RANI DURGAVATI VISHWAVIDYALAYA, JABALPUR
SYLLABUS PRESCRIBED FOR THE EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN PHYSICS
FIRST AND SECOND SEMESTERS (with effect from 2020-2021)
UNDER CHOICE BASED CREDIT SYSTEM

(In Accordance with University Ordinance No – 222) AND LEARNING OUTCOME BASED CURRICULUM FRAMEWORK

SYLLABUS

M.Sc. FIRST SEMESTER PHYSICS

Theory Courses		Marking Scheme			
Paper Code	**Title of Paper**	**Credits**	**End Semester Exam.**	**CCE**	**Total**
PY C- 101	Core Paper Mathematical Physics	5	60	40	100
PY C- 102	Core Paper Classical Mechanics	5	60	40	100
PY C- 103	Core Paper Electronic Devices	5	60	40	100
PY E - 101 PY E - 102	Elective Paper (any one) A - Computational Methods and Programming B - Physics of Electronic devices & Fabrication of IC & Systems	5	60	40	100

	Practical Course	Credits	End Semester Exam.	CCE			
				Pract Record. & Viva	Seminar related to Pract	Total	Total
PY L- 104	Lab A	3	60	20	20	40	100
PY L- 105	Lab B	3	60	20	20	40	100
PY S - 101	Skill Development	2					
	Total	28	360	240		600	

CORE PAPER – I

PY C – 101 MATHEMATICAL METHODS

60+40=100 MARKS **5 CREDITS**

Course Objectives: The objectives of the course are

1.	To develop an understanding of Tensors.
2.	To teach the use of different special functions/polynomials in solving physical problems.
3.	To provide an understanding of different Integral Transforms.
4.	Able to solve problems related to complex variables which contain real and imaginary parts.

5.	To give the basic knowledge of Group theory.

Course Outcomes: The purpose of the course is to introduce the methods of mathematical physics and after completion of the course students should be able to

1.	Learn about the concept and uses of Tensors and Tensor algebra (Null tensor, addition, subtraction, inner product, outer product).
2.	Familiarized with different special functions like Associated Legendre Polynomials, Laguerre's Polynomials, etc. and their solutions in solving different physical problems.
3.	To obtain knowledge of Fourier and Laplace Transforms in solving different problems of Mechanics and Electronics etc.
4.	Know about Green Function and its application in solving non homogeneous differential equations.
5.	Solve different physical problems which contain complex variables and implementation of complex variable for calculation of integrals, and also able to expand functions in Taylor's and Laurent's series. Knowledge of theorems of residues and contour integration.
6.	Obtain the basic knowledge of Group theory and its applications. This theory is also used to describe the crystal symmetry and electronic structure of crystals.

UNIT- I

Tensor Analysis

Elements of Cartesian tensors in three dimensions, Definition of transformation laws of scalars, vectors, tensors of second, third and fourth rank, covariant, contravariant and mixed tensors, Isotropic tensor δ^i_j , Levi-Civita symbol $\in_{ijk}$, Tensor algebra (Null tensor, addition, subtraction, inner product, outer product).

Green's Function

Elements of Green's function, Green's function for the Sturm-Liouville operator, Series expansions for G(x/ξ), Green's functions in two dimensions, Green's functions for initial conditions, Green's functions for boundary conditions, the Green's function method, A case of continuous spectrum.

UNIT II

Differential Equation

Recursion relation, generating function and orthogonality of Bessel and Legendre functions. Elementary ideas of Associated Legendre, Hermite and Laguerre's polynomials.

Integral Transforms

Fourier and Laplace transforms. Inverse Fourier and Laplace Transforms. Fourier and Laplace transforms of derivatives. Convolution theorem. Application to simple problems.

UNIT - III

Complex Variables

Analyticity of complex functions; Cauchy- Riemann equations; Cauchy's Theorem; Integral Formula; Taylor's and Laurent's series; Theorem of residues; Jordan's Lemma, simple cases of contour integration.

UNIT - IV

Group Theory

Introduction to Groups, Reducible and irreducible representation of groups, Concept of reducibility in terms of invariant subgroups, Schur's Lemma, orthogonality relations for irreducible representation, the characters of representations, reduction of a reducible representation, multiplication of conjugate classes. The number of irreducible representations of a finite group.

Crystal symmetry operators, Translation groups, Crystal systems and point groups: applications of group theory in the electronic structure of crystals, in the translation group and in reciprocal lattice. A brief introduction to continuous groups and their representations:O(2), O(3), SU (2), SU (3); generators of U(N) and SU(N).

UNIT - V

This unit will consist of short questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:-

(1) Geometrical representation of a second rank Cartesian tensor, principal axes system, application to electrical conductivity, quotient Rule.

(2) Green's function for a linear oscillator, Green's function and the Dirac δ-function, finding Green's function for Linear operators in 1-D.

(3) Potential due to discrete or continuous charge distribution; vibration of a circular membrane, solving the 1-D harmonic oscillator Schrodinger equation; Relation of the hydrogen atom, Schrodinger equation with Laguerre equation and solution.

(4) Solution of initial value problems by using Laplace transform; LT and inverse LT of various functions,

(5) Solution of limit dept problems by Fourier transform; FT of Gaussian function, Application of FT of Dirac delta function.

(6) Verification of analyticity of simple function, Evaluation of some definite integral using residues etc.

(7) Evaluation of integrals in complex variables

(8) Construction of the character table for the group D_3

In addition to above tutorial will also consist of solving problems given in the Text Reference books.

Text and Reference Books

- Mathematical Methods for Physicists : G. Arfken
- Matrices and Tensors for Physicists : A.W. Joshi
- Advanced Engineering Mathematical : E. Kreyszig
- Special functions : E.D. Rainville
- Special functions : W.W. Bell
- Mathematical Methods for Physicists Engineers : K.F. Reily, M.P.Hob Son and and S.J. Bence
- Mathematics for Physicist : Mary L Boas

CORE PAPER –II

PY C – 102 CLASSICAL MECHANICS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The course enables the students

1.	To define the concepts of Newtonian mechanics, Langrangian Equations
2.	To interpret the concepts of Hamiltonian Mechanics.
3.	To explain generating function, canonical transformation & Poisson brackets.
4.	To illustrate the dynamics of a rigid body and non-inertial frames of reference.
5.	To formulate the concepts of coupled oscillators.

