**
1.2	Environmental aspects of energy utilization	Discuss utilization of energy in various environments	**K2**
1.3	Renewable energy resources and their importance	Explain the importance of renewable energy resources in day to day life and	**K2**
1.4	Energy balance of the Earth	Describe the energy balance of the earth	**K1**

1.5	Basics of Solar Energy	Define the basic concepts in solar energy	**K1**
1.6	Global solar resources	Summarize the availability of solar energy resources in the world	**K2**
1.7	Solar spectrum - Electromagnetic spectrum	Define the different regions of electromagnetic spectrum	**K1**
1.8	Earth-Sun angles-Solar angles-Sun path diagram	Explain the terms associated with the Sun and the Earth	**K1**
1.9	Solar radiation on the earth surface	Discuss Sun - Earth relationship	**K2**
1.10	Measurement of Solar Radiation-Global, diffused and direct, measuring devices	Estimate solar energy irradiance	**K2**
1.11	Conversion of Solar Energy-Solar Thermal system-Solar Photovoltaic system.	Summarize solar energy conversion	**K2**

II	**Photovoltaic basics and balance of system**		
2.1	Basics of electricity	Define the basic concepts in electricity	**K1**
2.2	Measurement of electrical quantities	Estimatedifferent electrical quantities	**K2**
2.3	Electronic devices – Solar photovoltaic energy conversion – Principles	Explain the different electronic devices associated with solar photovoltaic energy conversion	**K2**
2.4	Photovoltaic effect	Describe Photovoltaic effect	**K2**
2.5	Solar cells- Structure and working of Solar Cells – Types	Summarize the working of solar cells	**K2**

2.6	Electrical properties and behavior of Solar Cells	Discuss the electrical behavior of solar cells	**K2**
2.7	Cell properties and design	Summarize the design and properties of solar cells	**K2**
2.8	Short and open-circuit properties, fill factor, and parasitic resistances	Estimate the different parameters of solar cells	**K2**
2.9	Solar cell energy conversion - Efficiency - I-V characteristics	Explain the characteristics of solar cells	**K2**
2.10	PV Cell Interconnection and Module Fabrication	Describe the fabrication of solar cells	**K2**
III	**Types of solar system and its components**		
3.1	Classification of solar PV power systems	Explain the classification of solar PV systems	**K2**
3.2	Standalone PV system, grid Interactive PV System, hybrid solar PV system	Describe the different types of solar PV power systems	**K2**
3.3	System Components - PV arrays, inverters, batteries, charge controls, net meter, Combiner box, Distribution board	Identify the different components of solar PV system	**K2**
3.4	Types of Solar Inverter/PCU-Off grid Inverter, Grid Tie Inverter-Losses & Loading of Inverter	Estimate the losses in an inverter	**K2**
3.5	Types of Batteries-Series & Parallel combination of batteries-Operation and Maintenance of batteries	Explain the types of batteries and their maintenance in a solar PV system	**K2**
IV	**Design of solar PV system**		
4.1	Single line diagram-Load Estimation-System Sizing	Estimate the load of a solar PV system	**K2**
4.2	PV module, Inverter, Battery sizing	Describe a PV module	**K2**

4.3	Determinationof Cable sizing both AC ,DC cable	Identify the cables used in a solar PV system	**K2**
4.4	Balancing of system-Factors involved in SPV Systems such as Plant load factor, Capacity Utilization factor, Grid Availability factor, Fill factor, Performance ratio	Estimate the different parameters in a solar PV distribution system	**K2**
4.5	Design of System Components for different PV Applications	Design a solar PV system using essential components for various applications	**K5**
4.6	Sizing and Reliability	Explain the reliability of solar cells	**K2**
4.7	Simple Case Studies- Cost evaluation and savings	Estimate the cost savings in a solar PV system	**K2**
V	**PV system applications and installation**		
5.1	Installation methods of solar PV power system	Explain the installation methods of a solar PV power system	**K2**
5.2	Site survey, shadow analysis, tilt angle importance	Analyse the installation of a solar PV power system	**K4**
5.3	Pre and post installation follow ups	Explain the pre and post installation follow ups in a solar PV system	**K2**
5.4	Maintenance & Service	Describe the maintenance and service needed for a solar PV system	**K2**
5.5	Trouble shooting & Electrical safety in SPV System	Summarize the safety measures and troubleshoot the problems in a solar PV system	**K2**
5.6	Home lighting and street lighting appliances - PV lantern ,solar water pumping systems- small appliances based on solar energy	Analyze small appliances based on solar energy	**K4**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH2: A	PO									PSO			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO 1	PSO 2	PSO 3	PSO 4
CO1	H	M	M	M	M	M	M	L	L	H	H	H	H
CO2	H	M	M	M	M	M	M	L	L	H	H	H	H
CO3	H	M	M	M	M	M	M	L	L	H	H	H	H
CO4	H	M	M	M	M	M	M	L	L	H	H	H	H
CO5	H	M	M	M	M	M	M	L	L	H	H	H	H
CO6	H	M	M	M	M	M	M	L	L	H	H	H	H

L-Low M-Moderate H- High

5. COURSEASSESSMENTMETHODS

Direct

1. ContinuousAssessmentTest(ModelExams) I,II
2. Openbooktest;Assignment,Seminar, Problem solving, Field visits
3. EndSemesterExamination

Indirect

1. Course-endsurvey

Course Co-ordinator: Dr. D. Gopalakrishna

ELECTIVE - III: VIRTUAL LABS – PHYSICS EXPERIMENTS

SEMESTER: II **COURSE CODE: P21PH2:P**

CREDITS: 4 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES

Afterthesuccessfulcompletionofthis coursethestudentswillbe ableto:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Select remote-access to labs in various areas related to Physics	**K1**	**I, II, III, IV, V**
CO2	Perform practical in the virtual mode	**K3**	**I, II, III, IV, V**
CO3	Construct virtually, electrical and electronic circuits and validate the corresponding theorems and laws	**K6**	**I, IV, V**
CO4	Evaluate the physical parameters from tabulated data and graph	**K5**	**IV, V**
CO5	Interpret the results obtained from virtual experiment	**K5**	**I, II, III, IV, V**
CO6	Illustrate the output data in graphical mode using relevant software	**K3**	**I, II, III**

2. A. SYLLABUS

Unit-I: Electric Circuits **(12 Hours)**

Parallel RC Circuits -Parallel LC Circuits - Thevenin's Theorem - Series RL Circuits - Norton's theorem - Series LCR Circuits - Kirchhoff's Laws-Series RC Circuits - Series LC Circuits - Parallel LCR Circuits - Parallel RL Circuits

Unit-II: Basic Electronics **(12 Hours)**

V-I characteristics of junction diode – V-I characteristics of Zener Diode – Ohm's law – Half wave rectification – Full wave rectification – Common base characteristics – Common emitter characteristics – Common emitter amplifier.

Unit-III: Digital Logic Circuits **(12 Hours)**

Adder – Multiplexer – Decoder with 7-segment display – ALU with function – Comparator – Latch and flip-flops – Register – Counters – Sensor Modelling.

Unit-IV: Thermodynamics and Laser Optics **(12 Hours)**

Newton's law of cooling – Thermocouple Seebeck effect – Characteristics of thermistor – Blackbody radiation- Michelson's Interferometer – Refractive index of glass plate – Newton's Rings – Refractive index of liquid – Michelson's Interferometer – wavelength of laser beam – Newton's Rings – wavelength of light – Brewster's angle determination – Numerical aperture of optical fiber.

Unit-V: Advanced Physics **(12 Hours)**

Frank-Hertz experiment – Photo electric effect – Plank's constant – Abbe's refractometer– Millikan's oil drop experiment – Magnetic Material characterization via hysteresis – Resistivity of four probe method – B-H curve – Hall effect – determination of charge carrier density.

B. TOPICS FOR SELF STUDY

1.Virtual Experiments

https://www.youtube.com/c/SimplyPhysics/videos

C. TEXT BOOKS

1. Introduction to solid state physics, 8th edition, C. Kittel
2. Advanced Mechanics of Solids by L Srinath
3. Laser and Non-Linear Optics by B.B. Laud

D. REFERENCE BOOKS

1. Heat and Thermodynamics by Mark Waldo Zemansky
2. Introduction to Modern Physics: Theoretical Foundations by John Dirk Walecka
3. Text Book of Simple Harmonic Motion and Wave Theory by D.K. Jha

E. WEBLINKS

1. www.iitg.ac.in
2. www.va-iitk.vlabs.ac.in
3. www.vlab.co.in
4. www.amrita.vlab.co.in

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Electric Circuits**		
1.1	Introduction to laws and theorems, Thevenin's Theorem, Norton's theorem, Kirchhoff's Laws	Apply thebasics theory of Thevenin's Theorem, Norton's theorem, Kirchhoff's Laws	**K3**
1.2	Electric Circuits- Series and Parallel RL, RC and LC Circuits, Series and Parallel LCR Circuits,	Construct theSeries and Parallel RL, RC and LC Circuits, Series and Parallel LCR Circuits	**K3**
II	**Basic Electronics**		
2.1	Diodes and rectifiers - V-I characteristics of junction diode and Zener Diode	Determine the input and output parameter of junction diode and Zener Diode	**K5**
2.2	Ohm's law	Verify Ohm's law	**K4**
2.3	Half and Full wave rectification	Explore the function of half and full wave rectifier circuits	K4
2.4	Transistor - CB, CE characteristics, CE amplifier	Explain the basic characteristics of Transistors	**K4**
III	**Digital Logic Circuits**		
3.1	Logic circuits – Adder, Multiplexer, Decoder with 7-segment display, ALU with function, Comparator	Explainthe basicopeartionsof digital circuits	**K4**
3.2	Latch and flip-flops, Register, Counters	Explain the working of Latch and flip-flops, Register, Counters	**K4**
3.3	SensorModelling	explain the functioning of sensors bymodelling	**K2**

IV	**Thermodynamics and Laser Optics**		
4.1	Newton's law of cooling, Thermocouple Seebeck effect, Characteristics of thermistor, Blackbody radiation	Measure the physical parameters involved in Newton's law of cooling, Thermocouple Seebeck effect, Characteristics of thermistor, Blackbody radiation, kinetics and thermodynamics of reactions and its mechanisms	**K5**
4.2	Laser Optics - Michelson's Interferometer - Refractive index of glass plate, Newton's Rings, Refractive index of liquid, wavelength of laser beam, Brewster's angle determination, Numerical aperture of optical fibre	Determine Refractive index Wavelength of laser beam, Brewster's angle determination, Numerical aperture Using suitable experiments	**K5**
V	**Advanced Physics**		
5.1	Frank-Hertz experiment - Photo electric effect, Plank's constant,	Determine the physical parameter after virtually setting up the experiments specified	**K5**
5.2	Abbe's refractometer, Millikan's oil drop experiment, Magnetic Material characterization via hysteresis		
5.3	Resistivity of four probe method, B-H curve, Hall effect, determination of charge carrier density.		

4. MAPPING SCHEME (PO, PSO& CO)

P21PH2: P	PO									PSO			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO 1	PSO 2	PSO 3	PSO 4
CO1	M	L	-	-	-	M	-	-	L	H	H	-	M
CO2	L	L	-	-	M	-	-	-	L	H	H	-	M
CO3	H	L	M	-	M	L	-	M	M	H	H	L	H
CO4	H	M	L	L	L	-	M	-	-	H	M	M	H
CO5	H	M	-	M	H	L	-	M	-	H	H	-	M
CO6	H	M	L	-	L	L	L	-	M	H	H	-	M

L – Low M – Moderate H – High

5. COURSEASSESSMENTMETHODS

Direct

1. ContinuousAssessmentTest(ModelExams) I, II

2. Cooperativelearningreport,Assignment,Seminar,Record Note Book, Problem solving etc.
3. EndSemesterExamination

Indirect

1. Course-endsurvey

Course Co-ordinator: Dr. P. MegavarnaEzhil Arasu

CORE VI: QUANTUM MECHANICS – I

SEMESTER: III **CODE:P21PH306**

CREDITS: 5 **NO. OF HOURS /WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course the student will be able to:

CO. NO.	**Course Outcomes**	**Level**	**Unit Covered**
CO1	Recall the in adequacy of classical mechanics in the microscopic domain.	**K1**	I
CO2	Explain concepts of wave mechanics, use particle duality as a basis to formulate quantum mechanics.	**K2**	I
CO3	Construct the Schrodinger equation of microscopic physical systems on the basis of quantum mechanical interpretations and solve it.	**K3**	I & II
CO4	Analyze the dynamics of simple quantum mechanical systems by setting up the Schrodinger equations and solve them.	**K4**	I & II
CO5	Formulate appropriate perturbation techniques to study the behavior of simple quantum mechanical systems under perturbation of various types.	**K5**	III & IV
CO6	Assess the effects due to various perturbations.	**K6**	III,IV& V

2. A. SYLLABUS

Unit-I: The Schrödinger Equation and Stationary States **(15 hours)**

Overview of inadequacy of classical concepts (no derivation) – Matter waves -Heisenberg's Uncertainty Principle – The Schrödinger equation – Physical interpretation and conditions on the wave function – Postulates – Self-adjoint operators - Expectation values and Ehrenfest's theorem – Stationary states and energy spectra – Particle in a square well potential.

Unit-II: Exactly Solvable Problems **(15 hours)**

Linear harmonic oscillator (power series method) – Eigenfunctions by solving one dimensional Schrödinger equation — Three dimensional harmonic Oscillator – Components of angular momentum and eigenvalue spectra of L^2 and L_z – Rigid Rotator – Hydrogen atom.

Unit-III: Perturbation Theory for stationary states **(15 hours)**

Time independent problems – Non–degenerate case – First and second order perturbation – Degenerate case – Zeeman Effect – Stark effect – The variation method – Ground state of Helium atom -The WKB Approximation – Application to tunneling problem and quantization rule.

Unit-IV: Perturbation Theory for time evolution problems **(15 hours)**

Time dependent problems – Time dependent perturbation theory – First order perturbation – Harmonic perturbation – Transition probability – Fermi's golden rule – Adiabatic approximation – Sudden approximation – Application: Semi classical theory of radiation.

Unit-V: Quantum Theory of Scattering **(15 hours)**

The Scattering cross section – Scattering amplitude - Born approximation – Green's function approach - Condition for validity of Born approximation – Scattering by a screened Coulomb potential – Rutherford's scattering formula–Partial wave analysis – Phase shift and optical theorem.

B. TOPICS FOR SELF STUDY

1. **Path integral formulation of quantum mechanics – The Propagator**
   https://ocw.mit.edu/courses/physics/8-321-quantum-theory-i-fall-2017/lecture-notes/
2. **Schrodinger equation from Path integral formulation**
   https://www.asc.ohio-state.edu/perry.6/
3. **Free particle**https://courses.physics.ucsd.edu/2016/Spring/physics142/Lectures/Lecture5/Lecture5.html
4. **Harmonic oscillator**
   https://www.ks.uiuc.edu/Services/Class/PHYS480/

C. TEXT BOOKS

1. P. M. Mathews and K. Venkatesan, A Text Book of QuantumMechanics, Tata McGraw Hill, New Delhi, 2007.
2. V. K. Thankappan, Quantum Mechanics, New Age International (P) Ltd., New Delhi, 2003.
3. L. Schiff, Quantum Mechanics 3e, Tata McGraw Hill, New Delhi, 2010.

D. REFERENCE BOOKS

1. Richard L. Liboff, Introductory Quantum Mechanics, 4e Pearson Education India 2003
2. AjoyGhatak and S. Loganathan, Quantum Mechanics: Theory and Applications 5e, Macmillan India, 2004.
3. Rajasekar and R. Velusamy, The Fundamentals of Quantum Mechanics, CRC Press, 2015.