Course Outcomes: To apprise the students of advanced classical formulations and completion of the course students will have understanding of

1.	Newtonian mechanics, Virtual work, DÁlembert's principle, Formulation of Lagrangian mechanics and problem solving with the help of it. Compare the formulation of Hamiltonian and Lagrangian mechanics and solve the problems of classical and relativistic mechanics
2.	Generating function, canonical transformation & Poisson brackets.
3.	Kepler problem, Legendre Transformations, Hamilton's equation, Canonical transformations and generating functions. Properties of Poisson's bracket.
4.	Understanding small oscillations, Solve the equations of coupled oscillator and to examine the two coupled pendulums, and double pendulum related problems. Understanding rotating coordinate system, Coriolis force and Eulerian coordinate system
5.	Understand space and time symmetries, covariant and four-dimensional formulation, covariant Lagrangian and Hamiltonian with examples.

UNIT - I

Newtonian mechanics of one and many particles systems; Conservation theorems for linear momentum, angular momentum and energy; Constraints; their classification; Principle of virtual work; D'Alembert's principle in generalized coordinates; The Lagrangian, Lagrange's equations; velocity dependent potential and dissipative function. Configuration space, Hamilton's principle; generalized momenta and Lagrangian formulation of the conservation theorems and Jacobi's integral. Reduction to the equivalent one body problem; the equation of motion and first integrals; the differential equation for the orbit and integration power-law potentials.

UNIT - II

The Kepler problem: inverse square law of force; Artificial satellites; Scattering in a central force field, Rutherford scattering; Legendre transformations and the Hamilton's equations of motion; Conservation theorems and the physical significance of the Hamiltonian. Derivation of Hamilton's equations from a variational principle. The principle of least action.

The equations of canonical transformations and generating functions; Poisson's Brackets: their canonical invariance; Simple algebraic properties of Poisson Brackets. The equations of motion in Poisson's Brackets notation; Poisson's theorem; Angular momentum PB's Hamilton's principal and characteristic functions; The Hamilton-Jacobi equation; Action Angle variables.

UNIT - III

Theory of small oscillations Equations of motion, Eigen frequencies and general motion. Normal modes and coordinates. Applications to coupled pendulum and linear triatomic molecule.

Rotating co-ordinate systems, Acceleration in rotating frames. Coriolis force and its terrestrial and astronomical applications. Elementary treatment of Eulerian co-ordinates and transformation matrices. Angular momentum inertia tensor. Euler equations of motion for a rigid body. Torque free motion for a rigid body. Symmetrical top and gyroscopic forces.

UNIT – IV

Symmetries of space and time. Invariance under Galilean transformation, Covariant four- dimensional formulation. 4-Vectors and 4-Scalars. Relativistic generalization of Newton's laws, 4-momenturn and 4-force. Invariance under Lorentz transformation relativistic energy. Lagrangian and Gange invariance Hamiltonian formulation in relativistic mechanics. Covariant Lagrangian, covariant Hamiltonian, Examples.

UNIT-V

This unit will consist of questions based on tutorial problems covering all the four units. The student will have to answer any two questions out of four. Some sample problems are-

(1) Simple pendulum with rigid support. Two connected masses with string passing over a pulley, virtual work.

(2) Various Poisson's brackets thin relation with PBs in quantum mechanics stability of orbits under central force' orbital elements of planetary orbits.

(3) Rotating frames, Foucault's pendulum, small oscillations in Linear triatomic molecule and coupled pendulum.

(4) Relativistic Kinetic energy, mass variation, 4-momentum and 4-force.

In addition to above the tutorial will also consists of solving problems given in the Texts and references books.

Text and References Books

- Classical Mechanics : N. C. Rana and P.S. Jog (Tata Mc Graw Hill, 1991)
- Classical Mechanics : H. Goldstein (Addision Wesley, 1980)
- Mechanics : A Sommerfiels (Academi Press 1952)
- Introduction to Dynamics : I. Perceival and Richards(Cambridge Univ. Press, 1982

CORE PAPER –III
PY C 103 ELECTRONIC DEVICES

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The aim and objective of the course on Electronics Devices is to introduce students to principal, construction and circuitry of various semiconductor devices and circuits for use in electronic instrumentation

1.	To introduce the formal structure of the subject and to equip them with the knowledge of various semiconductor field effect ransistors and Microwave devices.
2.	To describe Photonic devices
3.	Introduction to digital logic families and their characteristics
4.	To impart knowledge about various memory devices, systems, elements and materials used in developing them.
5.	An understanding on integrated circuit operational amplifiers and their applications.

Course Outcomes: At the end of the course, the student will be able to

1.	Understand working of Different Semiconductor devices like JFET, BJT, MOSFET & MESFET (Construction, Working Principles and V-I characteristics) and their applications.
2.	Understand photonic devices like LDR, LED and Diode Lasers along with their applications.
3.	Develop a comprehensive understanding of contemporary integrated circuits both saturated and unsaturated logic families like RTL, DTL, TTL TTC, ECL etc. Operational amplifier design and applications like adder, subtractor, differentiator function generator etc.
4.	Develop an insight into the physics and technology that go into the development of various memory devices using semiconductors and other electronic devices using elctro-acousto-magneto-optic effects. LCD. Piezoelectric effect based devices.
5.	Enjoy the new and stimulating ideas behind the future novel devices and also appreciate the link between electronics and the quantum effects that come into play.

UNIT-I

Transistors

JFET, BJT, MOSFET and MESFET, Construction, Structure, working Derivations of the equations for I-V characteristics under different conditions. High frequency limits.

Microwave Devices; Tunnel diode, transfer electron devices (Gunn diode), Avalanche transit time devices, Impatt diodes and parametric devices.

UNIT-II

PhotonicDevices

Radiative and non-radiative transitions. Optical absorption, Bulk and their film photoconductive devices (LDR), diode photodetectors, solar cell (open circuit voltage and short circuit current, fill factor). LED (high frequency limit, effect of surface and indirect recombination current, operation of LED).

Diode lasers (condition for population inversion, in active region, Light confinement factor. Optical gain and threshold current for lasing. Fabry-Perrot cavity length for lasing and the separation.

UNIT - III

Digital Integrated Circuits

Characteristics of logic families, saturated logic families. RTL, DCTL, DTL,TTL, IIL, HTL Non saturated bipolar logic families, TTC, ECL, Unipolar logic families, Digital integrated circuits-SSI, MSI, LSI and VLSI circuits.