E. WEBLINKS

1. https://nptel.ac.in/courses/115/104/115104096/
2. https://nptel.ac.in/courses/115/106/115106066/
3. https://nptel.ac.in/courses/115/101/115101107/
4. https://nptel.ac.in/courses/115/102/115102023/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	CourseContent	LearningOutcomes	Highest Bloom's Taxonomic Levelof Transaction
I	**TheSchrödingerEquationandStationaryStates**		
1.1	Overviewofinadequacyofclassicalconcepts(noderivation)	Recalltheinadequacyofclassicalmechanics withsuitableexamples	**K1**
1.2	Matter waves	Relate matter with wave packets	**K2**
1.3	Heisenberg's Uncertainty Principle	Estimate the uncertainty in measurement	**K2**
1.4	The Schrödinger equation	Develop Schrödinger equation	**K4**
1.5	Physical interpretation of wave functions	Interpret the meaning of wave function	**K2**
1.6	Conditions on the wave function	Deduce the condition for its validity	**K4**
1.7	Postulates	Define the postulates	**K1**

1.8	Self-adjoint operators	Summarize the meaning of operators	**K2**
1.9	Expectation values	Estimate the expectation values physical observables	**K4**
1.10	Ehrenfest's theorem	Explain and StateEhrenfest's theorem	**K2**
1.11	Stationary states and energy spectra	Classify the stationary states as per its energy	**K4**
1.12	Particle in a square well potential.	Evaluate the allowed energy levels	**K5**
1.13	Particle in a square well potential.	Propose eigen functions for a particle in a box	**K6**
II	**ExactlySolvableProblems**		
2.1	I-D Linearharmonicoscillator(powerseriesmethod)	Develop Schrödinger equation and evaluatetheallowedenergylevels	**K6**
2.2	Eigenfunctions by solving one dimensional Schrödinger equation	Proposeeigen functions with integrated physical conditions for Schrödingerequation	**K6**
2.3	Three dimensional harmonic Oscillator	Compose-ThethreedimensionalSchrödingerequations and deduce the eigen values and eigen functions	**K6**
2.4	Components of angular momentum and eigenvalue spectra of L^2 and L_z	Developtheformofangularmomentum operators,simplifyeigenvalueequationsand estimate the allowed eigen values	**K6**
2.5	Rigid Rotator	Describe and represent as a single body	**K2**
		Formulate Schrödingerequationanddeterminethe eigen values and eigen functions	**K6**
2.6	Hydrogen atom	Constructradialequationanddeterminetheeigen values and eigen functions	**K6**
III	**PerturbationtheoryforStationarystates**		
3.1	Timeindependentproblems	Explainthetimeindependentperturbationtheory	**K2**
3.2	Non–degenerate case	Applythetheorytoidentifycorrection(Various orders) in energy levels	**K3**
3.3	Degenerate case	Analyze the effect of perturbation over degenerate case	**K4**
3.4	First and second order perturbation– Stark effect	Formulate the perturbing Hamiltonian	**K6**
3.5	Stark Effect	Evaluatethecorrectionstoenergylevelsand predict the results	**K5**
3.6	Zeeman Effect	Formulate the perturbing Hamiltonian	**K6**
		Evaluatethecorrectionstoenergylevels and predict the results	**K5**

3.7	The variation method	Describethemethodoffindingtheenergyof ground state and exited states	**K2**
3.8	Ground state of Helium atom	Evaluate the ground state energy of a Helium atom by the method of variation	**K5**
3.9	The WKB Approximation	Explain the method of solving problems with spatially varying potentials	**K2**
3.10	Application to tunneling problem	Evaluate the reflection and transmission coefficient of a barrier	**K5**
3.11	Quantization rule.	Deduce the quantization rule	**K4**
IV	**Perturbationtheoryoftimeevolutionproblem**		
4.1	Timedependentproblems Timedependentperturbationtheory–Firstorder	Explain thetimedependentperturbationtheoryuptofirstorder	**K2**
4.2	Harmonic perturbation	Deducefirstordercorrectionforharmonic perturbation and discuss the results	**K4**
4.3	Transition probability Fermi's golden rule	Deduce Fermi Golden rule	**K4**
4.4	Adiabatic approximation	Propose the theory for adiabatic perturbation	**K6**
4.5	Sudden approximation	Formulate the theory for suddenly changing perturbation	**K6**
4.6	Application: Semi classical theory of radiation	Developsemiclassicaltheoryofradiationand discussthenatureofinteractionofradiation with matter	**K6**
V	**QuantumtheoryofScattering**		
5.1	TheScatteringcrosssectionScatteringamplitude	Describethequantumpictureof scattering	**K2**
5.2	Born approximation	Explain Born's approximation	**K2**
5.3	Green's function approach	Deductionofaformalexpressionfordifferential scattering cross-section	**K6**
5.4	Condition for validity of Born approximation	Deduction of conditions for validity	**K4**
5.5	Scattering by a screened Coulomb potential	Estimate the scattering cross-section for particles scattered byscreened Coulomb potential	**K5**
5.6	Rutherford's scattering formula–	Modify scattering amplitude to get Rutherford's scattering formula	**K6**
5.7	Partial wave analysis	Developamethodtocategorizeparticles based on their angular momentum	**K6**
5.8	Phase shift	Classifythenatureofscattereras per	**K2**

		thechangesin the phase shift	
5.9	Optical theorem	Comparethescatteringamplitudewith optical theorem and interpret the results	**K4**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH306	**PO**									**PSO**			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO 1**	**PSO 2**	**PSO3**	**PSO4**
CO1	**H**	**-**	**M**	**-**	**L**	**-**	**L**	**L**	**-**	**M**	-	**-**	M
CO2	**L**	**H**	**-**	**-**	**-**	**M**	**L**	**-**	**L**	**-**	**H**	**H**	
CO3	**-**	**-**	**M**	**-**	**-**	**H**	**-**	**-**	**-**	**H**	-	-	**H**
CO4	**-**	**-**	**M**	**M**	**H**	**-**	**L**	**-**	**M**	**-**	**M**	**-**	**H**
CO5	**-**	**-**	**H**	**-**	**-**	**M**	**-**	**H**	**M**	**M**	-	M	-
CO6	**-**	**M**	**-**	**-**	**L**	**H**	**H**	**-**	**-**	**M**	**-**	**-**	**M**

L-Low M-Medium H-High

5. COURSE ASSESSMENT METHODS

Direct

1. Continuous Assessment Test (Model Exam) I and II
2. Co-operative learning report – Assignment, Seminar, Group Presentation.
3. End Semester Examination.

Indirect

1. Course end survey

Course Co-ordinator: Mr. R. JebakumarPandian

CORE VII: SOLID STATE PHYSICS – I

SEMESTER : III **CODE: P21PH307**

CREDITS: 5 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After successful completion of this course the students will be able to:

CO. NO.	Course Outcome	Level	Unit Covered
CO1	Infer the ideas of crystals structure and diffraction phenomenon	**K2**	**I**
CO2	Compare lattice planes, crystals vibration and structure factors	**K2**	**I,II**
CO3	Distinguish the thermal and electrical properties of semiconductor crystal	**K4**	**II**
CO4	Identifies energy levels of free electron gas	**K3**	**III**
CO5	Classify the binding and periodic potential	**K4**	**IV**
CO6	Detect imperfections in solids and effect of impurities and defects	**K5**	**V**

2. A. SYLLABUS

Unit-I: Crystal Structures and X-ray Diffraction (15 Hours)

Crystal structure of materials -Fundamental concepts of lattices, symmetries, point groups, and space groups - relationship between crystal symmetries and physical properties – Brillouin zones - Structure factor of the bcc and fcc lattice – Atomic form factor - reciprocal lattice - Theory of X-ray diffraction by crystalline matter - Diffraction conditions – Laue equations (Conditions)- Bragg's law, relation to crystal structure - NaCl, CsCl, Hexagonal Close Packed (hcp) structure, Diamond, Cubic ZnS – Scattered Wave Amplitude – Fourier analysis Application of X-ray diffraction to proteins, electron diffraction and neutron diffraction (Concepts).

Unit-II: Crystal Vibrations and Thermal properties (15 Hours)

Vibrations of crystals with mono-atomic basis – Two atoms per primitive basis – Quantization of elastic waves – Phonon momentum – Inelastic scattering by phonons – Phonon heat capacity – Planck distribution – Normal mode – Density of states in 1D and 3D – Debye model – Einstein model – Thermal conductivity: Thermal resistivity – Umklapp processes – Imperfections.

Unit-III: Free Electron Fermi Gas and Energy Bands (15 Hours)

Free electrons – Energy levels in 1D – Effect of temperature on the Fermi-Dirac distribution – Free electron gas in 3D – Heat Capacity of the electron gas Classical free electron theory – Quantum free electron theory - Electrical and thermal conductivity – Motion in magnetic fields - –Nearly free electron model – Bloch functions – Tight binding approximation - Kronig-Penney model – electron in a periodic potential.

Unit-IV: Semiconductor Crystals, Fermi Surfaces and Metals (15 Hours)

Band gap – Equations of motion – Intrinsic carrier concentration – Impurity conductivity – Thermoelectric effect – Construction of Fermi surfaces – Electron orbits, hole orbits and open orbits – Calculation of energy bands – Tight binding method – Experimental methods in Fermi surface studies – de Hass-van Alphen effect.

Unit -V: Imperfections in solids (15 Hours)

Point defect – Line defect or dislocations - Interfacial defect - Bulk or volume defect – Atomic vibrations - Lattice vacancies– Diffusion – Color centers –Shear strength of single crystals – Dislocations – Burgers vectors – Stress fields of dislocations – Low-angle grain boundaries – Dislocation densities – Dislocation multiplication – Slip.

B. TOPICS FOR SELF STUDY

1. **Artificially layered structures**
   https://www.springer.com/gp/book/9781475700930
2. **Charge-density wave**
   https://guava.physics.uiuc.edu/~nigel/courses/569/Essays_Fall2009/files/morales.pdf
3. **Colloidal crystals**
   https://www.tandfonline.com/doi/abs/10.1080/00107518308227471?journalCode=tcph20
4. **Ion-solid interactions**https://physics.uwo.ca/~lgonchar/courses/p9826/Lecture9_Ion_RBS_Impl_partI.pdf

C. TEXT BOOKS

1. Charles Kittel, Introduction to Solid State Physics 8e, John Wiley & Sons Inc., NJ, 2016 (reprinted)
2. S.L. Gupta and V. Kumar, Solid State Physics, K. Nath& Co., Meerut, 2013.

D. REFERENCE BOOKS

1. R.L. Singhal, Solid State Physics, KedarNath Ram Nath& Co., Meerut, 2012.
2. Neil W. Ashcroft and N. David Mermin, Basic Solid State Physics, Brooks/Cole Publishing Company, CA, 2014. (reprinted)
3. M. Ali Omar, Elementary Solid State Physics, Addison-Wesley Publishing Company Inc., USA, 2018. (reprinted)
4. J. S. Blakemore, Solid State Physics 2e, Cambridge University Press, UK, 2012.(Online June)
5. A. Roy Chaudhuri, Basic Solid State Physics, Sarat Book House, Kolkatta, 2014.
6. M. A. Wahab, Solid State Physics: Structure and Properties of Materials, Narosa Publishing House, New Delhi, 2015.
7. A. J. Dekker, Solid State Physics, Macmillan, 2000.

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic levels of Transaction
I	**Crystal Structures and X-ray Diffraction**		

1.1	Material matter and properties	Recall the properties of materials	**K1**
1.2	Periodic arrays of atoms.	Infer the periodical arrangement of atom	**K2**
1.3	Lattice translation vectors Basis	Illustrates the vector translation with basis	**K2**
1.4	Crystal structure Primitive lattice cell	Identify the crystal structure	**K3**
1.5	Types of lattice	Classify types of lattice	**K4**
1.6	2D, 3D lattices	Identify the lattice type	**K3**
1.7	X-ray Diffraction and determinationof crystal structure	Analysis crystal structure	**K4**
1.8	Structure of NaCl, CsCl, Hexagonal Close Packed (hcp) structure Diamond, Cubic ZnS	Determine the structure	**K5**
1.9	Bragg's law Scattered Wave Amplitude	Apply the law	**K3**
1.10	Fourier analysis	Analysis wave property	**K4**
1.11	Real space and reciprocal space of crystals	Relate the real and reciprocal space	**K2**
1.12	Diffraction conditions	Apply the condition for diffraction	**K3**
1.13	Laue equations Brillouin zones	Constructing the zones	**K6**
1.14	Structure factor of the bcc and fcc lattice Atomic form factor	Identify the structure	**K3**
II	**Crystal Vibrations and Thermal properties**		
2.1	Vibrations of crystals with mono-atomic basis	Apply atomic crystals vibrations Evaluate the pattern	**K3**
2.2	Two atoms per primitive basis	Evaluate the pattern	**K5**
2.3	Quantization of elastic waves	Determine elastic wave quantization	**K5**
2.4	Phonon momentum Inelastic scattering by phonons	Identify types of scattering	**K3**
2.5	Phonon heat capacity	Examine the thermal property of Phonon	**K4**
2.6	Planck distribution	Analysis energy distribution	**K4**
2.7	Normal mode Density of states in 1D and 3D	Identify the mode & the density of states	**K3**

2.8	Debye model Einstein model	Explain the distribution model	**K5**
2.9	Thermal conductivity: Thermal resistivity	Classifies thermal conductivity & resistivity	**K4**
2.10	Umklapp processes Imperfections.	Analyze the type of imperfection	**K4**
3	**Free Electron Fermi Gas and Energy Bands**		
3.1	Energy levels in 1D	Construct the 1D energy level	**K6**
3.2	Effect of temperature on the Fermi-Dirac distribution	Concludes the effect of temperature on FD distribution	**K5**
3.3	Free electron gas in 3D	Apply & analyze free electron energy in 3D	**K3**
3.4	Heat Capacity of the electron gas Electrical conductivity and Ohm's law Thermal conductivity of metals.	Classify heat & electrical conductivity of electron gas using Ohm's law	**K4**
3.5	Motion in magnetic fields	Relates the motion & magnetic field	**K2**
3.6	Nearly free electron model Bloch functions	Apply the free electron model	**K3**
3.7	Tight binding approximation	Explain the binding approximate	**K5**
3.8	Kronig-Penney model	Concludes the potential content of electron	**K5**
3.9	Electron in a periodic potential.	Determines periodic potential	**K5**
IV	**Semiconductor Crystals, Fermi Surfaces and Metals**		
4.1	Band gap	Illustrate the energy gap	**K2**
4.2	Equations of motion	Make use of equations of motion	**K3**
4.3	Intrinsic carrier concentration Impurity conductivity	Determines carrier concentration & impurity present	**K5**
4.4	Thermoelectric effects	Identify the thermal effect for electrical conductivity	**K3**
4.5	Construction of Fermi surfaces	Construction of Fermi surfaces	**K6**
4.6	Electron orbits, hole orbits and open orbits	Relates electron , hole & open orbits	**K2**
4.7	Calculation of energy bands	Estimates the energy band gap	**K5**
4.8	Tight binding method	Explain the method	**K5**

4.9	Experimental methods in Fermi surface studies	Construction of Fermi surface	**K6**
4.10	DeHass-van Alphen effect	Explain the effect	**K5**
V	**Imperfections in solids**		
5.1	Types of imperfection and Lattice vacancies	Classify different types of imperfection	**K4**
5.2	Diffusion And Colour centers	Identify the type of imperfection	**K3**
5.3	Shear strength of single crystals	Analyze the shear strength	**K4**
5.4	Dislocations	Classify the types of dislocations	**K4**
5.5	Burgers vectors	Identify vectors	**K4**
5.6	Stress fields of dislocations	Classifies the cause of dislocations	**K4**
5.7	Low-angle grain boundaries	Determine the grain boundaries	**K5**
5.8	Dislocations densities	Examine the density ofdislocations	**K4**
5.9	Dislocation multiplication Slip.	Distinguish of dislocation types	**K4**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH 307	**PO**									**PSO**			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PS0 1**	**PS0 2**	**PS0 3**	**PSO 4**
CO1	L	-	M	-	H	M	-	-	-	H	-	M	H
CO2	-	-	M	-	L	-	-	-	-	H	-	M	L
CO3	M	-	H	-	-	-	M	-	L	M	M	H	-
CO4	M	M	H	M	L	L	M	M	L	M	M	M	M
CO5	-	-	M	H	-	-	-	-	-	M	-	M	-
CO6	H	-	H	-	-	H	L	H	-	-	L	H	M

L-Low M-Medium H-High

5. COURSE ASSESSMENT METHOD

Direct

1. Two continuous internal assessments Test, Closed Book.
2. Two Open Book Assignments
3. Unit Seminars and Quiz
4. Pre-Semester and End-Semester Examinations External Valuation

Indirect

1. Course end survey (Feedback)

Course Co-ordinator: Dr. D. J. S. AnandKarunakaran

CORE-VIII: MICROPROCESSOR AND MICROCONTROLLER

SEMESTER : III **CODE:P21PH308**

CREDITS: 5 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES(CO)

After completing the Course, Students are able to :

CO. NO.	COURSE OUTCOMES	LEVEL	UNIT COVERED
CO1	Study and recall architecture of Microprocessor INTEL 8085	**K1**	**I**
CO2	Identify a detailed s/w & h/w structure of the Microprocessor.	**K2**	**II**
CO3	Apply how the different peripherals are interfaced with Microprocessor	**K3**	**III**
CO4	Distinguish and analyze the properties of	**K4**	**IV**

	Microprocessors &Microcontroller		
CO5	Establish the data transfer information among different peripherals	**K5**	**V**
CO6	Evaluate their knowledge through some programs using 8085 and 8051	**K6**	**I-IV**

2. A. SYLLABUS

UNIT-I: MICROPROCESSOR ARCHITECTURE AND INTERFACING (15 hours)

Intel 8085 microprocessor architecture – Pin configuration – Instruction cycle – Timing diagram – Instruction and data formats – Addressing modes – Memory mapping and I/O mapping I/O scheme – Memory mapping I/O interfacing – Data transfer schemes – Synchronous and asynchronous data transfer – Interrupt driven data transfer - Interrupts of Intel 8085.

UNIT-II: ASSEMBLY LANGUAGE PROGRAMS (8085 ONLY) (15 hours)

Addition and subtraction two 8-bit and 16-bit numbers – Largest and smallest num
bers in a data set – Ascending order and descending order – Sum of a series of a 8-bit numbers – Sum of a series of multibyte decimal numbers – Square root of a number – Block movement of data - Time delay – Square-wave generator.

UNIT III: PERIPHERAL DEVICES AND MICROPROCESSOR APPLICATIONS (15 hours)

Generation of control signals for memory and I/O devices – I/O ports – Programmable peripheral interface – Architecture of 8255A – Control word – Programmable interrupt controller (8259) – Programmable counter – Intel 8253 – Architecture, control word and operation – Block diagram and interfacing of analog to digital converter (ADC 0800) – Digital to analog converter (DAC 0800) – Traffic control.

UNIT-IV: MICROCONTROLLER (15 hours)

Introduction to Microcontroller – Comparison of Microcontrollers and Microprocessor – overview of 8051– Pin description of 8051 – Registers – Program counters – ROM & RAM space – Stack and PSW - Addressing modes – Instruction set.

UNIT-V: ON-CHIP PERIPHERALS OF 8051 AND PROGRAM (15 hours)

Counters/Timers – Basics of serial communication – RS232 and MAX 232 IC connection – Serial communication registers – Serial communication – Interrupts –addition – Multiplication – Decimal to Hexadecimal Conversion – Ascending and Descending order – Largest Number in an array – LCD Interfacing, Temperature controller – Stepper motor.

B. TEXT BOOKS

1. B. Ram, Fundamentals of Microprocessor and Microcomputers (Dhanpat Rai Pub., New Delhi, 2006).
2. M.A. Mazidi, J.G. Mazidi and R.D. Mckinlay, The 8051 Microcontroller and Embedded Systems using Assembly and C (Dorling Kindersley, New Delhi, 2013).
3. A.P. Godse and D.A. Godse, Microprocessors and Microcontrollers (Technical Pub., Pune, 2008).

C. REFERENCE BOOKS

1. R. Gaonkar, Microprocessor Architecture, Programming and Applications with 8085 (Penram International Publishing, Mumbai, 2006) 5th edition.
2. K. Ayala, The Microcontroller (Cengage Learning India, New Delhi, 2013) 3rd edition.

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	**Course Content**	**Learning Outcomes**	**Highest Bloom's Taxonomy Level of Transaction**
I	**ARCHITECTURE OF MICROPROCESSOR 8085**		
1.1	Intel 8085 microprocessor architecture	List the component in the architecture of INTEL 8085 (K1) Explain about the architecture of Intel 8085 with a proper block diagram (K5)	K5
1.3	Pin configuration	Discuss the working of each pins iin Intel 8085	K2
1.4	Instruction cycle	Explanation with neat diagram	K5

	Timing diagram Instruction and data formats	Examples for each type	K5
1.5	Addressing modes	List the different types of addressing modes in Intel 8085 and explain each with an example	K5
1.6	Memory mapping and I/O mapping I/O scheme	Explanation with neat diagram	K5
1.7	Memory mapping I/O interfacing – Data transfer schemes – Synchronous and asynchronous data transfer – Interrupt driven data transfer – Interrupts of Intel 8085	Distinguish and explain with necessary diagram	K4
II	**ASSEMBLY LANGUAGE PROGRAMS (8085 ONLY)**		
2.1	BCD arithmetic	Apply the instructions of Intel 8085, to write a program for each and store the result in different locations	K5
2.2	Addition and subtraction two 8-bit and 16-bit numbers	Apply the instructions of Intel 8085, to write a program for each and store the result in different locations	K5
2.3 2.4	Largest and smallest numbers in a data set Ascending order and descending order Sum of a series of a 8-bit numbers	Apply the instructions of Intel 8085, to write a program for each and store the result in different locations	K5
2.5	Sum of a series of multibyte decimal numbers	Apply the instructions of Intel 8085, to write a program for each and store the result in different locations	K5

2.6 2.7 2.8	Square root of a number Block movement of data Time delay – Square-wave generator	Apply the instructions of Intel 8085, to write a program for each and store the result in different locations	K5
III	**PERIPHERAL DEVICES AND MICROPROCESSOR APPLICATIONS**		
3.1	Generation of control signals for memory and I/O devices - I/O ports	Interfacing with Intel 8085 for performing different acts	K5
3.2	Programmable peripheral interface -- Architecture of 8255A -- Control word		K5
3.3	Programmable interrupt controller (8259) -- Programmable counter		K5
3.4	Intel 8253 --Architecture, control word and operation – Block diagram and interfacing of analog to digital converter (ADC 0800)	Explanation about each with neat diagram and write the program to do so	K5
3.5	Digital to analog converter (DAC 0800) – Stepper motor – Traffic control.		K5
IV	**MICROCONTROLLER**		
4.1	Introduction to Microcontroller	Recalling the features of microcontroller	K1
4.2	Comparison of Microcontrollers and Microprocessor	Comparing microcontroller and microprocessor	K2
4.3	overview of 8051	Explaining about 8051	K2
4.4	Pin description of 8051	Describing about various pins of 8051	K2
4.5	Registers	Classification of registers that are available in 8051	K2
4.6	Program counters	Discussing about program counter	K2
4.7	ROM & RAM space	Description about RAM and	K2

		ROM	
4.8	Stack and PSW	Explain about stack and PSW	K2
4.9	Addressing modes	Explaining about various addressing modes	K2
4.10	Instruction set.		K2
VON-CHIP PERIPHERALS OF 8051 AND PROGRAM			
5.1	Counters/Timers	Explaining the functions of counters and timers	K2
5.2	Basics of serial communication	Understanding the methods of serial communications	K2
5.3	RS232 and MAX 232 IC connection	Describing pin configuration , hand shaking signal and connection with 8051	K2
5.4	Serial communication registers	Describing various registers like SBUF,SCON	K2
5.5	Serial communication – Interrupts	Explaining interrupt priority ,triggering the interrupt by software	K2
5.6	Addition	Using 8051 ALP perform 16-bit addition of two 16-bit data using immediate addressing	K3
5.7	Multiplication	Using 8051 ALP perform 8 -bit multiplication of two 8-bit data using immediate addressing	K3
5.8	Decimal to Hexadecimal Conversion	Using 8051 ALP, develop an 8051 ALP to perform decimal to hexadecimal conversion	K5
5.9	Largest Number in an array	Using 8051 ALP, develop an 8051ALP to perform finding the largest number in an array.	K5
5.10	Ascending and Descending order	Develop an 8051 ALP to arrange the given set of numbers in ascending/	K5

		descending order	
5.11	LCD Interfacing,	Develop an 8051 ALP to interface LCD	K5
5.12	Temperature controller	Explain the interfacing of temperature sensor with 8051 and develop an ALP for the same.	K5

4. MAPPING SCHEME (PO, PSO& CO)

P21 PH3 08	PO									PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO 1	PSO 2	PSO 3	PSO 4
CO1	H	M	L	-	L	L	-	-	-	H	H	M	L
CO2	M	H	L	H	M	H	L	-	-	H	H	M	L
CO3	L	L	H	L	M	H	H	-	-	H	H	L	M
CO4	M	M	H	H	L	M	M	-	-	H	H	H	H
CO5	M	M	M	H	H	H	H	-	-	H	H	H	H
CO6	L	L	M	M	H	H	H	-	-	H	H	H	H

L-LowM-Moderate H-High

5. COURSEASSESSMENTMETHODS

Direct

1. Continuous Internal Assessment Tests I & II
2. Model Exam
3. Open book test, Assignment, Quiz, Seminar,GroupPresentation, Poster preparation, Problem solving etc.
4. End Semester Examination

Indirect

1.Course-endsurvey

Course Co-ordinator: Mrs. A. Anitha

ELECTIVE-IV: NUCLEAR PHYSICS

SEMESTER: III **CODE: P21PH3:4**

CREDITS: 5 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After successful completion of the course, students are able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Explain the constituents and stability of nucleus, nuclear models and nuclear forces.	**K2**	**1**
CO2	Evaluate the energy released during nuclear fission and fusion reactions and study the construction of nuclear reactors.	**K5**	**2**
CO3	Explain the theory and applications of various radioactive decays.	**K5**	**3**
CO4	Categorize various principle of particle detector.	**K4**	**3**
CO5	Classify the nuclear reaction and account for its energetics.	**K4**	**4**
CO6	Analyze the elementary constituents of a nucleon based on several theories and laws of conservation.	**K4**	**5**

2. A. SYLLABUS

Unit-I: Nuclear Structure **(12 Hours)**

Basic nuclear properties: size, shape, charge distribution, mass, spin, parity and magnetic moment – Binding energy – Semi empirical mass formula – Nuclear shell model – Liquid drop model – optical model – collective model. Nuclear force – Exchange force – Yukawa's meson theory – Ground state of deuteron – Scattering ideas – Low energy n–p scattering: phase shift, scattering length – spin dependence and charge independence of nuclear forces

Unit-II: Nuclear Fission and Fusion **(12Hours)**

Characteristics of fission – Mass and energy distribution of nuclear fragments – Nuclear chain reaction – Four factor formula – Bohr Wheeler's theory – Atom bomb - Fission reactor – power and breeder reactors – Fusion processes – Solar fusion – controlled thermonuclear reactions – stellar energy – evolution and life cycle of a star.

Unit-III: Radioactive Decays **(12Hours)**

Alpha decay – Gamow's theory – Geiger-Nuttal law – Neutrino hypothesis – Fermi's theory of beta decay – Non–conservation of parity in beta decay – Gamma decay – Internal Conversion – Nuclear isomerism – Basic principles of particle detectors – Ionization chamber – Proportional counter – Geiger–Muller Counter – BF_3 counter – Scintillation Counter – Solid state detector – junction diode detectors – nuclear radiation hazards – safe limits – disposal of nuclear wastes.

Unit-IV: Nuclear Reaction **(12Hours)**

Types of Nuclear reactions - Energetics of reactions – Q equation – Nuclear reaction cross section – Partial wave analysis – Level width – Compound nucleus model – Breit-Wigner one level formula – Direct reactions – Theory of Stripping and pick-up reactions

Unit-V:Elementary Particles **(12Hours)**

Types of interactions and classification of elementary particles – Quantum numbers (charge, spin, parity, isospin, strangeness, hypercharge) – Gell-Mann-Nishijima formula – Baryons – Leptons – Invariance principle and symmetries – Invariance under charge, parity, time reversal (CPT) – CP violation in neutral K-meson decay – Quark model – SU(2) and SU(3) symmetry – Types of quarks and their quantum numbers – Gell-Mann and Okubo mass formula.

B. TOPICS FOR SELF STUDY

1. **Alpha Particles**
   https://www.youtube.com/watch?v=cPRFF-eCGT8
2. **Exotic Nuclei**
   https://www.youtube.com/watch?v=Bfh9bURKcJk
3. **Atomic Nucleus**
   https://www.youtube.com/watch?v=qQ5FfYMTql4
4. **Symmetry**
   https://www.youtube.com/watch?v=fYGxNucvfR4

C. TEXT BOOKS

1. D.C Tayal, Nuclear physics, Himalaya Publishing House, New Delhi, 2011.
2. S.N. Ghoshal, Nuclear Physics, S. Chand and Co., New Delhi, 2003.
3. V. Devanathan, Nuclear Physics, Narosa publishing house, New Delhi, 2008

D. REFERENCE BOOKS

1. R.R. Roy and B.P. Nigam, Nuclear Physics theory and experiment, New Age International, NewDelhi,1991.

2. ArtherBeiser, Concepts of Modern Physics, 5th Edition, Mc.Graw Hill, Inc. New York, 1995.

E. WEBLINKS

1. https://nptel.ac.in/courses/115/103/115103101/
2. https://onlinecourses.nptel.ac.in/noc21_ph26/preview

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit / Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
I	**Nuclear Structure**		
1.1	Basic nuclear properties: size, shape, charge distribution, mass, spin, parity and magnetic moment	Account for the stability of the nucleus based on magic numbers.	**K4**
1.2	Binding energy, Semi empirical mass formula	Analyze the various constituent energies in accounting for the total Binding energy of a nucleus.	**K4**
1.3	Nuclear shell model, Liquid drop model, optical model, collective model	Explain various models for nucleus.	**K5**
1.4	Nuclear force	Explain characteristics of nuclear forces	**K2**
1.5	Properties of Deuteron	Derive the bounded state of deuteron	**K5**
		Justify why deuteron does not exist in excited state	**K5**
1.4	Scattering ideas	Explain n-p scattering based on partial wave analysis.	**K5**
		Discuss nuclear scattering phase shift with energy.	**K6**
II	**Nuclear Fission and Fusion**		
2.1	Characteristics of fission	Summarize the characteristics of nuclear fission	**K2**
2.2	Mass and energy distribution of nuclear fragments.	Evaluate the mass and energy distribution between nuclear fragments during fission	**K5**
2.3	Nuclear chain reaction	Analyze the conditions for	**K4**

		nuclear fission reaction.	
		Explain the nuclear chain reaction	**K2**
2.4	Four factor formula.	Derive four factors formula for nuclear chain reaction	**K5**
2.5	Bohr Wheeler's theory	Elaborate on Bohr Wheeler's Theory to find address nuclear fission.	**K6**
2.6	Atom bomb	Explain the principle behind Atom Bomb	**K2**
		Explain the working of atom bomb by using nuclear fission process	**K5**
2.6	Fission reactor – power and breeder reactors	State the applications of nuclear fission.	**K2**
		Explain the fission process in Breeder and Power Reactors.	**K2**
		Address the role of nuclear fission in power production.	**K3**
2.7	Fusion processes	Outline the nuclear fusion process.	**K2**
2.8	Solar fusion	Analyse the source of solar energy on the basis of nuclear reaction.	**K4**
2.9	Controlled thermonuclear reactions	Explain how nuclear fusion reactions can be realized at the laboratory scale	**K2**
		Elaborate on controlled thermonuclear reactions	**K6**
2.10	Stellar energy – evolution and life cycle of a star	Outline the life cycle and evolution of the star	**K2**
III	**Nuclear Disintegration**		
3.1	Alpha decay – Gamow's theory, Geiger-Nuttal law	Classify alpha, Beta and gamma particles	**K4**
		Analyze how tunnel effect is applied on Gamow's theory using Alpha decay	**K4**

		Explain Geiger-Nuttal law	**K2**
		Evaluate an expression for decay probability according to Gamow's theory.	**K5**
3.2	Neutrino hypothesis, Fermi's theory of beta decay.	Assess the controversies in beta decay	**K5**
		Explain Neutrino hypothesis	**K2**
		Account for the role of neutrino according to Fermi's theory of beta decay	**K4**
3.3	Non–conservation of parity in beta decay	Justify parity is not conserved in beta decay.	**K5**
3.4	Gamma decay, Internal Conversion, Nuclear isomerism	Outline the process of gamma decay and nuclear isomerism	**K2**
3.5	Basic principles of particle detectors	Summaries the principles of particle detectors	**K2**
3.6	Ionization chamber, Proportional counter, Geiger–Muller Counter, BF_3 counter, Scintillation Counter	Explain the principles of Geiger–Muller Counter	**K4**
		Analyze the merits and Demerits of BF_3 counter and Scintillation Counter	**K4**
3.5	Solid state detector – junction diode detectors	Analyze a simple detector system for identifying nuclear radiation.	**K4**
3.6	Nuclear radiation hazards, safe limits	Discuss nuclear radiation hazards and safe limits	**K2**
3.7	Disposal of nuclear wastes	Measures for the disposal of nuclear waste	**K5**
IV	**Nuclear Reactions**		
4.1	Types of Nuclear reactions	Classify the types of nuclear reactions	**K2**
4.2	Energetics of reactions, Q equation	Derive Q equation and interpret the reaction based on Q value	**K5**
4.3	Nuclear reaction cross section	Explain nuclear reaction cross section	**K2**
4.4	Partial wave analysis	Deduce total cross section of nucleus by partial wave analysis.	**K5**
4.5	Level width	Outline on level width in nuclear reaction	**K2**
4.6	Compound nucleus model	Explain the formation of compound nucleus model	**K2**