Operational Amplifiers

DC Amplifier, Difference amplifier, operational amplifier, OP-AMP Parameters, Inverting and Non-Inverting modes, Use of OPAMP as adder, substractor, inverter, differentiator, integrator, function generator.

UNIT - IV

Memory Devices: Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non- volatile memory, magnetic, optical and ferroelectrics memories, charge coupled devices (CCD).

Introduction to other electronic devices: Electro optic, magneto optic and Acousto-optic effects; Examples of some active devices in integrated optics based on theseeffects. Liquid crystal display devices.

Piezoelectric effect, important materials exhibiting this property, piezoelectric filters and resonators, high frequency piezoelectric devices – surface acoustic devices. Capacitor, Electrets and piezo electric electro mechanical transducer devices.

UNIT – V

This unit will consist of questions based on tutorial problems covering all the four units. The student will have to answer any two questions out of four.

1. Design of MOSFET amplification in different configurations.
2. Microwave oscillators: Klystron and Magnetron.
3. Deviation of the condition of lasing action in a two level system, optical pumping
4. Derivation of rate equation for three – Laval Devices system.
5. Design of gates using DL, DTL etc. logics OPAMP
6. Derivation of expressions for OPAMP adder, substrates differentiator, integrator current voltage.
7. Derivation of expansions negated to pier clement effect.

The problems given in this Text and preference books will form tutorial course.

Text and reference books

- Semi-Conductor Devices – Physics and Technology : SM Sze (Wiley, 1985)
- Introduction to Semiconductor devices : M.S. Tyagi (John Wiley and Sons)
- Measurement, Instrumentation and Experimental Design in Physics and Eugineeruin : M. Sayer and A. Mansingh
- Optical Electronics: Ajoy Ghatak and K. Thygarajan (Cambridge Univ. Press.)
- Digital Principles and Applications: Albert Paul Malvino and Donald P.Leach (TATA McGRAW-HILL)
- Modern Digital Electronics: R,P,Jain (TATA McGRAW-HILL)

ELECTIVE PAPER IV (ANY ONE OF THE FOLLOWING)
PY E – 101
IV (A) COMPUTATIONAL METHODS AND PROGRAMMING

60+40= 100 Marks **5 CREDITS**

Course Objectives: To impart the basic knowledge of computational Physics with the numerical methods used in computation and programming using BASIC language.

1.	Teach the basics of computers and BASIC programming.
2.	Train them to solve systems of linear and non-linear equations.
3.	Teach them the concept of interpolation.
4.	Instruct them to calculate integrals and differentials using different numerical methods.
5.	Computational methods for solving differential equations.

Course Outcomes: At the end of the course, the student will be able to

1.	Understand the basics of computer and BASIC programming. Estimate errors while solving equations and effectively use methods like matrix inversion, Gauss elimination and LU decomposition to solve linear equations.
2.	Understand the methods of linear and non-linear algebraic equations, simultaneous linear equations
3.	Enrich a given set of data points using interpolation methods, Newton's divided difference, etc.
4.	Numerically differentiate and integrate expressions and solve equations from physics.
5.	Enriched with various computational methods like Euler, Newton-Raphson and Runge-Kutta etc.

	to solve problems. Idea of random variables and Monte Carlo evaluation.

UNIT - I

Programming: Elementary information about digital computer principles, compilers, interpreters and operating system. BASIC programming, Flow charts, integer and floating point arithmetic expressions, built in functions, executable and non-executable statements, assignments, control and input-output elements, subroutines and functions, operations with files, Graphics, statements.

UNIT-II

Methods for determination of zeros of linear and nonlinear algebraic equation and transcendental equations, convergence of solutions. Solutions of simultaneous linear equation, Gaussianelimination, pivoting, iterative method, matrix inversion.

UNIT-III

Eigen values and Eigen vectors of matrices, power and Jocobi method, finite differences, and interpolation with equally spaced and unevenly spaced points. Curve fitting, polynomial least squares and cubic spline fitting.

Numerical differentiation and integration, Newton-Cotes formulae, Error estimates, Gauss method.

UNIT - IV

Random variables, Monte Carlo evaluation of integrals, Methods of importance sampling, Random walk and metropolis method, Numerical solution of ordinary differential equation, Euler and Runge- Kutta Methods, Predictor and corrector method, Elementary ideas of solution of partial differential equation.

UNIT-V

This unit will have four questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four some sample problems are-

(1) Explain the use of sequential formatted data files. What are Random data files?

(2) How is a sequential data file created in Basic?

(3) Write a program to obtain the roots of a quadratic equation with the provision that if the roots are complex, the execution should stop.

(4) Invert and diagonalizable 3×3 and 4×4 symmetric matrices for example.

$$2 \begin{pmatrix} 0.5 & 0.1 & \\ 0.5 & 3 & 0.1 \\ 0.1 & 0.1 & 4 \end{pmatrix} \quad 3 \begin{pmatrix} 1 & 1 & 0.5 & \\ 1 & 4 & 1 & 1 \\ 1 & 1 & 5 & 1 \\ 0.5 & 1 & 1 & 6 \end{pmatrix}$$

(5) Find equations for the coefficients ‘a’ and ‘b’ of the curve $y=ae^{bx}$ by the least squares method.

(6) Use the Lagrange from to find the quadratic interpolation polynomial to the function f(x) having values.

X	:	1	2	3
F(x)	:	2	3	7

(7) Find out C_0, C_1, X_0 and X_1 such that the Gaussion quadrature rule

$$f(x)dx = c_0f(x_0) + c_1f(x_1)$$

is exact for polynomials of degree upto three. Hence evaluate the integral of exp(x) over x from x = 0 to x = 2.

(8) What are the methods to solve partial differential equations? Write down the difference analogue of the Laplace equations.

$$U_{xx}+U_{yy}=0$$

(9) Write a program to solve the Laplace equations using Lattice method.

(10) Give In addition to above, the tutorial will also consist of Solving problems given in the Text and Reference books.