4.7	Breit-Wigner one level formula.	Estimate energy level of Compound nucleus by Breit-Wigner one level formula.	**K5**
4.8	Direct reactions Theory of Stripping and Pick-up reactions.	Explain direct reactions	**K2**
		Distinguish stripping and pickup reactions	**K4**
V	**Elementary Particles**		
5.1	Types of interactions	Summarize the types of interactions	**K2**
5.2	Classification of elementary particles – Quantum numbers (charge, spin, parity, isospin, strangeness, hypercharge)	Classify the elementary particles according to quantum numbers.	**K4**
5.3	Gell-Mann-Nishijima formula	Explain the critical condition of the electromagnetic field modes around a hadron.	**K2**
5.4	Baryons, Leptons, Invariance principle and symmetry	Distinguish Baryons and Leptons using invariance principles.	**K4**
5.5	Invariance under charge, parity, time reversal (CPT)	Justify that all interactions should be invariant under the combined application of charge conjugation parity and time reversal in any order.	**K5**
5.6	CP violation in neutral K-meson decay	Explain the violation of CP symmetry.	**K2**
5.7	Quark model	Classify hadrons in terms of their valence quarks.	**K4**
5.8	SU(2) and SU(3) symmetry.	Explain symmetries which accounts for the spin and interactions of quarks.	**K2**
5.9	Types of quarks and their quantum numbers	Describe quark and antiquark	**K2**
		Determine quantum numbers from quark composition.	**K5**
5.10	Gell-Mann and Okubo mass formula	Explain the sum rule for the masses of hadrons within a specific multiplet.	**K2**

4. MAPPING SCHEME (PO, PSO& CO)

P21PH 3:4	PO									PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	L	L	L	L	L	-	-	-	M	L	M	H	-
CO2	H	M	M	L	M	-	L	-		M	L	-	-
CO3	M	M	H	H	H	H	-	M	-	M	H	M	L
CO4	H	H	L	M	H	H	M	-	-	H	L	M	-
CO5	H	-	H	H	M	H	M	-	H	L	M	H	H
CO6	-	L	M	M	L	L	H	H	M	H	L	H	M

L-Low M-Moderate H-High

5. COURSE ASSESSMENT METHODS

Direct

1. ContinuousAssessmentTest(ModelExams) I, II
2. Openbooktest;Cooperativelearningreport,Assignment,Seminar,GroupPresentation, Project report, Poster preparation, Problem solving etc.
3. EndSemesterExamination

Indirect

1.Course-endsurvey

Course Co-ordinator: Mr. A. VeeraPandian

ELECTIVE-IV: RADIATION PHYSICS

SEMESTER: III **CODE:P21PH3:A**

CREDITS:5 **NO. OFHOURS/WEEK:6**

1. COURSE OUTCOMES (CO)

After the completion of this course the students will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Explain the fundamental concepts of atomic physics and nuclear transformation.	**K2**	**I**
CO2	Explain the different interaction mechanism of radiation with matter.	**K3**	**II**
CO3	Understand the various dosimetric quantities and concepts.	**K1**	**III**
CO4	Analyze the interaction of charged particles and radiation with matter.	**K4**	**II & IV**
CO5	Evaluate the radiation interaction with matter using radiation monitoring instruments.	**K5**	**II,III& V**
CO6	Estimate the exposure of radiation &dosimetric quantities using various radiation detecting devices/dosimeters.	**K6**	**III & IV**

2. A. SYLLABUS

Unit-I: Atomic Physics and Nuclear Transformation (15 hours)

Structure of matter - atom - nucleus -atomic mass and energy units -distribution of orbital electrons - atomic energy levels -nuclear forces -nuclear energy levels- particle radiation - Binding energy - General properties of alpha, beta and gamma rays – modes of radioactive decay -nuclear reactions - natural and artificial radioactivity - reactor and cyclotron produced isotopes - fission products – fusion.

Unit-II: Interaction of Radiation with Matter (15 hours)

Interaction of electromagnetic radiation with matter, Thomson scattering, Rayleigh scattering, Compton scattering, Photoelectric absorption, Pair production – Interaction of light (electrons and positrons) and heavy charged particles with matter–specific ionization – Cerenkov radiation-mass-energy- attenuation and absorption coefficient - Bethe-Block formalism for energy loss by heavy charged particles, mass-collision – Bragg peak, mass-radioactive stopping power, range and path length of charged particles - Interaction of neutron with matter.

Unit-III: Dosimetric Quantities and Units (15 hours)

Introduction -Exposure-Roentgen - photon fluence and energy fluence -KERMA-Kerma and absorbed dose -CEMA -Absorbed dose - Radiation Dose Equivalent - stopping power - relationship between the dosimetric quantities - stopping power ratio.

Unit-IV: Principles of Radiation Detection and Dosimeters (15 hours)

Principles of Radiation detection – properties of dosimeters - Theory of gas filled detectors – Ion chamber dosimetry systems - free air ion chamber – parallel plate chamber - ionization chamber – proportional chamber - GM counter– thimble chambers working and different applications – film dosimetery- Luminescence dosimetry - TLD - OSLD - semiconductor dosimetry – Gel dosimetry – radiographic and radiochromic films – scintillation detections.

Unit-V: Radiation Monitoring Instruments (15 hours)

Introduction – operational quantities for Radiation monitoring – Area survey meters – Ionization chambers – proportional counters – neutron area survey meters – GM survey meters – scintillation detectors – Personal monitoring -Pocket Dosimeters– film badge – TLD – Properties of personal monitors.

B. TOPICS FOR SELF STUDY

Dental Radiography

https://www.sciencedirect.com/topics/medicine-and-dentistry/dental-radiography

https://www.slideshare.net/masurizvi/radiology-in-dentistry

Computed Tomography

https://www.nibib.nih.gov/science-education/science-topics/computed-tomography-ct

C. TEXT BOOKS

1. E.B.Podgorsak, Radiation Physics for Medical Physicists, 3rd Edition, Springer, 2016.

2. F.M.Khan, The Physics of Radiation Therapy, Fifth Edition, Lippincott W il l ia m s and Wilkins, U.S.A.,2015.

3. W. J. Meredith and J. B. Massey, Fundamental Physics of Radiology, John Wright and Sons, U. K., 2000.

D. REFERENCE BOOKS

1. H. E. Johns, J. R. Cunningham, The Physics of Radiology, Charles C. Thomas, New York, 2002

2. Frank Herbert Attix, Introduction to Radiological Physics and Radiation Dosimetry, Wiley-VCH Verlag, 2007.

3. Donald T. Graham, Paul J. Cloke, Principles of Radiological Physics, Churchill Livingstone, 2003.

E. WEBLINKS

https://www-pub.iaea.org/mtcd/publications/pdf/pub1564webnew-74666420.pdf

3.SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Atomic Physics and Nuclear Transformation**		
1.1	Structure of matter – atom – nucleus	Explain structure of atom and nucleus	**K2**
1.2	Atomic mass and energy units	Explain atomic mass and energy units	**K2**
1.3	Distribution of orbital electrons	Demonstrate the distribution of electrons in orbitals	**K3**
1.4	Atomic energy levels	Examine the energy levels of an atom	**K2**
1.5	Nuclear forces	Deduce an expression for nuclear forces	**K5**
1.6	Nuclear energy levels	Deduce an expression for nuclear energy levels	**K5**
1.7	Particle radiation	Explain the concept of particle radiation	**K4**
1.8	Binding Energy	Estimate the binding energy	**K5**
1.9	General properties of alpha, beta and gamma rays	Explain the general properties of alpha, beta and gamma rays	**K3**
1.10	Nuclear reactions	List and explain the types of nuclear reactions	**K3**
1.11	Natural and artificial radioactivity	Explain natural and artificial radioactivity	**K3**
1.12	Reactor and cyclotron produced isotopes	Explain the reactor and cyclotron produced isotopes	**K4**
1.13	Fission	Define fission	**K1**
1.14	Fusion products	Define fusion	**K1**
II	**Interaction of Radiation With Matter**		
2.1	Interaction of electromagnetic radiation with matter	Explain the interaction of electromagnetic radiation with matter	**K2**

2.2	Thomson scattering, Rayleigh scattering, Compton scattering	Analyse the interaction of radiation with matter using different scattering	**K4**
2.3	Photoelectric absorption	Explain photoelectric absorption	**K3**
2.4	Pair production	Define pair production	**K1**
2.5	Interaction of light (electrons and positrons) and heavy charged particles with matter	Analyze the interaction of light and heavily charged particles	**K4**
2.6	specific ionization	Define specific ionization	**K1**
2.7	Cerenkov radiation	Explain Cerenkov radiation	**K2**
2.8	attenuation and absorption coefficient	Define attenuation and absorption coefficient	**K1**
2.9	Bethe-Block formalism for energy loss by heavy charged particles	Estimate energy loss by heavy charged particles using Bethe-Block formalism	**K5**
2.10	mass-collision – Bragg peak, mass-radioactive stopping power, range and path length of charged particles	Define mass-collision, Bragg peak, mass, radioactive stopping power, range and path length of charged particles	**K1**
2.11	Interaction of neutron with matter	Analyze the interaction of neutron with matter.	**K4**
III	**Dosimetric Quantities and Units**		
3.1	Introduction	Illustrate Laws of electromagnetic induction	**K2**
3.2	Exposure	Define Exposure	**K1**
3.3	Roentgen	Define Roentgen	**K1**
3.4	photon fluence and energy fluence	Define photon fluence and energy fluence	**K1**
3.5	Kerma and absorbed dose	Define Kerma and absorbed dose	**K1**
3.6	CEMA- Absorbed dose	Explain CEMA and absorbed dose	**K3**
3.7	Radiation Dose Equivalent	Determine radiation dose equivalent	**K5**

3.8	stopping power	Define stopping power	**K1**
3.9	relationship between the dosimetric quantities	Obtain the relationship between dosimetric quantities	**K5**
3.10	stopping power ratio	Estimate stopping power ratio	**K6**
IV	**Principles of Radiation Detection and Dosimeters**		
4.1	Principles of Radiation detection	State principles of radiation detection	**K1**
4.2	properties of dosimeters	List the properties of dosimeters	**K2**
4.3	Theory of gas filled detectors	Explain the theory of gas filled detectors	**K3**
4.4	Ion chamber dosimetry systems	Estimate the absorbed radiation using Ion chamber dosimetry system	**K6**
4.5	free air ion chamber, parallel plate chamber, ionization chamber and proportional chamber	Estimate the intensity of radiation using different type of chamber	**K6**
4.6	GM counter	Detect & measure the ionizing radiation	**K5**
4.7	thimble chambers working and different applications	Determine the intensity of beam of radiation using thimble chambers	**K5**
4.8	film dosimetery- Luminescence dosimetry	Measure the exposure of radiation using film dosimetry and luminescence dosimetry	**K5**
4.9	TLD - OSLD	Explain the function of TLD and OSLD	**K4**
4.10	semiconductor dosimetry – Gel dosimetry	Estimate absorbed radiation dose using semiconductor dosimetry& Gel dosimetry	**K5**
4.11	radiographic and radiochromic films	Measure the radiation dose using radiographic and radiochromic films	**K5**
4.12	scintillation detections	Explain the principle scintillation detection	**K3**
V	**Radiation Monitoring Instruments**		
5.1	Introduction		**K1**

		Understand the basic of radiation monitoring instruments	
5.2	operational quantities for Radiation monitoring	Define the operational quantities for Radiation monitoring	**K1**
5.3	Area survey meters	Explain the working of Area survey meters	**K3**
5.4	Ionization chambers	Explain the principle and working of ionization chambers	**K3**
5.5	Proportional counters	How does a proportional counter used to measure particles of ionizing radiation	**K5**
5.6	neutron area survey meters	Evaluate radiation hazard using neutron area survey meters	**K5**
5.7	GM survey meters	Organize an experiment to detect radiation contamination using GM survey meters	**K5**
5.8	scintillation detectors	Explain the principle and working of scintillation detector	**K3**
5.9	Personal monitoring	Understand the principle of personal monitoring	**K1**
5.10	Pocket Dosimeters	Detect and measure exposure of radiation using pocket dosimeters	**K5**
5.11	film badge	Explain the measurement of exposure to ionizing radiation	**K4**
5.12	TLD	Explain how TLD is used to measure radiation exposure	**K4**
5.13	Properties of personal monitors	List the Properties of personal monitors	**K2**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH3:A	**PO**									**PSO**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO 1	-	L	M	-	M	M	L	-	M	H	M	M	M
CO 2	M	H	M	M	H	M	-	L	L	M	H	M	M
CO 3	L	M	H	M	M	M	L	-	L	M	H	H	L
CO 4	M	H	M	M	H	H	-	L	L	M	H	M	L

CO 5	M	H	L	M	H	M	L	-	M	M	H	M	M
CO 6	M	H	M	M	M	M	-	L	M	M	M	M	M

L-Low M-Moderate H- High

5. COURSEASSESSMENTMETHODS

Direct

1. ContinuousAssessmentTest(ModelExams) I,II
2. Openbooktest;Cooperativelearningreport,Assignment,Seminar,GroupPresentation, Project report, Poster preparation, Problem solving etc.
3. EndSemesterExamination

Indirect

1.Course-endsurvey

Course Co-ordinator: Mr. K. Karthikeyan

CORE- IX: QUANTUM MECHANICS – II

SEMESTER: IV **CODE:**

P21PH409

CREDITS: 5 NO. OF HOURS / WEEK: 6

1. COURSE OUTCOMES

After successful completion of the course, students are able to:

CO. NO.	Course Outcomes	Level	Unit Covered

CO1	Outline the notion, Dirac, ket-bra vectors, Hilbert space and representation of operators	**K2**	**I**
CO2	Interpretthe threepictures of quantum mechanics and analyze to Linear harmonic oscillator using Heisenberg pictures	**K5**	**I**
CO3	Deducethe eigenvalue spectrum for total angular momentumand to determine theClebsch Gordon (CG) Co–efficient	**K5**	**II**
CO4	Formulate the quantum theory of identical particles	**K5**	**III**
CO5	Justify the need for relativistic quantum theory and apply it to Klein-Gordan and Dirac equations.	**K5**	**IV**
CO6	Develop the second quantization procedure for quantum fields	**K6**	**V**

2. A. SYLLABUS

Unit-I: Matrix Formulation 15 Hours

The Hilbert space – Dirac's Bra and Ket vectors – Matrix representation – Representation of state vectors and operators – Hermitian operators and their properties – space and time displacements – The Schrödinger, Heisenberg and interaction pictures – Matrix theory of Linear harmonic oscillator.

Unit-II: Angular Momentum 15 Hours

The Eigenvalue spectrum of J^2 and J_z – matrix representation of J – Spin angular momentum – Pauli's spin matrices – spin or wavefunctions (S = ½ and 1) – Addition of angular momentum - Clebsch Gordon (CG) Co–efficients – Recursion relation of CG Co–efficient - Calculation of CG Co–efficients for J_1=1/2 and J_2 =1/2.

Unit-III: Identical Particles and Spin 15 Hours

System of identical particles - Distinguishability of identical particles – symmetric and antisymmetric wave functions –- Exchange degeneracy – Pauli's exclusion principle - relation between spin and statistics.

Many electron system – Central field approximation – Thomas Fermi statistical model – Hartee'sself consistent field.

Unit -IV: Relativistic Wave Mechanics 15 Hours

Klein-Gordon (KG) equation – free particle – KG equation in the presence of Electromagnetic field – The Dirac equation – Probability density and current densities – Dirac matrices – Plane wave solutions – Spin of Dirac particles – Negative energy states - Dirac's equation for a central field – Spin angular momentum – Spin orbit coupling.

Unit-V: Quantization of Fields **15 Hours**

Lagrangian formulation of classical field: Euler – Lagrange equations – Hamilton's formulation – Poisson brackets – Quantum field: Second quantization – the Klein-Gordon field – Non-relativistic Schrödinger field – Dirac field.

B. TOPICS FOR SELF STUDY

1. Dirac Delta function, representation in the continuous basis, P. M. Mathews and K. Venkatesan, A Text Book of Quantum Mechanics 2e, Tata McGrawHill, New Delhi, 2010.

2. SO (3), SO (2) and Euler Rotations inn Quantum Mechanics, Modern Quantum Mechanics, J.J. Sakurai, JIM Napolitano Addison Wesley New York 2011.

3. Spin correlation measurements and Bell's Inequality, Modern Quantum Mechanics, Sakurai, JIM Napolitano Addison Wesley New York 2011.

4. Quantum Entanglement, Basis of Quantum Computing, Quantum Mechanics, A.I.M. Rae, JIM Napolitano CRC Press New York 2016, Quantum Mechanics, L. Schiff, Tata McGraw Hill, New Delhi, 2010.

C. TEXT BOOKS

1. P. M. Mathews and K. Venkatesan, A Text Book of Quantum Mechanics 2e, Tata McGrawHill, New Delhi, 2010.
2. L. Schiff, Quantum Mechanics 3e, Tata McGraw Hill, New Delhi, 2010.
3. V. K. Thankappan, Quantum Mechanics 2e, Wiley–Eastern, New Delhi, 2003.
4. Amitabha Lahiri and P.B. Pal, A First Book of Quantum Field Theory, Narosa Book Distributors Pvt. Ltd., New Delhi, 2005.

D. REFERENCEBOOKS

1. Richard L. Liboff, Introductory Quantum Mechanics, (4th Edition) Addison Wesley, New York, 2003.

2. Jasprit Singh, Quantum Mechanics: Fundamentals and Applications to Technology, John Wiley, New York, 2004.
3. AmitGoswami, Quantum Mechanics 2e, Waveland Press, 2003.
4. V. Devanathan, Quantum Mechanics, Narosa Publishing House, 2005.
5. S. Rajasekar and R. Velusamy, Advanced Topics in Quantum Mechanics, CRC Press, 2015.

E. WEBLINKS

1. https://ocw.mit.edu/courses/physics/
2. https://ocw.mit.edu/courses/physics/8-05-quantum-physics-ii-fall-2013/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit	CourseContent	LearningOutcomes	HighestBloom's Taxonomic levelof transaction
I	**Matrix Formulation**		
1.1	The Hilbert space	Recall the vector spaces. Study inner product space	**K1**
1.2	Dirac's Bra and Ket vectors	Description of Dirac's Bra vectors	**K2**
1.3	Representation of state vectors and operators	Formulate the matrix representation of State vector and operators	**K2**
1.4	Hermitian operators and their properties	Outline the Properties of Hermitian operators	**K2**
1.5	Space and Time displacements	Construct the unitary operator for and space Time and displacements	**K3**
1.6	The Schrödinger pictures	Interpret the Schrödinger pictures	**K5**
1.7	Heisenberg pictures	Interpret the Heisenberg pictures	**K5**
1.8	Interaction pictures	Interpret the Interaction pictures	**K5**
1.9	Matrix theory of Linear harmonic oscillator	Apply the matrix theory to analyse the quantum Linear harmonic oscillator	**K5**

II	**Angular Momentum**		
2.1	The Eigenvalue spectrum of J^2 and J_z	Solve the eigen value problem for total angular momentum operator	**K3**
2.2	Matrix representation of J	Deduce the Matrix representation of total angular momentum	**K5**
2.3	Spin angular momentum	Derive the matrix for spin angular momentum operator	**K5**
2.4	Pauli's spin matrices	Construct the spin or wavefunction	**K2**
2.5	Spinorwavefunctions (S = ½ and 1)		
2.6	Addition of angular momentum	Formulation of additional angular momentum	**K5**
2.7	Clebsch Gordon (CG) Co–efficients		
2.8	Recursion relation of CG Co–efficient		
2.9	Calculation of CG Co–efficients for J_1=1/2 and J_2 =1/2	Determine CG Co–efficients for J_1=1/2 and J_2 =1/2	**K5**
III	**Identical Particles and Spin**		
3.1	System of identical particles	Formulation of identical particle	**K5**
3.2	Distinguishability of identical particles	Explain the concepts of distinguishability	**K2**
3.3	symmetric and antisymmetric wave functions	Construct symmetric and antisymmetric wave functions	**K5**
3.4	Relation between spin and statistics	Establish Connection between spin and statistics	**K5**
3.5	Exchange degeneracy	Outline the Exchange degeneracy of it particle	**K1**
3.6	Pauli's exclusion principle.	Explain the Pauli's exclusion principle.	**K3**
3.7	Central field approximation	Summarise Central field approximation	**K2**
3.8	Thomas Fermi statistical model	Apply Thomas Fermi statistical model to study many electron system	**K4**

3.9	Hartee’s self-consistent field	Analyse many electron systems using Hartee’s self-consistent field theory	**K4**
IV	**Relativistic Wave Mechanics**		
4.1	Klein-Gordon (KG) equation Free particle	Derive Klein-Gordon (KG) equation Free particle	**K2**
4.2	KG equation in the presence of Electromagnetic field	Solve KG equation	**K3**
4.3	The Dirac equation	Deduce Dirac Hamiltonian	**K5**
4.4	Probability density and current densities	ObtainProbability density and current densities	**K2**
4.5	Dirac matrices	Construct the Dirac matrices and study its properties	**K5**
4.6	Plane wave solutions	Solve Dirac equation	**K3**
4.7	Spin of Dirac particles	Describes Spin of Dirac particles	**K2**
4.8	Negative energy states	Explain negative energy states.	**K5**
4.9	Dirac's equation for a central field	Discuss the influence of central field in Dirac's equations in a	**K5**
4.10	Spin angular momentum	Analyze the momentum of Relativistic particle in the presence of magnetic field	**K4**
4.11	Spin orbit coupling.	Explain the spin orbit interaction in the presence of a central potential.	**K2**
V	**Quantization of Fields**		
5.1	Lagrange equations	Derive Euler Lagrange equations for a classical	**K3**
5.2	Hamilton’s formulation	Develop Hamilton’s formulation for classical field	**K3**
5.3	Poisson brackets	Outline the Poisson bracket study for the Classical field	**K2**
5.4	Quantum field: Second quantization	Description of Second quantization	**K2**
5.5	The Klein-Gordon field	Develop the second Quantization procedure toKlein-Gordon field	**K6**
5.6	Non-relativistic Schrödinger field	Elaborate the quantization of Non-relativistic Schrödinger equation	**K6**
5.7	Dirac field.	Formulate the quantum theory for Dirac field	**K6**

4. MAPPING SCHEME (PO, PSO& CO)

P21PH409	PO									PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO 1	PSO 2	PSO3	PSO4
CO1	H	M	L	L	H	L	M	L	L	M	L	L	M
CO2	H	M	L	L	H	L	M	L	L	H	L	L	M
CO3	H	H	L	L	H	L	M	L	L	H	L	L	H
CO4	H	M	L	L	M	L	M	L	L	H	L	L	M
CO5	H	M	M	L	H	L	M	L	L	H	L	L	L
CO6	M	H	M	M	H	L	M	L	L	M	L	L	H

L – Low M – Medium H-High

5.COURSEASSESSMENTMETHODS

Direct

1. Continuous Assessment Test I & II
2. Open book test; Cooperative learning report, Assignment; Journal paper review, Group Presentation, Project report, Poster preparation, Prototype or Product Demonstration etc. (as applicable)
3. End Semester Examination

Indirect

1. Course-end survey

Course Co-ordinator: Mr. V. Antony Raj

CORE-X: SOLID STATE PHYSICS – II

SEMESTER: IV **CODE: P21PH410**

CREDITS: 5 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course the students will be able to:

CO. NO.	Course Outcomes	Level	Unit
CO1	Explain the fundamental theories to explain the behavior of dielectric and ferroelectric materials	**K2**	**I**
CO2	Explain the properties, theories and applications of superconductors	**K2**	**IV**
CO3	Apply the band structure theory to study the optical behavior of conductors, semiconductors and insulators	**K3**	**V**
CO4	Interpret the phase changes and related properties in magnetic, ferroelectric and superconducting materials	**K5**	**I,II&IV**
CO5	Assess the temperature dependent spontaneous magnetization and dispersion relations of magnons in ferromagnetic and antiferromagnetic materials	**K5**	**III**
CO6	Analyze the origin for non-linear optical properties of materials based on crystal symmetry	**K4**	**V**

2. A. SYLLABUS

Unit -I: Dielectrics and Ferroelectrics (15 hours)

Macroscopic electric field – Local electric field in an atom – Dielectric constant and polarizability – ClausiusMossotti equation – Response and relaxation phenomenon – Ferro elastic crystals Polarization catastrophe – Landau theory of phase transition – Ferroelectric domains – Antiferroelectricity – Piezo electricity – crystal elasticity – Pyroelectricity.

Unit-II: Diamagnetism and Paramagnetism (15 hours)

Langevin's diamagnetism theory – quantum theory of diamagnetism – Langevin'sparamagnetism theory – quantum theory of Paramagnetism – Weiss theory – Hund's rule – Iron earth ions – Rare earth ions – crystal field splitting – cooling by isentropic demagnetization – paramagnetic susceptibility of conduction electrons – Kondo effect.

Unit-III: Ferromagnetism, Antiferromagnetism and Ferrimagnetism (15 hours)

Ferromagnetism – Curie point - Weiss theory of ferromagnetism – Temperature dependance of saturation magnetization – Hysteresis and ferromagnetic domain – Antiferromagnetism – Molecular field theory of antiferromgnetism - Susceptibility of antiferromagnetism below the Neel temperature – Ferrimagnetism – Magnons – Ferromagnetic magnons - Antiferromagnetic Magnons – Introduction to Magnetoresistance (GMR, CMR).

Unit-IV: Superconductivity (15 hours)

Occurrence of Superconductivity – properties- Meissner Effect – Energy gap – Isotope effect – Thermodynamics of superconducting transition – Type I & Type II Superconductors – Vortex state – London equation – BCS theory – Coherence Length – Flux quantization in a ring – single particle tunneling – Josephson Superconductor tunneling, AC and DC effect – Application of Superconductors – Superconducting Quantum Interference Device (SQUID) – Development of High Tc Superconductors.

Unit-V: Optical Properties of Materials (15 hours)

Optical absorption in metals, semiconductors and insulators – Band to band absorption - Luminescence – types – Photoluminescence: Activators – Materials - Excitation and emission spectra – Measurement system – Photoconductivity – Nonlinear polarization – Non-centro symmetric materials and second harmonic generation.

B. TOPICS FOR SELF STUDY

1. **Impedance spectroscopy in dielectrics**

https://www.youtube.com/watch?v=r5BC2_NvLaA

2. **Spintronics**

https://www.youtube.com/watch?v=N72g0CcKT3Y

3. **Magnetic levitation**

https://www.youtube.com/watch?v=RDvH76Cj-UY

4. **Z-scan technique**

https://www.youtube.com/watch?v=yMhNLLIYb5w

C. TEXT BOOKS

1. C. Kittel, Introduction to Solid State Physics, Wiley India Pvt. Ltd., New Delhi, 2013.

2. S. Gupta and V. Kumar, Solid State Physics, IX Edition, K Nath and Co, Meerut, 2017.

3. S. O. Pillai, Solid State Physics. New Age International (p) Limited, India, 2010.

4. Robert W. Boyd, Nonlinear Optics, Elsevier Science & Technology, 2008.

D. REFERENCE BOOKS

1. M. Ali Omar, Elementary Solid state physics: Principle and applications, Pearson Education Asia, 2002.
2. S.L. Kakani and C. Hemarajani, Solid State Physics, Sultan Chand & Sons, New Delhi, 1990.
3. Franc C. Grum and K.D. Mielenz, Measurement of Photoluminescence, Academic Press, 1982.
4. Geoffrey. New, Introduction to Nonlinear Optics, Cambridge University Press, 2011.
5. B.B Laud, Lasers and Non-linear Optics, New Age International Publishers Pvt. Ltd., New Delhi 2011.
6. V. Raghavan, Materials Science & Engineering, Prentice Hall, India, 2007.

E. WEB LINKS

1. https://nptel.ac.in/courses/115/103/115103039/
2. https://nptel.ac.in/courses/115/104/115104109/

3. SPECIFIC LEARNING OUTCOMES

Unit/ Section	Content	Learning Outcomes	Highest Bloom's TaxonomicLevel of Transaction
I	**Dielectrics and Ferroelectrics**		
1.1	Macroscopic electric field	Define the basic concepts of polarization, dielectric constant Explain macroscopic electric field	**K1** **K2**
1.2	Local electric field in an atom,	Evaluation of local field in an atom for cubic structured dielectric material	**K5**

1.3	Dielectric constant and polarizability.	Outline the experimental determination of dielectric constant of materials	**K2**
1.4	Classius -Mosotti equation	Inspect the relationship between dielectric constant of an insulator and the polarizability of atoms	**K4**
1.5	Response and relaxation phenomenon	Explain the anomalous dispersion of dielectric materials for different frequencies	**K2**
1.6	Ferro elastic crystals	Outline the properties of ferroelastic crystals	**K2**
1.7	Polarization catastrophe	Apply the concept of anharmonic restoring forces to explain polarization catastrophe	**K3**
1.8	Landau theory of phase transition	Classify the order of phase transition in ferroelectrics Deduce the relation for phase transition of ferroelectric crystals based on Latent heat, Gibb's Free energy	**K4** **K5**
1.9	Ferroelectric domains – AntiferroelectricityPiezo electricity crystal elasticity Pyroelectricity	Illustrate ferroelectric domains and antiferroelectricity Apply crystal symmetry operations to differentiate pyro and piezoelectric materials	**K2** **K3**
II	**Diamagnetism and Paramagnetism**		
2.1	Langevin's theory of diamagnetism	Recall the basic ideas of magnetic moment, susceptibility and Bohr magneton Evaluate and prove that magnetic susceptibility of diamagnetic materials is independent of temperature based on Langevin's classical theory	**K1** **K5**
2.2	Quantum theory of diamagnetism	Apply Larmor theorem and quantum theory to explain the susceptibility of diamagnets	**K3**
2.3	Langevin's theory of paramagnetism	Examine magnetic susceptibility of paramagnetic materials is dependent on temperature based on Langevin's classical theory	**K4**
2.4	Quantum theory of paramagnetism	Estimate the susceptibility of paramagnetic materials using quantum theory for low and high temperature	**K5**
2.5	Weiss theory of paramagnetism	Interpret the local molecular field and determine Langevin's and Brillouin function to explain the temperature dependent	**K5**

		paramagnetic susceptibility	
2.6	Hund's rule	Explain the steps to estimate the values of J in the light of Hund's rule	**K2**
2.7	Rare earth ions	Assess the magnetic moment and account for the validation in rare earth ions	**K2**
2.8	Iron earth ions	Justify the quenching of orbital angular momentum in iron group ions	**K5**
2.9	Crystal field splitting	Explain crystal field splitting Apply crystal field splitting and quenching of angular momentum to explain paramagnetism in iron group salts	**K5**
2.10	Paramagnetic susceptibility of conduction electrons	Apply quantum theory to explain paramagnetism of conduction electrons above the Fermi level	**K3**
2.11	Cooling by isentropic demagnetization	Analyze the thermodynamics of isentropic demagnetization in materials to achieve temperatures less than 1 mK	**K4**
2.12	Kondo effect	Explain the Kondo effect Interpret the reason for ρ_{min} at low temperature upon doping of magnetic impurities	**K5**
III	**Ferromagnetism, Antiferromagnetism and Ferrimagnetism**		
3.1	Ferromagnetism and Curie Point	Define curie point and Explain spontaneous magnetization	**K1**
3.2	Weiss theory -Temperature dependence on saturation magnetization of ferromagnetism	Analyze the temperature dependent saturation magnetization on the basis of Weiss theory	**K4**
3.3	Hysteresis and ferromagnetic domain	Explain Hysteresis Define retentivity and coercivity Classify the ferromagnetic materials on the basis of hysteresis loss Sketch the domain structure of ferromagnetic materials and illustrate B-H loop	**K2**
3.4	Antiferromagnetism, Molecular field theory of antiferromagnetism - Susceptibility of antiferromagnetism	Interpret the susceptibility of antiferromagnetic magnetic materials using molecular field theory	**K5**