Text and reference books

- Introductory Methods of Numerical Analysis : Sastry
- Numerical Analysis : Rajaraman
- Fortran Programming : Rajaraman
- Numerical Recipes : Utter mind Teukolsky, Press and Flattery
- Programming with Basic : Gottfried (Schema Series)
- Programming with Basic : Balaguruswamy
- Numerical Analyses : Balagurswamy

PY E - 102

(b) PHYSICS OF ELECTRONICS DEVICES & FABRICATION OF INTERGRATED CIRCUITS AND SYSTEMS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The course enables the students

1.	To provide basic knowledge and concepts of Semiconductor materials and devices.
2.	To understand operation of semiconductor devices and carrier transport in semiconductors.
3.	To apply concepts for the design of Junction Devices.
4.	To know the fabrication techniques of Integrated Devices.
5.	To be able to implement mini projects based on concept of electronic devices and ICs.

Course Outcomes: The purpose of the course is to introduce the methods of mathematical physics and after completion of the course students should be able to

1.	Understand the basic concepts of various Inorganic and Organic Semiconductor materials for electronic device applications in modern electronic industry.
2.	Understand the carrier transport in semiconductors. Drift, Diffusion, Conductivity measurement, Direct and Indirect Band gap semiconductors.
3.	Analyze various junction devices: p-n junction, Schottky and MOS devices..
4.	Understand fabrication techniques of integrated devices such as thin film, vapor deposition, etching, lithography ,sputtering etc.
5.	Evaluate and understand behavior of semiconductor Electronics and their applications in design of various circuitry.

UNIT-I

Semiconductor Materials

Energy Bands, Intrinsic carrier concentration. Donors and Acceptors, Direct and Indirect band semiconductors. Degenerate and compensated semiconductors, Elemental (Si) and compound semiconductors (GaAs). Replacement of group III element and Group V elements to get tertiary alloys such as $Al_x\ Ga_{(1-x)}$ As or $GaP_yAs_{(1-y)}$ and quaternary $In_xGa_{(1-x)}P_yAs_{(1-y)}$ alloys and their important properties such as band gap and refractive index changes with x and Y. Doping of Si

(Group III (n) and Group V (P) compounds) and GaAs (Group II (P) , IV (n-p) and VI (n compounds) . Diffusion of impurities – Thermal Diffusion, constant surface concentration, Constant Total Dopant Diffusion, ion implantation.

UNIT-II

Carrier Transport in Semiconductors

Carrier Drift under low and high fields in (Si and GaAs) saturation of drift velocity. High field effects in two valley semiconductors. Carrier Diffusion carrier injection, Generation Recombination processes- Direct, indirect bandgap semiconductors. Minority carrier Life Time, Drift and Diffusion of minority carriers (Haynes= Shockley Experiment) Determination of conductivity (a) four probe and (b) van der Pauw techniques. Hall coefficient, minority carrier Life Time.

UNIT- III

Junction Devices: (i) p-n junction- Energy Band diagrams for homo and hetro junctions. Current flow mechanism in p-n junction, effect of indirect and surface recombination currents on the forward biased diffusion current, p-n junction diodes-rectifiers (high frequency limit) (ii) Metal-semiconductor (Schottkey Junction): Energy band diagram current flow mechanisms in forward and reverse bias, effect of interface states. Applications of Schottky diodes, (iii) bimetal Oxide – Semiconductor (MOS) diodes. Energy band diagram depletion and inversion layer, High and low frequency capacitance voltage (c-v) characteristics. Smearing of c-v curve, flat band shift. Applications of MOS diode.

UNIT- IV

Fabrication of Integrated Devices

Thin film Deposition Techniques; Vacuum pumps and gauges- pumping speed, throughout Effective conductance control chemical vapor Deposition (CVD), MOCVD, PEMOCVD (plasma enhanced chemical vapour deposition) Physical vapor Deposition: Thermal Evaporation, Molecular Beam Epitaxy (MBE), Sputtering and Laser Ablation.

Lithography, Etching and Micro- Machining of Silicon, Fabrication of integrated circuits and integrated micro- electro- mechanical – Systems (MEMS)

UNIT-V

The unit will have four short questions based on the tutorial problems covering all the four units. The students will have to answer any two questions. Some samples problems are:

1. Obtain an expression for intrinsic carrier density in a semiconductor.
2. Derive the expression for the concentration of a diffusant at a distance x at time t from the surface having a constant concentration N_o.
3. Derive an expression for Hall coefficient for semiconductors.

4. Prove that the minimum conductivity of an extrinsic semiconductor is given by

$$\sigma = 2n_i e (\mu_n \mu_p)^{1/2}$$

Show that the conductivity minimum occurs when

$$N_A - N_D = n_i [(\mu_n / \mu_p)^{1/2} - (\mu_p / \mu_n)]^{1/2}$$

5. Discuss the Mechanism of forward and reverse current flow in p-n junction.
6. Applications of Schottky Diode
7. Thin film deposition techniques.
8. Discuss Sputtering and Laser Ablation.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books

- The Physics of Semiconductor Devices - D.A. Eraser, oxford physics Series (1986)
- Semiconductor Devices - Physics and Technology. By SM Sze Wiley (1985).
- Introduction to semiconductor devices - M.S. Tyagi, John Wiley & Sons
- Measurement, Instrumentation and Experimental Design in physics and Engineering - M. Sayer and A. Mansingh, prentice Hall India (2000)
- Thin film phenomena - K.L. Chopra
- Solid State Physical Electronics - Aldert van der Ziel
- Solid State Physics - J.P. Srivastava Prentice Hall of India (2001)
- The material science of thin films - Milton S. Ohring
- Optical electronics - Ajoy Ghatak and K. Thyagarajan, Cambridge Univ. Press
- Material science for engineers - James F. Shackelford, Prentice Hall
- Deposition techniques for films and coatings - R.F. Bunshah (Noyes publications)
- Solid State Electronics - Ben G. Streetman (Prentice Hall of India) 1994.
- Integrated Circuit - K.R. Botkar (Khanna) 1997.
- Integrated Circuit - Nagchoudhary

M.Sc. SECOND SEMESTER PHYSICS

Theory Courses		Marking Scheme			
Paper Code	**Title of Paper**	**Credits**	**End Semester Exam.**	**CCE**	**Total**
PY C-201	**Core Paper** **Quantum Mechanics -I**	**5**	**60**	**40**	**100**
PY C-202	**Core Paper** **Statistical Mechanics**	**5**	**60**	**40**	**100**
PY C-203	**Core Paper** **Electrodynamics and Plasma Physics**	**5**	**60**	**40**	**100**
PY E-201 **PY E-202**	**Elective Paper (any one)** **A - Condensed Matter Physics** **B - Informatics**	**5**	**60**	**40**	**100**

			CCE				
	Practical Course	**Credits**	**End Semester Exam.**	**Pract Record. & Viva**	**Seminar related. to Pract**	**Total**	**Total**
PY L-204	**Lab A**	**3**	**60**	**20**	**20**	**40**	**100**
PYL-205	**Lab B**	**3**	**60**	**20**	**20**	**40**	**100**
PY S - 201	**Skill Development**	**2**					
Total		**28**	**360**	**240**			**600**

CORE PAPER – I
PY C - 201
QUANTUM MECHANICS- I

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objectives of the course are to give exposure about the various tools employed to analyze the quantum mechanical problems.