3.5	Ferrimagnetism	Explain Ferrimagnetism	**K1**
3.6	Magnons: Ferromagnetic magnons and Antiferromagnetic magnons	Derive the dispersion relations of magnons in ferromagnetic and antiferromagnetic materials	**K4**
3.7	Introduction to magnetoresistance (GMR , CMR)	Explain GMR and CMR	**K2**
IV	**Superconductivity**		
4.1	Occurrence of Superconductivity	Recall the history of superconductors.	**K1**
4.2	Properties	Explain critical current and critical magnetic field. Mention the ways to destroy the superconducting state.	**K2**
4.3	Meissner effect	Explain Meissner effect Illustrate the Meissner effect with an experiment	**K2**
4.4	Type-I and Type-II superconductors Vortex state	Categorize different types of superconductors based on critical fields	**K4**
4.5	Energy gap and Isotope effect	Outline Energy gap and Isotope effect in superconductors	**K2**
4.6	Thermodynamics of superconducting transition	Analyze the variation of thermodynamic parameters upon superconductor phase transition	**K4**
4.7	London equations	Explain normal and superconducting electrons Derive London Equations and discuss its drawbacks Discuss the electrodynamics of superconducting transition Deduce an expression for penetration depth applying London equations	**K5**
4.8	BCS theory – coherence length	Explain Cooper pairs and coherence length Justify the role of phonons in the creation of Cooper pairs Inspect the formation of Cooper pairs according to BCS theory	**K5**
4.9	Flux quantization in a ring	Illustrate the flux quantization in a superconducting ring is the sum of external and internal field	**K2**
4.10	Single particle tunneling	Explain single particle tunneling effect across a junction	**K2**

4.11	Josephson Superconductor tunneling - AC effect	Estimate the frequency of alternating current developed for a dc potential drop across the junction	**K4**
4.12	Josephson Superconductor tunneling - DC effect	Analyze the current of superconducting pairs across the junction depends on the phase difference in DC josephson effect	**K4**
4.13	Superconducting quantum interface device (SQUID)	Apply Josephson effect to construct superconducting quantum interface device (SQUID)	**K3**
4.14	Development of High T_c Superconductors	Classify the superconductors based on critical temperature Analyze the newly reported compounds with high Tc values	**K4**
V	**Optical Properties of materials**		
5.1	Optical absorption in metals, semiconductors and insulators	Illustrate the interaction of light with solids.	**K2**
5.2	Band to Band absorption	Interpret the different band to band absorption in semiconductors	**K3**
5.3	Luminescence- Types	Classify the types of luminescence in solids	**K2**
5.4	Photoluminescence	Explain Photoluminescence Analyze the origin of excitation and emission in photoluminescence spectra	**K4**
5.5	Activators	Explain the role of activators in enhancing the luminescent property of solids	**K2**
5.6	Photoluminescence Measurement system	Explain the construction and working of the photoluminescence measurement system	**K2**
5.7	Excitation and Emission spectra	Apply band theory and Fermi Golden rule to study emission and excitation spectra in solids	**K3**
5.8	Photoconductivity	Explain photoconduction process in insulators	**K2**
5.9	Nonlinear polarization Non-centrosymmetric materials	Outline the process in Nonlinear optical crystals Classify non-linear optically active materials on the basis of symmetry	**K2**

5.10	Second Harmonic Generation	Analyze the optical harmonic generation of nonlinear crystals Compare the functionality of different nonlinear crystals exhibiting second harmonic generation for various applications	**K4**

4. MAPPING SCHEME (PO, PSO &CO)

P21PH410	**PO**									**PSO**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	M	M	H	H	L	H	H	L	L	H	M	M	M
CO2	H	M	M	L	L	L	M	L	L	H	M	L	M
CO3	H	M	M	L	L	M	M	L	L	H	L	M	L
CO4	H	L	L	L	M	H	H	L	L	H	M	M	M
CO5	M	M	M	L	M	L	L	L	L	H	M	L	L
CO6	L	L	L	L	L	L	L	L	L	H	L	L	M

L-Low M-Moderate H-High

5. COURSE ASSESSMENT METHODS

Direct

1. Continuous Assessment Test (Internal Exams) I,II
2. Open book test; Assignment, Seminar, Problem solving etc.
3. End Semester Examination

Indirect

1. Course-end survey

Course Co-ordinator: Dr. R. Venkatesh

ELECTIVE-V: CRYSTAL GROWTH, THINFILMS AND NANOSCIENCE

SEMESTER: V **CODE: P21PH4:5**

CREDITS: 4 **NO. OF HOURS/WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course the students will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Summarize the theory of nucleation and crystal growth.	**K2**	**I**
CO2	Explain thermodynamics and kinetics of thin film deposition process	**K2**	**I**
CO3	Classify the different crystal growth techniques and outline their principles.	**K4**	**II**
CO4	Contrast different thin film coating techniques.	**K4**	**III**
CO5	Infer the advantages and disadvantages of various synthesis techniques for nanomaterials.	**K4**	**IV**
CO6	Evaluate the physical parameters from various characterization techniques.	**K5**	**V**

2. A. SYLLABUS

Unit-I: Basics of Crystal Growth and Thin Film **(15 Hours)**

Nucleation – Different kinds of nucleation – Formation of crystal nucleus – Energy formation of a nucleus – Classical theory of nucleation - Gibbs Thomson equations for vapour and solution- spherical and cylindrical nucleus – Thin films –Thermodynamics of nucleation - Growth kinetics of Thin film – Crystal growth process in thin films - Epitaxial growth of thin films (basic concept only)

Unit-II: Crystal Growth Techniques **(15 Hours)**

Classification of crystal growth methods -Growth from low temperature solutions: Meir's solubility diagram – Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods - Basics of melt growth – Czochralski pulling method – Vernueil flame fusion method – Hydrothermal growth method. Growth by chemical vapour transport reaction: Transporting agents, Sealed capsule method, Open flow systems.

Unit-III: Thin Film Preparation Techniques (15 Hours)

Thin films – Introduction to vacuum technology – Deposition techniques - Physical methods – Resistance heating – Electron beam method - Sputtering – Reactive sputtering – RF sputtering - DC planar magnetron sputtering - Pulsed laser deposition – Chemical methods – Chemical bath deposition – Electrodeposition – Electro plating and Electroless plating – Deposition mechanisms - Spin and Dip coating –Spray pyrolysis deposition

Unit-IV: Synthesis of Nanomaterials (15 Hours)

Top-Down Approach, Grinding, Ball Milling, Melt mixing, Photolithography. Bottom-Up Approach, Wet Chemical Synthesis Methods, Micro emulsion Approach, Synthesis of metal & semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Sol Gel Methods, Microwave and Atomization, Gas phase Production Methods: Chemical Vapour Depositions.

Unit-V: Characterization Techniques (15 Hours)

Characterization using X-ray powder method - Single Crystal methods -Spectroscopic methods: FTIR, Raman, SEM, EDAX, U.V. Visible - Band gap energy calculation. Thermal properties: Thermogrametric analysis (TGA), Differential thermogram (DTA) and Differential Scanning Calorimetry (DSC) – Vicker micro hardness - Thin Film thickness measurement – Microbalance method – Optical interference method, Four probe method to determine film resistivity- Hall effect.

B. TOPICS FOR SELF STUDY

1. **Types of nucleation in thin films**
   https://nptel.ac.in/courses/113/104/113104075/

2. **Bridgman Technique**
   https://www.alineason.com/en/knowhow/crystal-growth/

3. **Molecular beamepitaxy**
   https://nptel.ac.in/content/storage2/courses/115103039/module16/lec38/5.html

4. **Applications of crystals, thin films and nanomaterials**
   https://nptel.ac.in/courses/104/106/104106093/
   https://nptel.ac.in/courses/118/102/118102003/
   https://www.youtube.com/watch?v=qK6yoptt9Is

C. TEXT BOOKS

1.P. SanthanaRaghavan and P. Ramasamy, Crystal Growth Processes and Methods, KRV Publication, Kumbakonam, 2001.

2.A. Goswami, Thin Film Fundamentals, New Age international (P) Ltd., New Delhi, 2013

3. C.P. Poole Jr. and Franck J. Ownes, Introduction to Nanotechnology, Wiley India Pvt Ltd, 2007.

4. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience and Nanotechnology, PHI Learning Pvt. Ltd., 2009.

5. H.H. Willard, L.L. Merritt, J.A. Dean and F.A. Settle, Instrumental Methods of Analysis 7e, CBS Publishers and Distributors, New Delhi, 1988

D. REFERENCE BOOKS

1. G. Dhanraj, K. Byrappa, V. Prasad, Michael Dudley (Eds.), Handbook of Crystal Growth, Springer Heidelberg Dordrecht London New York, 2010.
2. A.W. Vere, Crystal Growth: Principles and Progress, Plenum Press, New York, 1987.
3. M. Ohring, Materials Science of Thin Films: Deposition and Structure, 2e, Academic Press (An Imprint of Elsevier), 2002.
4. L. I. Maissel and R. Clang, Hand Book of Thin Films Technology, McGraw Hill, New York, 1970.
5. K. L. Chopra, Thin Film Phenomena, McGraw Hill, New York, 1990.
6. M. S. RamachandraRao and S. Singh, Nanoscience and Nanotechnology, Fundamentals to Frontiers, Wiley, 2013.
7. C.N.R. Rao, A. Muller and A. K. Cheetham (Eds.), The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley VCH VerlagGmbh&Co, Weinheim, 2004.

8. Kaufmann, Characterization of Materials, 2e, Wiley, 2003.

E. WEBLINKS

1. https://nptel.ac.in/content/storage2/courses/112108092/module2/lec08.pdf
2. https://nptel.ac.in/content/storage2/courses/103104045/pdf_version/lecture19.pdf
3. https://nptel.ac.in/courses/118/102/118102003/
4. https://nptel.ac.in/content/storage2/courses/118102003/downloads/module1.pdf

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic level of Transaction
I	**Basics of Crystal Growth and Thin Film**		
1.1	Nucleation	Explain the process of nucleation	**K2**
1.2	Different kinds of nucleation	Classify nucleation	**K2**
1.3	Formation of crystal nucleus	Explain the formation of nucleus	**K2**
1.4	Energy formation of a nucleus	Explain energy formation of a nucleus	**K2**
1.5	Classical theory of nucleation	Analyze the kinetics of nucleation.	**K2**
1.6	Gibbs Thomson equations for vapour and solution	Apply classical theory of nucleation to construct Gibbs Thomson equations for vapour and solution	**K3**
1.7	spherical and cylindrical nucleus	To deduce Gibbs Thomson equations for spherical and cylindrical nucleus	**K3**
1.8	Thin films	Define Thin Films	**K1**

1.9	Thermodynamics of nucleation	Outline the steps involved in nucleation on the basis of thermodynamics	**K2**
1.10	Growth kinetics of Thin film	Summarize the kinetics involved in thin film growth.	**K2**
1.11	Crystal growth process in thin films	Explain the crystal growth of thin films	**K2**
II	**Crystal Growth Techniques**		
2.1	Classification of crystal growth methods -	Classify the various methods of crystal growth	**K1**
2.2	Growth from low temperature solutions:	Elaborate on low temperature solution growth methods	**K4**
2.3	Meir's solubility diagram	Analyze Meir's solubility diagram	**K4**
2.4	Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods -	Explain solvent evaporation, slow cooling and temperature gradient methods of crystal growth	**K2**
2.5	Basics of melt growth	Outline the basics of melt growth	**K2**
2.5	Czochralski pulling method, Vernueil flame fusion method, Hydrothermal growth method.	Compare the experimental design and crystal growth by Czochralski, Vernueil and hydrothermal method	**K4**
2.6	Growth by chemical vapour transport reaction:	Explain chemical vapour transport reaction	**K2**
2.7	Transporting agents	List various transporting agents	**K1**
2.8	Sealed capsule method, Open flow systems.	Explain sealed capsule method and open flow systems.	**K2**
III	**Thin Film Preparation Techniques**		
3.1	Thin films	Classify thin films with reference to thickness	**K1**
3.2	Introduction to vacuum technology method.	Illustrate the method of vacuum technology	**K2**
3.3	Deposition techniques	Categorize various deposition techniques under physical and chemical methods	**K4**

3.4	Physical methods: Resistance heating, Electron beam method, Sputtering, Reactive sputtering, RF sputtering, DC planar magnetron sputtering, Pulsed laser deposition.	Explain the experimental design, coating process, advantages and limitations of various physical deposition methods	**K2**
3.5	Chemical methods: Chemical bath deposition, Electrodeposition, Electro plating and Electroless plating, Spin and Dip coating, Spray pyrolysis deposition.	Compare the experimental design, coating process, advantages and limitations of various physical deposition methods	**K2**
3.6	Physical/Chemical Methods	Contrast the difference between physical and chemical methods of thin film preparation technique	**K2**
IV	**Synthesis of Nanomaterials**		
4.1	Top-Down/Bottom-Up Approach	Classify Top-Down and bottom up approaches	**K2**
4.2	Grinding, Ball Milling, Melt mixing, Photolithography	Explain the design and synthesis of nanomaterial using various methods under Top-Down approach	**K2**
4.3	Wet Chemical Synthesis Methods, Micro emulsion Approach, Synthesis of metal & semiconductor nano particles by colloidal route, Langmuir-Blodgett method, Sol Gel Methods, Microwave and Atomization, Gas phase Production Methods: Chemical Vapour Depositions	Discuss the synthesisof nanomaterial using various methods under Bottom-Up approach	**K2**
V	**Characterization Techniques**		
5.1	Characterization using X-ray powder method - Single Crystal methods	Characterize the synthesized materials using powder and single crystal XRD	**K4**
5.2	Spectroscopic methods: FTIR, Raman, U.V. Visible - Band gap energy calculation.	Apply the knowledge of various spectroscopic techniques to characterize materials and calculate energy band gap value	**K3**

5.3	SEM, EDAX	Explain the experimental design and working of SEM and EDAX.	**K2**
5.4	Thermal properties: Thermo gravimetric analysis (TGA), Differential thermo gram (DTA) and Differential Scanning Calorimetry (DSC)	Apply various thermo gravimetric analysis to study the thermal properties	**K3**
5.5	Vicker's micro hardness	Explain micro hardness testing	**K2**
5.6	Thin Film thickness measurement – Microbalance method – Optical interference method	Measurement of thin film thickness by various methods	**K4**
5.7	Four probe method to determine film resistivity-	Determination of electrical properties by four probe method	**K4**
5.8	Hall effect.	Examine the magnetic properties by Hall effect	**K4**

4. MAPPING SCHEME (PO, PSO & CO)

P21PH4:5	PO									PSO			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO8**	**PSO9**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	L	L	-	L	-	-	-	L	L	M	M	L	L
CO2	L	L	-	L	-	L	-	L	L	M	M	M	M
CO3	H	L	M	H	L	L	M	L	M	M	H	M	H
CO4	H	L	M	H	M	L	M	L	L	H	H	M	M
CO5	H	L	H	H	M	M	M	L	M	H	H	H	H
CO6	H	H	H	H	H	H	M	L	M	H	H	H	H

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

Direct

1. Continuous Assessment Test (ModelExams) I,II
2. Slip Test/Surprise Test, Assignment, Quiz, Seminar, Group Presentation, Oral presentation,
Problem solving etc.
3. End Semester Examination

Indirect

1. Course-endsurvey

Course Co-ordinator: Mrs. H. Sirajunisha

ELECTIVE V: ASTROPHYSICS

SEMESTER: IV **CODE: P21PH4:A**

CREDITS: 4 NO. OF HOURS/WEEK: 6

1. COURSE OUTCOMES (CO)

After the completion of this course the students will be able to:

CO. NO.	Course Outcomes	Level	Unit Covered
CO1	Analyze the Positionsofstars, Propermotionsofstarsandplanets, All-SkySurveysandVirtualObservatories	**K4**	**I**
CO2	ExplainthePhysicalProcessesinthesolarsystem, FormationofPlanetarySystems, SearchforExtrasolarPlanets.	**K2**	**II**
CO3	Categorize the Spectralclassification,Stellarrotation,Stellar magneticfields,Starswithpeculiarspectra.	**K4**	**III**
CO4	Infer the characteristics of Interstellarextinctionandreddening.	**K4**	**IV**
CO5	Analyze thegalacticmagneticfieldandcosmicrays.	**K4**	**IV**
CO6	Estimate the kinematics,expansionofthe Universe,activegalaxies,clustersofgalaxies.	**K6**	**V**

2. A. SYLLABUS

Unit-I: CelestialMechanicsandAstrometry (15 hours)

ThecelestialSphere,Positionsofstars,Propermotionsofstarsandplanets,Distancesofnearbystars.

Tools ofAstronomy: Telescopes:BasicOptics,OpticalTelescopes,RadioTelescopes,Infrared,Ultraviolet,X-ray,andGamma-RayAstronomy–detectorsandobservatories GravitationalWavesdetectorsandNeutrinoDetectorsAll-SkySurveysandVirtualObservatories.

Unit-II: TheSolarSystem (15 hours)

TheSun,ThePhysicalProcessesinthesolarsystem,TheTerrestrial and the GiantPlanets,FormationofPlanetarySystems.

BasicStellarParameters:

Thebrightnessofthestars,Color-magnitudediagrams(TheHRdiagrams),Theluminositiesofthestars,Angularradiiofstars,Effectivetemperaturesofstars,Massesandradiiofstars:Binarystars,SearchforExtrasolarPlanets.

Unit-III: TheNatureofStars (15 hours)

Spectralclassification, understandingstellarspectra, populationIIstars,Stellarrotation,Stellar magneticfields,Starswithpeculiarspectra,Pulsatingstars,Explosivestars,Interstellarabsorption.

Unit-IV: OurGalaxyandTheInterstellar Matter (15 hours)

TheshapeandsizeofourGalaxy,Interstellarextinctionandreddening,Galacticcoordinates,Galacticrotation,Stellarpopulation,InterStellarMedium, thegalacticmagneticfieldandcosmicrays.

Unit-V: ExtragalacticAstronomy (15 hours)

NormalGalaxies-Morphologicalclassificationandkinematics,ExpansionoftheUniverse,Activegalaxies,Clustersofgalaxies,Large-scaledistributionofgalaxies,Gammaraybursts.

B. TOPICS FOR SELF STUDY

1. The Solar System
   https://youtu.be/P2nw2UWV-dU

2. Astrophysics & Cosmology - Video course

https://nptel.ac.in/courses/115/105/115105046/

C. TEXT BOOKS

1. T. Padmanabhan, Theoretical Astrophysics vols 1-3, Latest Edition, Cambridge University Press.
2. BW Carroll & DA Ostlie, An Introduction to Modern Astrophysics, Latest Edition, Addison-Wesley.
3. Frank Shu, The Physical Universe, Latest Edition, University Science Books
4. Martin Harwit, Astrophysical Concepts, Latest Edition, Springer.

D. REFERENCES BOOKS

1. IntroductiontoStellarAstrophysics,Volume**1,***Basicstellarobservationsanddata,*ByErikaBohm-Vitense, CambridgeUniversityPress
2. AnIntroductiontoModem Astrophysics, SecondEdition,ByCarrollB.W.,OstlieD.A.,PearsonAddisonWesley.
3. "AstrophysicsforPhysicists"byAmabRaiChaudhuri,CambridgeUniversityPress,2010
4. GalacticAstronomy:StructureandKinematicsbyMihalas&Binney,W.H.Freeman&CoLtd; 2ndRevisededition1981.

E. WEBLINKS

https://youtu.be/P2nw2UWV-dU

https://nptel.ac.in/courses/115/105/115105046/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	CourseContent	Learning Outcomes	Highest Blooms Taxonomic level of transaction
I	**CelestialMechanicsandAstrometry**		
1.1	ThecelestialSphere,Positionsofstars	Recollect the basic concepts celestialSphere,Positionsofstars.	**K2**
1.2	Propermotionsofstarsandplanets,Distancesofnearbystars.	Explain motionsofstarsandplanets	**K5**
1.3	Telescopes:BasicOptics,OpticalTelescopes	Explain the operation principle of the telescopes	**K2**

1.4	RadioTelescopes,Infrared,Ultraviolet,X-ray,andGamma-RayAstronomy	Illustrate the operational characteristics of RadioTelescopes,Infrared,Ultraviolet,X-ray,andGamma-RayAstronomy	**K5**
1.5	Detectorsand observatories GravitationalWavesdetectorsandNeutrino detectorsAll-SkySurveysandVirtualObservatories.	Explain the detectorsand observatories GravitationalWavesdetectorsandNeutrinodetectors.	**K2**
II	**TheSolarSystem**		
2.1	TheSun,ThePhysicalProcessesinthesolarsystem,TheTerrestrialandtheGiantPlanets, FormationofPlanetarySystems.	Explain the basics of thesolarsystem, TerrestrialandtheGiantPlanets	**K2**
2.2	Thebrightnessofthestars,Color-magnitudediagrams(TheHRdiagrams),	Explain the brightnessofthestars,Color-magnitudediagrams.	**K2**
2.3	Theluminositiesofthestars,Angularradiiof stars.	Analyze the luminositiesofthestars,Angularradiiofstars.	**K4**
2.4	Effectivetemperaturesofstars,	Explain the effectivetemperaturesofstars.	**K2**
2.5	Massesandradiiofstars:Binarystars,Search forExtrasolarPlanets	Analyze the massesandradiiofstars:binarystars	**K4**
III	**TheNatureofStars**		
3.1	Spectralclassification,Understandingstellar spectra	Summarize the Spectralclassification, Understandingstellarspectra	**K3**
3.2	Population II stars	Interpret the PopulationIIstars	**K5**
3.3	Stellarrotation,Stellar magnetic fields	Analyze the stellarrotation, s tellar magneticfields	**K4**
3.4	Starswithpeculiarspectra,Pulsatingstars,Explosivestars,Interstellarabsorption.	Outline the starswithpeculiarspectra,pulsatingstars,explosivestars,Interstellarabsorption	**K2**
IV	**OurGalaxyandTheInterstellar Matter**		
4.1	TheshapeandsizeofourGalaxy,	Classify the galaxy	**K2**
4.2	Interstellarextinctionand reddening	Illustrate the Interstellarextinctionandreddening	**K2**
4.3	Galacticcoordinates,Galacticrotation.	Calculate the Galacticcoordinates,Galacticrotation	**K3**

4.4	Stellarpopulation,InterStellarMedium,	Analyze the stellarpopulation,InterStellar Medium	**K4**
4.5	Thegalacticmagneticfieldandcosmicrays	Interpret thegalacticmagneticfieldandcosmicrays	**K5**
V	**ExtragalacticAstronomy**		
5.1	Normalgalaxies	Describe the Normalgalaxies	**K2**
5.2	Morphologicalclassificationandkinematics	Explain the Morphologicalclassificationandkinematics	**K2**
5.3	Expansionofthe Universe.	Explain the expansionofthe Universe	**K2**
5.4	Activegalaxies,Clustersofgalaxies,Large-scaledistributionofgalaxies	Revise the activegalaxies,clustersofgalaxies,large-scaledistributionofgalaxies	**K3**
5.5	Gammaraybursts.	Analyze the Gammaraybursts.	**K4**

4. MAPPING SCHEME (PO, PSO& CO)

P21PH4:A	PO									PSO			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	H	M	H	H	M	M	L	L	M	H	M	H	L
CO2	H	M	H	H	L	L	L	M	L	H	L	H	M
CO3	H	M	M	H	L	L	M	M	L	H	L	M	L
CO4	H	M	L	M	L	L	L	L	M	M	L	H	L
CO5	H	M	L	M	M	L	L	M	M	H	L	M	L
CO6	H	M	H	M	L	L	L	M	M	H	M	H	L

L-Low M-Moderate H- High

5. COURSEASSESSMENTMETHODS

Direct

4. Continuous Internal AssessmentTests I & II

5. Model Exam
6. Openbooktest, Assignment, Quiz, Seminar,GroupPresentation, Poster preparation, Problem solving etc.
7. EndSemesterExamination

Indirect

1. Course-endsurvey

Course Co-ordinator: Dr. P. MegavarnaEzhilarasu

MAJOR PRACTICALS - I

SEMESTER: I **CODE: P21PH1P1**

CREDITS: 3 **NO. OF HOURS/WEEK: 6**

1.COURSE OUTCOMES (CO)

After the successfulcompletion of this course the students will be able to:

CO.NO.	Course Outcomes	Level	Experiments Covered
CO1	Observe and study the mechanical, optical, thermal, magnetic, dielectric, electrical and electronic properties of various materials.	**K2 & K3**	**1,2,3,4,5 & 6**
CO2	Understand and explain various properties of materials and the modern equipment's used for investigation of the same.	**K2& K3**	
CO3	Determine and describe certain constants and coefficients and other properties of the various materials.	**K3 & K4**	**7,8 &9**
CO4	Analyze, Discuss, Calculate and Compare some properties at large and other related properties of the materials using various means and methods.	**K3 & K4**	**10**
CO5	Operate and optimize various mechanical, electrical, electronic and other modern equipment's used for characteristic analysis of materials.	**K4& K5**	**11, 12, 13 & 14**
CO6	Apply the various concepts learned to Design modern equipment's to perform characteristic analysis of materials and to support the Research and Development.	**K6**	**15, 16, 17 & 18**

2. SYLLABUS

List of Experiments

Any 15 of the following experiments

1. Four Probe method – Determination of resistivity of powdered sample
2. Determination of carrier concentration and Hall coefficients in semi-conductors
3. Determination of magnetic susceptibility of liquid by Gouys method
4. Determination of magnetic susceptibility of a solid in the form of a thin rod by Gouys method
5. Determination of magnetic susceptibility of liquid by Quincke's method
6. Determination of dielectric constant of a liquid by RF oscillator method
7. Determination of wavelength of monochromatic source using biprism
8. Determination of refractive index of liquids using biprism (by scale & telescope method)
9. Rydberg's constant using spectrometer
10. Determination of coefficient of coupling of AC bridge method
11. Forbe's method of determining thermal conductivity
12. "g" factor determining by using ESR spectrometer
13. Polarization of liquid – Hollow prism
14. Optical fiber – Determination of numerical aperture, acceptance angle and power loss
15. Determination of wavelength by using Michelson's interferometer
16. Determination of thickness of a film using Michelson's interferometer
17. Determination of wavelength of the laser source - Michelson Interferometer
18. Determination of thickness of glass plate - Michelson Interferometer

3. SPECIFIC LEARNING OUTCOMES (SLO)

Experiment No.	Course Content	Learning Outcomes	Highest Bloom's Level of Transaction
1	Four Probe method – Determination of resistivity of powdered sample	Determine the resistivity of a semiconductor for varying temperature.	**K2**
2	Determination of carrier concentration and Hall coefficients in semiconductors	Determine the Hall Coefficients of the semiconductor by varying the voltage and current.	**K3**

3	Determination of magnetic susceptibility of liquid by Gouys method	Observe and calculate the magnetic susceptibility value of the solid or liquid substance using Guoys balance by varying the magnetic field. Perform fine adjustments and measure precisely the minor differences in the weight of the substance under study.	**K4**
4	Determination of magnetic susceptibility of a solid in the form of a thin rod by Gouys method		
5	Determination of magnetic susceptibility of liquid by Quincke's method		
6	Determination of dielectric constant of a liquid by RF oscillator method	Determine the dielectric constant of the liquid substance by varying the RF.	**K3**
7	Determination of wavelength of monochromatic source using biprism	Determine the wavelength from the spectral lines formed using the monochromatic source with the help of the biprism and spectrometer. Determine the refractive index of the liquid substance with the same arrangement. Apply the concept of reflection and make precise adjustments for measurements.	**K5**
8	Determination of refractive index of liquids using biprism (by scale & telescope method)		
9	Rydberg's constant using spectrometer	Observe and calculate the Rydberg's constant from the spectral lines formed using hydrogen source.	**K4**
10	Determination of coefficient of coupling of AC bridge method	Apply Wheatstone's bridge concept to determine the Self and mutual induction of the coils.	**K4**
11	Forbe's method of determining thermal conductivity	Determine the thermalproperty of the material using forbes method by observing the temperature	**K5**
12	"g" factor determining by using ESR spectrometer	Determine the 'g' factor by forming and matching the spectral peaks observed using Cathode Ray Oscilloscope.	**K5**
13	Polarization of liquid – Hollow prism	Determine the polarization of liquid using hollow prism.	**K4**
14	Optical fiber – Determination of numerical aperture, acceptance angle and power loss	Observe, adjust and calculate the NA of the given fiber using laser source.	**K4**
15	Determination of wavelength by using Michelson's interferometer	Observe and calculate the wavelength of the monochromatic	**K6**

16	Determination of thickness of a film using Michelson's interferometer	source by performing fine adjustments of the mirrors in the Michelson Interferometer.	
17	Determination of wavelength of the laser source - Michelson Interferometer	Determine the thickness of the glass plate using hydrogen source along with the monochromatic source.	
18	Determination of thickness of glass plate - Michelson Interferometer	Determine the above said thing	

4. MAPPING SCHEME(PO,PSO&CO)

P21PH1P1	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	M	L	M	L	L	L	-	-	M	M	L	-
CO2	M	M	-	M	L	L	L	-	-	M	M	L	-
CO3	M	L	-	M	L	L	L	-	-	M	M	L	-
CO4	M	L	-	M	L	L	L	-	-	M	M	L	-
CO5	M	M	L	M	L	L	L	-	-	M	M	L	L
CO6	H	M	M	M	L	L	L	L	M	M	M	L	M

L- Low M-Moderate H-High

5. COURSE ASSESSMENT METHODS

Direct

1.Continuous Assessment Test (Model Practical Exams)
2. Record, Assignment, Problem solving, Design new circuits and set up, Skill Assessment etc.,
3. End Semester Examination

Indirect

1. Course-end survey

Course- coordinator: Mr. A. Veerapandian

MAJOR PRACTICAL – II

SEMESTER: II **CODE: P21PH2P2**

CREDITS: 3 **NO. OF HOURS/ WEEK: 6**

1. COURSE OUTCOMES (CO)

After the successful completion of this course the student will be able to:

CO. NO.	Course Outcomes	Level	Experiment covered
CO1	Test the charge and mass ratio using various experimental methods.	**K2**	**1,2,5,6**
CO2	Construct the circuits and verify characteristics of given electronic components.	**K3**	**1-16**
CO3	Examine the function of semiconductor switching devices (Thyristors).	**K4**	**15,16,17**
CO4	Measure Young's modulus, Numerical aperture, Thermal conductivity and energy loss of various materials.	**K5**	**1-7, 14**
CO5	Determine physical constants such as specific charge of electron, Stefan's constant and Planck's constant.	**K5**	**3, 5, 6,7**
CO6	Construct amplifier, oscillator circuits and analyze their frequency responses.	**K6**	**8, 9, 10, 11, 12, 13, 18**

2. SYLLABUS

List of Experiments

General Experiments

1. Determination of q, n, σ by elliptical fringes method.
2. Determination of q, n, σ by hyperbolic fringes method.
3. Determination of Stefan's constant.
4. B-H loop – Energy loss of a magnetic material – Anchor ring using B.G.
5. Determination of e/m of an electron by magnetron method.
6. Determination of e/m of an electron by Thomson's method.
7. Photoelectric effect - determination of Planck's constant.

Electronics Experiments

8. Study of feedback amplifier – Determination of bandwidth, input and output impedances.
9. Design and study of monostablemultivibrator.

10. Design and study of phase shift oscillator.
11. Characteristics of UJT and UJT relaxation oscillator.
12. FET oscillator.
13. Darlington pair amplifier.
14. Characteristics of LDR.
15. Characteristics of SCR.
16. Characteristics of DIAC.
17. Characteristics of TRIAC.
18. Frequency divider using IC 555.