1.	To know the basics of quantum mechanics. Understanding Schrodinger equation and its solution in different problems. To define Heisenberg & Dirac formulation of quantum mechanics and explain their importance.
2.	To demonstrate the linear harmonic oscillator and hydrogen-like atom using Dirac formulation.
3.	To explain the angular momentum operators associated with spherical and symmetrical systems.

Course Outcomes: The purpose of the course is to introduce the concept of Quantum Mechanics and on completion of the course; the student should acquire basic knowledge and will be able to

1.	To understand and apply principles of Quantum mechanics for understanding the physical systems in quantum realm.

2.	Importance of quantum mechanics compared to classical mechanics at microscopic level.
3.	To formulate the Heisenberg & Dirac formulation of quantum mechanics
4.	To solve the linear harmonic oscillator and hydrogen-like atom problems using Dirac formulation
5.	To demonstrate angular momentum operators associated with spherical and symmetrical systems and various tools to calculate Eigen values and total angular momentum of particles.

UNIT – I

Why QM? Brief prevision. Basic postulates of quantum mechanics, equation of continuity, Normality, orthogonlity and closure properties of eigen functions, Expectation values and Ehrenfest theorems. Free particle solution of Schrodinger equation, Box normalization, Dirac delta-function and its properties, solution of Schrodinger equation for one dimensional (a) potential well (b) potential step and (c) potential barrier.

UNIT – II

Linear vector space, concept of Hilbert space, Bra and Ket notation for state vector, Representation of state vectors and dynamical variables by matrices, change of basis and Unitary transformation (Translation and rotation), Schrodinger, Heisenberg and Interaction pictures, Matrix theory of linear harmonic Oscillator, Creation and annihilation operators, Matrices for x, p, H. Heisenberg uncertainty relation through operators (Schwartz inequality).

UNIT – III

Solution of Schrodinger equation for (a) linear harmonic oscillator (b) hydrogen-like atom (c) three-dimensional harmonic oscillator (d) square well potential and their respective applications to atomic spectra, molecular spectra and low energy nuclear states (deuteron).

UNIT – IV

Angular momentum is quantum mechanics, Eigen values and Eigen functions of L^2 and L_2 in terms of spherical harmonics, Relation of angular momentum with rotation operator, commutation relations, Matrix representation of angular momentum, Pauli spin matrices and their algebra, Coupling of two angular moments and Clebsch-Gorden coefficients for $j_1=j_2=1/2$ and $j_1=1/2$ and $j_2=1$.

UNIT –V

This Unit will have four questions based as tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are :

(1) Black body radiation and Planck's hypothesis, Insignificance of de Broglie hypothesis in macrophysics.

(2) Plotting of Harmonic oscillator wave functions in 1-d.

(3) Energy levels of a particle of mass 'm' moving in one-dimensional potential.

$$V(x) = \begin{cases} +\infty & x < 0 \\ +\frac{1}{2} m\omega^2 x^2 & x > 0 \end{cases}$$

(4) Admissible wave functions, stationary states.

(5) Wave function corresponding to minimum uncertainty product. Gaussian wave packet. Spread of wave packet in time.

(6) Continuous basis corresponding to position Eigen values and wave functions corresponding to state vectors using position and momentum representation.

(7) Rotational spectra of diatomic molecules.

(8) Vibrational and rotational spectra of diatomic molecules.

(9) Obtaining the matrices for L+, L-, Lx, Ly, L^2, Lz, $[L_+, L_-]$.

(10) Problems related to panli spin matrices. eq

$$e^{i\sigma y\theta/2} = \cos\,\theta/2 + i\sigma y\,\sin\theta/2$$

In additions to above the tutorial will also consist of solving problems given in the Text and Reference Books.

Text and Reference Books

- Quantum Mechanics : L I. Schiff (Mc Graw-Hill)
- Quantum Physics : S. Gasiorowiz (Wiley)
- Quantum Mechanics : B. Craseman and J.D. Powel (Addison Wesley)
- Quantum Mechanics : AP Messiah
- Modern Quantum Mechanics : J.J. Sakurai
- Quantum Mechanics : Mathews and Venkatesan

CORE PAPER – II
PY C - 202
STATISTICAL MECHANICS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of this course is to learn the properties of macroscopic systems using the knowledge of the properties of individual particles.

1.	To equip with the techniques of Ensemble theory in order to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents and compute thermodynamic parameters by using classical statistics.
2.	To learn the use of methods of quantum statistics to obtain properties of systems made of microscopic particles which either obey Fermi-Dirac statistics or Bose-Einstein statistics.
3.	To grasp the concepts of first order and second order phase transitions and critical phenomena.
4.	To understand phase transition arising in Ising model.
5.	To learn to obtain the properties of out-of-equilibrium systems using concepts from equilibrium physics.

Course Outcomes: At the end of the course, the student will be able to

1.	To use various ensemble theories to calculate the thermodynamic properties of different systems.
2.	To compute properties of systems behaving as ideal Fermi gas or ideal Bose gas.
3.	To describe the features and examples of Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics.
4.	The student should be able to know Cluster expansion, Viril equation, Ising model and Landau theory.
5.	Understand the thermodynamic fluctuations, Langevin theory, Fokker-Planck and Onsager relations.

UNIT-I

Foundations of statistical mechanics, specification of states of a system, contact between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox.

Microcanonical ensemble, Phase space, trajectories and density of states, Liouville's theorem, canonical and grand canonical ensembles; partition function calculation of statistical quantities, Energy and density fluctuations.

UNIT - II

Statistics of ensembles, statistics of indistinguishable particles, Density matrix, Maxwell-Boltzmann, Fermi-Dirac and Bose- Einstein statistics, properties of ideal Bose gases, Bose-Einstein condensation. Properties of ideal Fermi gas, electron gas in metals. Boltzmann's transport equation

UNIT - III

Cluster expansion for a classical gas, Virial equation of state, Dynamical model of phase transition, Ising model in zeroth approximation, Ising model in first approximation. Exact solution in one-dimension.

Landau theory of phase transition, scaling hypothesis for thermodynamic functions.

UNIT - IV

Thermodynamics fluctuation, spatial correlation. Brownian motion, Langevin theory, fluctuation dissipation theorem. The Fokker-Planck equation. Onsager reciprocity relations.

UNIT - V

This unit will have four questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

(1) Calculation of number of states and density of states.
(2) Relative population of particles in two energy levels.
(3) Liquid helium II
(4) Electrical and thermal conductivities.
(5) Evaluation of virial coefficient
(6) Critical indices.
(7) Applications of Onsager relation
(8) Diffusion co-efficient

In addition to above the tutorial will also consist of soloing and reference books.

Text and Reference Books

- Fundamentals of Statistical and Thermal Physics : F. Reif
- Statistical Mechanics : K. Huang
- Statistical Mechanics : R.K. Pathria
- Statistical Mechanics : R. Kubo
- Statistical Mechanics : Landau and Lifshitz

CORE PAPER – III
PY C - 203
ELECTRODYNAMICS AND PLASMA PHYSICS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: To apprise the students regarding the concepts of electrodynamics and its use in various situations.

1.	To cover Electrostatics and Magneto statics including Maxwell equations, and their applications to propagation of electromagnetic waves in dielectrics; EM waves in bounded media, waveguides, Radiation from time varying sources.
2.	Introducing the mathematical tools used in electrodynamics & Review of electrostatics and magneto statics in matter.
3.	Providing easy headway into the covariant formulation of Maxwell's equations.
4.	Teaching basic principles of waveguides and transmission lines & Rendering insights into fields generated by oscillating sources, and their applications.
5.	To expose the basics of the challenging research field of Plasma physics.

Course Outcomes: At the end of the course, the student will be able to

1	Understand and apply the laws of electromagnetism and Maxwell's equations. Basics of electrostatics and magneto statics Solve the electric and magnetic fields problems for different configurations.
2	Radiations by moving charges and retarded potentials. Fields of accelerated charged particle with different velocity. Angular distribution of radiated power. Abrahm- Lorentz method.
3	Understand 4Vectors and Lorentz transformation in 4- dimensional space, relativistic transformation properties of E and H.
4	Understand the plasma oscillations and its limit, Debye screening.
5	Know Magneto hydrodynamic equations, magnetic diffusion, MHD flow, Pinch effect MHD waves.

UNIT – I

Review of basics of electrostatics and magnetostatics. (Electric field, Gausse law, Laplaces and Poisson's equations, method of images. Biot-sawart law, Ampere's law). Maxwell's equations, scalar and vector potentials, Guage transformation Lorentz Guage, Coulomb guage, Solution of Maxwell's equation in conducting media.

UNIT – II

Radiations by moving charges, Retarded potentials, Lienard-wiechert potentials, Fields of charged particle in uniform motion, Fields of arbitrarily moving charged particle, Fields of an accelerated charged particle at low velocity and high velocity. Angular distributions of power radiated, Bremsstrahlung, Reaction force of radiation, Abrahm-Lorentz method of self-force, Difficulty with the Abrahm-Lorentz model, line-breadth and level-shift of an oscillator.

UNIT - III

Review of Four-vectors and Lorentz transformation is 4-dimensional spaces Invariance of electric charge, relativistic transformation properties of E and H fields, electromagnetic field tensor in 4-dimensionl Maxwell equation 4-vector current and potential and their invariance under Lorentz transformation, covariance of electrodynamics Lagrangian and Hamiltonion for a relativistic charged particle in External EM field; motion of charged particles in electromagnetic fields, uniform and non-uniform E and B fields, Particle Drifts in Non-uniform field, static magnetic fields, Adiabatic invariant.

UNIT – IV

Magnetohydrodynamic equations, Magnetic diffusion, viscosity and Pressure, Magnetohydrodynamic flow between Boundaries with crossed Electric and magnetic fields, Pinch Effect, Instability in a Pinched Plasma column, magnetohydrodynamic waves, magneto sonic and Alfven waves, Plasma oscillations, short wave length limit for plasma oscillations and Debye Screening Distance.

UNIT – V

This unit will have four questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

(1) Obtain the formal solution for electromagnetic boundary value problem with Green function.

(2) Discuss the problem of conducting sphere is a uniform electric field by method of images and Green's functions.

(3) For a solenoid wound with N turns per unit length and carrying a current I, show that the magnetic flux density on a point on the axis is given (for $N \rightarrow \infty$) by

$$B_z = \frac{2\pi NI}{C}(\cos\theta_1 + \cos\theta_2)$$

Where θ_1, θ_2 are the angles between the axis and the lines joining the point on the axis to the first and last turns of the solenoid.

(4) A linear accelerator accelerates protons to almost relativistic speeds. Determine fraction of power radiated by the protons to the power supplied in terms of the gradients of the linear electric field.

(5) A charged particle oscillated according to the harmonic law Determine the total average intensity of the emitted radiation.

(6) Discuss the Lagrangian and Hamiltonian for a relativistic charged particle in External electromagnetic field.

(7) Obtain the expression for energy radiated as Cherenkov radiation per unit distance along the path of the particle.

(8) Consider a magnetic field configuration that is cylindrically symmetric and a charged particle is injected into it. Use the adiabatic invariant of motion to describe conditions in which the injected particle would bounce back from the direction of increasing field gradient.

(9) Consider the problem of waves in an electronic plasma when an external magnetic field B_0 is present. Use the fluid model, neglecting the pressure term as well as collisions.

    (a) Write down the linearized equations of motion and Maxwell equations, assuming all variables vary as exp (ik.x-iωt).

    (b) Show that the dispersion relation for the frequencies of the different modes in terms of the wave number can be written.

$$\omega^2(\omega^2-\omega_p^2)(\omega^2 - \omega^{p2} - k^2c^2) = \omega^2_B(\omega^2 - k^2c^2)[\omega^2(\omega^2 - \omega p^2 - k^2c^2) + \omega p^2c^2(k\,.b)^2]$$

where b is the unit vector in the direction of B, ω_p and ω_B are the plasma and precession frequencies, respectively.