3. SPECIFIC LEARNING OUTCOMES (SLO)

Experiment No.	Course Content	LearningOutcomes	Highest Bloom'sTaxonomiclevelof transaction
1	Determination of q, n, σ by elliptical fringes method.	Estimate the Young's modulus, Poison's ratio and Rigidity modulus of the glass material by applying cornus method.	**K2**
2	Determination of q, n, σ by hyperbolic fringes method.	Estimate the Young's modulus, Poison's ratio and Rigidity modulus of the glass material by applying cornus method.	**K2**
3	Determination of Stefan's constant.	Calculate the following physical constants. (a) Stefan's constant (b) Specific charge of electron (c) Planck's constant	**K4**
4	Determination of e/m of an electron by magnetron method.		**K4**
5	Determination of e/m of an electron by Thomson's method.		**K4**
6	Photoelectric effect - determination of Planck's constant.		**K4**
7	BH loop – Energy loss of a magnetic material – Anchor ring using B.G.	Discuss the energy loss of a magnetic material	**K3**
8	Study of feedback amplifier – Determination of bandwidth, input and output impedances.	Design and construct the amplifier and analyze its frequency response.	**K5**
9	Design and study of	Design and construct the	**K5**

	monostablemultivibrator.	monostablemultivibrator and measure the pulse width.	
10	Design and study of phase shift oscillator.	Design the RC circuit and analyze the phase shift of sine wave.	**K6**
11	Characteristics of UJT and UJT relaxation oscillator.	Analyze the characteristics of UJT and construct the relaxation oscillator.	**K5**
12	Frequency divider using IC 555	Construct the circuit to reduce the frequency.	**K5**
13	Characteristics of SCR	Investigate the voltage current characteristics of unidirectional solid-state device.	**K6**
14	Characteristics of DIAC	Investigate the voltage current characteristics of bidirectional solid-state devices and analyze the switching ability.	**K6**
15	Characteristics of TRIAC		**K6**
16	Characteristics of LDR	Investigate the spectral response of Light dependent resistor.	**K6**

4.MAPPING SCHEME (PO, PSO& CO)

P21PH2P2	**PO**									**PSO**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	H	M	H	H	M	-	L	-	-	H	-	M	-
CO2	H	-	M	-	M	-	-	-	-	H	M	-	M
CO3	H	-	M	L	-	-	-	-	-	H	-	M	-
CO4	H	L	-	M	L	-	-	M	L	H	L	H	-
CO5	H	-	M	M	-	-	-	-	-	H	-	-	L
CO6	H	M	H	-	-	H	-	M	M	-	M	-	L

L- Low **M-Moderate** **H-High**

5. COURSE ASSESMENT METHODS

Direct

1. Record and Observation Evaluation
2. Continuous Assessment (Minimum Two)
3. End Semester Practical Examinations

In-Direct

1. Assignments

2. Laboratory / Field visits
3. Course end survey/Feedbacks

Course-coordinator: Mr. A. Veerapandian

MAJOR PRACTICAL– III

SEMESTER: III **CODE: P21PH3P3**

CREDITS: 3 **NO. OF HOURS /WEEK:6**

1. **COURSE OUTCOMES (CO)**

After the successful completion of this course the students will be able to:

CO. NO.	Course Outcomes	Level	Experiment Covered
CO1	Construct the OPAMP circuits and study characteristics and responses of circuits.	**K3**	**1,2,3,4,5.**
CO2	Apply the concepts of operational amplifier to solve differential and simultaneous equations.	**K2**	**6**
CO3	Construct the circuits and verify the characteristics of non-linearity and modulation -demodulation.	**K4**	**7,8,9,10**
CO4	Make use of light to determine the physical properties of materials, Measure dielectric properties of solid and liquid materials.	**K5**	**11,12,13,14.**
CO5	Develop thin film and study the physical properties of prepared materials.	**K5**	**15,16,17**
CO6	Determine magnetic properties of materials.	**K5**	**18,19**

2. **SYLLABUS**

List of Experiments

Analog

1. Characteristics of Op-amp, open loop differential gain, output resistance, CMRR and frequency response.
2. Op-amp low pass, high pass, band pass and active filters.
3. Op-amp Integrator and differentiator.
4. Op-amp sine, square, triangular and ramp wave generator.
5. Op-amp Log and antilog and second order transfer function amplifier.
6. Op-amp solving simultaneous equations.
7. D/A Conversion R-2R and weighted resistor network – to determine the resolution, linearity and accuracy.
8. Modulation – demodulation.

9. Characteristics of Chua diode. Chaotic dynamics of Chua diode.

10. Nonlinear exhibited by Colpitts oscillator and Wein bridge oscillator

Material Science Lab

11. Linear Optical studies – UV – Visible Studies (absorbance and optical bandgap)

12. Dielectric studies using microwave– parameters of a liquid.

13. Dielectric studies using microwave – parameters of a solid.

14. Thin film preparation by dip coating – measurement of thickness.

15. Electrical properties of thin film – Calculation of activation energy by Resistance variation with temperature. (Two probe).

16. X-ray diffraction analysis – D, İ, N and į.

17. Gas sensing properties of a thin film.

18. Susceptibility of a material by Hysteresis.

19. Zeeman effect.

3. SPECIFIC LEARNING OUTCOMES(SLO)

<table>
<tr><th>Experiment No.</th><th>Course Content</th><th>LearningOutcomes</th><th>Highest Bloom’s Taxonomic levelof transaction</th></tr>
<tr><td>1</td><td>Characteristics of Op-amp, open loop differential gain, output resistance, CMRR and frequency response.</td><td rowspan="2">Prove the characteristics of Op-Amp gain, output resistance, CMMR and frequency response.
Analyze the low pass, high pass and band pass active filter using OP-Amp.</td><td>K5</td></tr>
<tr><td>2</td><td>Op-amp low pass, high pass, band pass and active filters.</td><td>K4</td></tr>
<tr><td>3</td><td>Op-amp Integrator and differentiator.</td><td rowspan="2">Make use of Op-Amp to verify integrator and differentiator.
Analyze the sine, square, triangular, ramp wave generations using Op-Amp circuit.
Test for second order transfer function using Op-Amp Log and anti-Log.</td><td>K4</td></tr>
<tr><td>4</td><td>Op-amp sine, square, triangular and ramp wave generator.</td><td>K4</td></tr>
<tr><td>5</td><td>Op-amp solving simultaneous equations.</td><td>Solve simultaneous equation using Op-Amp.</td><td>K5</td></tr>
</table>

6	Modulation – demodulation.	Construct the circuits to verify modulation and demodulation.	**K6**
7	Characteristics of Chua diode. Chaotic dynamics of Chua diode.	Construct the Chua diode and verify the characteristics and dynamics.	**K3**
8	Nonlinear exhibited by Colpitts oscillator and Wein bridge oscillator	Determine characteristics of non-linearity using Colpitts and Wein bridge oscillator.	**K5**
9	. Linear Optical studies – UV – Visible Studies (absorbance and optical bandgap)	Evaluate the band gap of materials by UV-Visible spectroscopy.	**K5**
10	Dielectric studies using microwave– parameters of a liquid.	Estimate the dielectric properties of liquids by source of microwave instrument.	**K5**
11	Dielectric studies using microwave – parameters of a solid.	Investigate the dielectric properties of solids by source of microwave instrument.	**K6**
12	Thin film preparation by dip coating – measurement of thickness.	Construct the dip coating setup to prepare the thin film and measure the thickness of coatings.	**K6**
13	Electrical properties of thin film – Calculation of activation energy by Resistance variation with temperature. (Two probe).	Construct the dip coating setup to prepare the thin film and measure the activation energy and variation of resistances of coatings.	**K6**
14	X-ray diffraction analysis – D, İ, N and į.	Analyze the crystallographic information by X-ray diffraction data's.	**K5**
15	Gas sensing properties of a thin film.	Determine gas sensing properties of thin film.	**K5**
16	Susceptibility of a material by Hysteresis.	Interpret the susceptibility of the materials by Hysteresis loop.	**K5**
17	Zeeman effect.	Construct and verify the Zeeman effect.	**K6**
18	Photoelectric effect - determination of Planck's constant.	Determine the Planck's constant by photoelectric effect.	**K5**

4. **MAPPING SCHEME (PO, PSO& CO)**

P21PH 3P3	PO									PSO			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	H	M	H	H	M	-	L	-	-	H	-	M	-
CO 2	H	-	M	-	M	-	-	-	-	H	M	-	M
CO 3	H	-	M	L	-	-	-	-	-	H	-	M	-
CO 4	H	L	-	M	L	-	-	M	L	H	L	H	-
CO 5	H	-	M	M	-	-	-	-	-	H	-	-	L
CO 6	H	M	H	-	-	H	-	M	M	-	M	-	L

L- LowM-Moderate H-High

5. COURSE ASSESMENT METHODS

Direct
1. Record and Observation Evaluation
2. Continuous Assessments (Minimum Two)
3. End Semester Practical Examinations

In-Direct
1. Assignments
2. Laboratory / Field visits
3. Course end survey/Feedbacks

Course co-ordinator: Mr. A. Veerapandian

MAJOR PRACTICAL– IV

SEMESTER: IV **CODE: P16PH4P4**

CREDITS: 3 **NO OF HOURS /WEEK: 6**

1. COURSE OUTCOMES (CO)

After successful completion of the course, the students will be able to:

CO. NO.	Course Outcomes	Level	Experiments covered
CO1	Examine the functionalities of basic combinational circuits.	**K4**	**1,2,3,4**
CO2	Make use of basic sequential circuits using Flip-flop.	**K3**	**5,6,7**
CO3	Construct logic circuits and simplify the Boolean expression.	**K5**	**8,9,10**
CO4	Test and debug ALP using microprocessor (8085) and microcontroller (MCS51) systems	**K4**	**11,12**
CO5	Interface various A/D, D/A convertor, Traffic light controller and Stepper motor controller.	**K5**	**13,14,15, 16,17**
CO6	Make use of numerical methods to the application of physics (RK2, RK4, Newton-Rapson) and C Programming and plotting the data using Origin.	**K5**	**18,19,20**

2.SYLLABUS

List of Experiments

Digital Electronics

1. Multiplexer – Demultiplexer.

2. Study of 7490 (0-9 and 0-99).

3. One shot multivibrator – Using ICs, determination of pulse width.

4. Digital comparator using EXOR and NAND gates.

5. Study of 7-segment display decoder – IC 7447.

6. Study of FLIP FLOP, Synchronous UP and Down counter.

7. Shift register using FLIP FLOPS.

8. Study of memory circuits – RAM, ROM, EPROM, PROM.

9. Half adder, Half Subtractor and Full adder, Full Subtractor circuits using NAND Gates.

10. Simplification of Boolean expression by Karnaugh Map method and verification.

Microcontroller andMicroprocessor Practical

11. a) 8-bit addition, multiplication, multibyte addition, subtraction, division and multibyte subtraction.

b) 16-bit addition Subtraction by 1’s complement and 2’s complement.

12. Conversion from decimal to octal and hexa systems, octal and hexa to decimal systems

13. Study of DAC interfacing (DAC 0800)

14. Study of ADC interfacing (ADC 0809)

15. Traffic Control System using microprocessor

16. Generation of square, triangular, sawtooth, staircase and sine waves using DAC 0800

17. Control of stepper motor using microprocessor.

Computer Practical (C Language)

18. Solving equations by Newton – Raphson method

19. Numerical differentiation by Runge-Kutta Method (II and IV Order)

20. Plotting, merging and editing the data using Origin.

3. SPECIFIC LEARNING OUTCOMES (SLO)

Experiment No.	Course Content	Learning Outcomes	Highest Bloom’s Taxonomic level of Transaction
1	Multiplexer – Demultiplexer.	Examine Mux and Demux	**K4**
2	Study of 7490 (0-9 and 0-99).	Verify the output of decade counter	**K4**
3	One shot multivibrator – Using ICs, determination of pulse width.	Determine one shot multivibrator using IC.	**K4**
4	Digital comparator using EXOR and NAND gates.	Construct digital comparator using EXOR and NAND	**K3**
5	Study of 7-segment display decoder – IC 7447	Apply 7-segment display with IC 7447	**K3**
6	Study of FLIP FLOP, Synchronous UP and Down counter	Construct synchronous up and down counter using IC7476	**K3**
7	Shift register using FLIP FLOPS.	Analyze the function of shift register using flip flop	**K4**
8	Study of memory circuits – RAM, ROM, EPROM, PROM.	Construct RAM, ROM, EPROM and PROM studied.	**K5**

9	Half adder, Half Subtractor and Full adder, Full Subtractor circuits using NAND Gates.	Construct half adder, half ultracareful adder and full subtractor using NAND gates	**K5**
10	Simplification of Boolean expression by Karnaugh Map method and verification.	Simplify Boolean expression by Karnaugh map method.	**K4**
11	a) 8-bit addition, multiplication, multibyte addition, subtraction, division and multibyte subtraction. b) 16-bit addition Subtraction by 1’s complement and 2’s complement.	Solve 8-bit addition multiplication, multibyte addition, subtraction, division, multibyte subtraction and 16-bit addition Subtraction by 1’s complement and 2’s complement using 8085MP.	**K3**
12	Conversion from decimal to octal and hexa systems, octal and hexa to decimal systems	Develop ALP for conversion from decimal to octal,hexa systems, octal and hexa to decimal systems	**K3**
13	Study of DAC interfacing (DAC 0800)	Study and recall DAC 0800	**K1**
14	Study of ADC interfacing (ADC 0809)	Determine generation of character wave using ADC 0809	**K5**
15	Traffic Control System using microprocessor	Analyze the traffic control system using 8085 processor	**K4**
16	Generation of square, triangular, sawtooth, staircase and sine waves using DAC 0800	Determine Generation of square, triangular, sawtooth, staircase and sine waves using DAC 0800	**K5**
17	Control of stepper motor using microprocessor.	Develop ALP for stepper motor control using 8085MP	**K3**
18	Solving equations by Newton – Raphson method	Develop a C program by Newton-Raphsonmehod.	**K3**
19	Numerical differentiation by RungeKutta Method (II and IV Order)	develop a C program by RungeKuttaMehod (II and IV order)	**K5**
20	Plotting, merging and editing the data using Origin.	Interpret plotting, merging and editing the data using Origin	**K5**

4. MAPPING SCHEME (PO, PSO& CO)

P21PH4P4	PO									PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO 1	PSO 2	PSO 3	PSO 4
CO1	H	M	M	H	L	-	M	-	-	H	H	H	M
CO2	H	M	M	H	L	-	M	-	-	H	H	H	M
CO3	H	H	M	M	L	-	H	-	-	H	M	L	M
CO4	H	H	L	L	M	-	H	-	-	M	M	H	M
CO5	H	H	L	M	M	-	H	-	-	H	H	H	M
CO6	H	H	L	M	H	-	H	-	-	H	L	M	M

L-Low M-Moderate H- High

5. COURSE ASSESMENT METHODS

Direct

1. Record and Observation Evaluation
2. Continuous assessments (Minimum Two)
3. End Semester Practical Examinations

In-Direct

1. Assignments
2. Laboratory / Field visits
3. Course end survey/Feedbacks

Course coordinator: Mr. A. Veerapandian

PROGRAMME ARTICULATION MATRIX (PG-2021-2022)

S.No.	COURSE NAME	COURSE CODE	CORRELATION WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES												
			PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO 1	PSO2	PSO3	PSO4
1.	Mathematical Physics I	P21PH101	H	H	M	L	M	M	M	M	L	H	M	L	M
2.	Classical Dynamics	P21PH102	H	H	H	H	M	M	M	L	L	H	H	H	H
3.	Statistical Mechanics	P21PH103	H	M	M	L	M	L	M	L	L	H	M	M	M
4.	Analog And Digital Electronics	P21PH1: 1	H	M	L	M	L	L	M	L	L	M	M	M	L
	Modern Communication System	P21PH1: A	M	M	M	M	M	M	L	L	L	M	M	M	M
5.	Mathematical Physics - II	P21PH204	H	M	M	M	M	M	M	L	L	H	H	H	H
6.	Electromagnetic Theory	P21PH205	M	H	M	H	H	M	M	L	H	H	M	M	H
7.	Atomic And Molecular Physics	P21PH2: 2	H	M	H	M	M	M	M	L	L	M	M	H	H
	Solar PV Technology and its Application	P21PH2: A	H	M	M	M	M	M	M	L	L	H	H	H	H
8.	Virtual Labs – Physics Experiments	P21PH2: P	H	M	L	M	M	L	M	M	M	H	H	M	M
9.	Quantum Mechanics I	P21PH306	M	H	M	M	M	H	M	H	M	H	H	H	H
10.	Solid State Physics – I	P21PH307	H	M	L	-	M	L	L	L	L	H	H	M	M
11.	Microprocessor and Microcontroller	P21PH308	M	M	M	H	H	H	H	H	H	H	H	H	M
12.	Nuclear Physics	P21PH3: 4	M	L	M	M	M	L	L	L	L	M	L	M	L
	Radiation Physics	P21PH3: A	M	H	M	M	H	M	L	L	M	M	H	M	M
13.	Quantum Mechanics - II	P21PH409	H	M	L	L	H	L	M	L	L	H	L	L	M
14.	Solid State Physics - II	P21PH410	M	M	M	L	L	M	M	L	L	H	M	L	M
15.	Crystal Growth, Thinfilms And Nanoscience	P21PH4: 5	H	M	M	H	M	M	M	L	M	H	H	H	H

	Astrophysics	P21PH4:A	H	M	M	H	L	L	L	M	M	H	L	H	L
16.	Major practicals - I	P21PH1P1	M	M	L	M	L	L	L	M	M	M	M	L	M
17.	Major Practicals - II	P21PH2P2	H	L	M	M	L	L	L	L	L	H	L	L	L
18.	Major Practicals - III	P21PH3P3	H	H	-	H	M	H	-	-	-	H	H	H	H
19.	Major Practicals - IV	P21PH4P4	H	H	M	M	M	-	H	-	-	H	M	H	H