(c) Show that for propagation parallel to B_0 the dielectric constant is recovered.

(d) Assuming $\omega_B << \omega_p$, solve approximately for the various roots for the cases

(i) K parallel to b

(ii) K perpendicular to b. Sketch your result for w^2 versus k^2 in the two cases.

Text and Reference Books

- Classical Electronics : Jackson
- Electromagnetic Theory : B.B. Laud
- Classical Electricity and Magnetism : Pan of sky and Philips
- Plasma Physics : Chen
- Plasma Physics : Buttencourt

ELECTIVE PAPERS (ANY ONE OF THE FOLLOWING)

PY E - 201

ELECTIVE PAPER

IV (A) CONDENSED MATTER PHYSICS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: To study some of the basic properties of the condensed phase of materials especially solids.

1.	To expose the students with topics like crystal structure using XRD, defects in crystals, dielectric properties, energy band and transport theory so that they are equipped with the to understand advanced aspects of the matter in condensed phase.
2.	To relate crystal structure to symmetry, recognize the correspondence between real and reciprocal space.
3.	Acquire knowledge of the behavior of electrons in solids based on classical and quantum theories.
4.	To become familiar with the different types of magnetism and magnetism based phenomenon & to develop an understanding of the dielectric properties and ordering of dipoles in ferroelectrics.
5.	To get familiarized with the different parameters associated with superconductivity.

Course Outcomes: The purpose of the course is to introduce the concept of Condensed Matter Physics and on completion of the course; the student should acquire basic knowledge and will be

1.	Able to understand the X-ray diffraction and its use in crystal structure, Concept of reciprocal lattice, defects in solids and their observation.
2.	Able to understand the electronic properties of solids and understand the difference in the classical free electron theory, quantum free electron theory and the nearly free electron model.
3.	Able to understand types of polarizabilities, Hall effect and quantum hall effect. Superconductivity and high T_c superconductors.
4.	Able to understand ferromagnetism and its theory, Curie-Weiss law, magnetic order.
5.	Able to understand optical properties, Kramer-Kronig relations, cyclotron resonance, Raman effect.

UNIT – I

Interaction of X-rays with matter, absorption of x-ray, Elastic scattering from a perfect lattice. Thereciprocal lattice and its applications to diffraction techniques in the Laue, powder and rotating crystal methods. Crystal structure factor and intensity of diffraction maxim.

Point defects, line defects and planer (stacking) faults. The role of dislocation in plastic deformation and crystal growth. The observation of imperfections in crystals – x-ray and electron microscopic techniques.

UNIT - II

Free electron Fermi gas, Energy levels of orbital in one and three dimensions. Electrons in a periodic lattice, Bloch theorem band theory of solids. Classification of solids Effective mass. Tight-binding, cellular and pseudo potential methods, Fermi surface, de Hass von Alfen effect.

UNIT - III

Atomic and molecular polarizability, Claussius-Mossotti relation, types of polarizabilities, Dipolar polarizability, and frequency dependence of dipolar polarizability. Ionic and electronic polarizability .Hall effects in low fields, Quantum Hall effect, Magneto-resistance. Super conductivity, critical temperature persistent current, Meissner effect. General idea about high temperature superconductors.

UNIT - IV

Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, spin waves and magnons, Curie-Weiss law for susceptibility, Ferri and antiferro-magnetic order, Domains and Bloch-wall energy.

Optical reflectance, Kramer-Kronig relations, Light absorption spectrum of semiconductors cyclotron resonance Photo electromagnetic effect, Faraday effect, Elements of Raman effect in solids.

UNIT - V

This unit will have four questions based on tutorial problems covering all four units. The students will have to answer any two questions out of four. Some sample problems are:

(1) Given that the primitive basis vectors of a lattice a = (a/2) (i + j), b = a/2 (j + k) and c = a/2 (k + j) where i, j and k are usual three unit vectors along Cartesian coordinates. What is the Bravais lattice?

(2) Determine planes in a fcc structure having highest density of atoms.

Or

Evaluate density of atoms for Cu. in atoms/cm^2.

(3) For the delta function potential and with p > 1 find at k = 0 the energy of the lowest energy band. Also find the band gap at $k = \pi /a$.

(4) Consider a square, lattice in two dimensions with the crystal potential.

$$U(x,y) = 4U \cos (\pi x/a) \cos (\pi y/a)$$

Apply the central equation to find approximately the energy gap at the corner point $(\pi/a, \pi/a)$ of the Brillouin Zone.

(5) Explain why the Hall constant is inversely proportional to the electron concentration M.

Text and Reference Books

➢ Solid State Physics	:	C. Kittel
➢ Introduction to Solid	:	Azaroff
➢ Crystallography for Solid State Physics	:	Verma and Shrivastava
➢ Solid State Physics	:	A.J. Dekker
➢ Elementary Solid State Physics	:	Omar
➢ Solid State Physics	:	Aschroft and Mermin
➢ Principles of Condensed Matter Physics	:	Chaikin and Lubensky
➢ X-ray Diffraction –Its Theory and Applications	:	S.K.Chatterjee
➢ Solids	:	H,C.Gupta

ELECTIVE PAPER
PY E - 202
IV (B) INFORMATICS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The aim and objective of the course on Informatics is to familiarize with the information methods

1.	To provide an understanding of Integral Transform and Probability.
2.	To expose the basics of Fourier series and transform and application in data communication.
3.	Acquire knowledge of about Transmission and their types.
4.	To know about UNIX/LINUX and introduction to C/ C++ language.
5.	To get familiarized with the web enabling technologies & related languages.

Course Outcomes: At the end of the course, the student will be able to

1.	Use Fourier series and transformations as an aid for analyzing experimental data.
2.	Understand the principles of fiber optics communication in different media
3.	Intended to enrich the learner about transmission types, codes and communication. Modems and Transmission media.
4.	Introduction to UNIX/ LINUX, Programme with the C/ C^{++}, Data types, Functions and Program structures.
5.	Able to know Object oriented concepts, the languages used to delivered web enabling technologies.

UNIT – I

Introduction to Probability and Random variables, Introduction to Information theory and queuing theory.

Fourier series and transform and their applications to data communication. Introduction and evolution of Telecommunication, Fundamentals of electronic communication: Wired, Wireless, Satellite and Optical Fibre, Analog/Digital, Serial/Parallel, Simplex/half and full duplex, Synchronous/ Asynchronous, Bit/baud rates, Parity and error control, Signal to Noise ratio.

UNIT – II

Transmission types, Codes, Modes, Speed and throughput. Modulation types, Techniques and standards. Base band and carrier communication, Detection, Interference, Noise signal and their characteristics, Phase locked loops.

Modems, Transmission media (guided and unguided), common Interface standards.

UNIT – III

Introduction to Unix/Linux and shell scripting. Introduction to C/ C^{++}. Data types and operators, Statements and Control flow, Functions and Program structures, Strings, The preprocessor, Pointers, Memory allocation, Input and output, Sub program, Recursion, File access.

UNIT – IV

Object orientation concepts: Classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance and polymorphism, analysis and design; Notations for object-oriented analysis and design, Application of some object oriented programming languages.

Introduction to web enabling technologies and authoring tools/ languages, (web casting data base integration, CGI, Peri, Java, HTML, C#)

UNIT - V

This unit will have four short question based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

(1) A raised cosine pulse used in commutation systems shows a signal $g_p(t)$ [1+ cos2πt] that is a periodic sequence of these pulses with equal spacing between them. Show that the Fourier series expansion of $g_p(t)$ is given by

$$g_p(t) = \frac{1}{2} + \frac{8}{3\pi}\cos(\pi t) + \frac{1}{2}\cos(2\pi t) + ---$$

What is channel capacity for a teleprinter channel with a 300 Hz bandwidth and a signal – to- noise ratio of 3 dB?

(2) Estimate the thermal noise level of a channel with bandwidth of 10 kHz carrying 1000 watts of power operating at 50^{o}c?

(3) A transmitter receiver pair is connected across a coaxial cable. The signal power measured at the receiver is 0.1 watt. Signal levels change 100 times per second. Noise energy is 0.05 μ Joules for every 1 milliseconds. If E_b/N_o= 10 dB is desired, determine how many levels must be accommodated in the signal to encode the bits. What would be the bit rate?

(4) Write an awk script to process Lete/ password file and print (a) List of accounts with access of super user (b) All accounts with no password.

(5) Write C/C^{++} program to manipulate file.

(6) For each of the following system identity the relative importance of three aspects of modeling (a) Object modeling (b) Dynamic modeling (c) Functional modeling. (1) Remote controlled machine (2) Telephone answering machine.

(7) How Java and HTML is implemented.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and References Books

➢ Data Networks	-	Gallager
➢ Data Communication	-	William stalling
➢ Analog and Digital communication	-	S. Haykins
➢ Object oriented Analysis and Design with Application	-	G. Booch, Addison Wesley, 2nd Edition, 1994
➢ Beginning Object Oriented Analysis and Design using C ++,	-	Jesse Liberty Wrox Press, 1998.
➢ Multimedia Networking	-	Bohdan O. Szuprowic, McGraw Hill, Snigapore, 1995 (ISE)
➢ Computer Networks	-	William Stalling, PHI
➢ Computer Networks	-	A.S. Tanenbaum Prentice Hall of India.

ABILITY ENHANCEMENT AND SKILL DEVELOPMENT
PRACTICAL COURSES
SEMESTER I & II
LIST OF PRACTICALS
LAB A: PY L 104 and PY L 204

Section – I (General Physics)

(Preferably six experiments to be performed by the students)

(1) Determination of separation of two plates of Febry Perot Etalon.

(2) (a) Measurement of Wavelength of He-Ne Laser.
(b) Measurement of thickness of thin wire with laser.

(3) Determination of Poisson's Ratio of glass plate by Cornu's method.

(4) Optical Fibre
(a) Determination of numerical aperture.
(b) Attenuation loses.
(c) Bending loss.

(5) Production and study of elliptically and circularly polarized light by Fresnel's Rhomb.

(6) Verification of Hartman's formula by constant deviation spectrometer.

(7) Verification of Fresnel's law of reflection for polarized light.

(8) Study of the fluorescence spectrum of DCM dye and to determine the quantum yield of fluorescence maxima and full width at half maxima for this dye using monochromator.

(9) To study Faraday Effect using He-Ne Laser.

(10) Determination of e/m eluting by normal Zeman effect.

(11) Measurement of resistively of a semiconductor by four probe method at different temperature and determination of band gap.

(12) Measurement of Hall coefficient of given semiconductor identification of type of semiconductor and sign of charge, carrier concentration.

(13) Determination of lande's factor of DPPH using ESR.

TUTORIAL

(1) Coherence and its relevance in diffraction.
(2) Effect of magnetic field on the plane of polarization.
(3) Normal Zeaman effect by Ferry Pert Etelon.
(4) Longitudinal and transverse bending of glass plate.
(5) Variation of refractive index with wave length of light.
(6) Propagation of light wave through optical fiber.
(7) Identification of charge type by Hall voltage measurement.
(8) Four prove method and the contact renitence problem.

Section – I (Electronics)

(Preferably six experiments to be performed by the students)

(1) Design of a regulated power supply.
(2) Design of a common Emitter Transistor Amplifier.
(3) Experiment on Bias stability.
(4) Negative Feedback (Voltage Series/ Shunt and Current Series/Shunt).
(5) Astable, Monostable and bistable Multivibrator.
(6) Characteristics and application of Silicon controlled Rectifier.
(7) Experiment on FET and MOSFET characterization and application as an amplifier.
(8) Experiment an UJT and its applications.
(9) Digital I: Basic Logic Gates, TTL, NAND and NOR.
(10) Digital II:Combinational Logic.
(11) Flip-Flops.
(12) Operational Amplifier (741).
(13) Differential Amplifier.
(14) expEYES based Physics practicals(a) Transient response of LCR,(b) Two phase AC Generator using a rotating magnet and two coils(c)Interference of sound from piezo-electric buzzers(d) PN junction Diodeas half wave rectifier and its IV characterics

TUTORIAL

(1) Network Analysis- Thevnin and Norton's equivalent circuits.
(2) Basics of p-n junction-Diffusion current, Drift current, junction width, forward and reverse biasing, significance of Fermi level in stabilizing the junction.
(3) Zener Diode- characteristics and Voltage regulation.
(4) Transistor biasing and stability.
(5) Wien Bridge and phase shift oscillators.
(6) Solving Boolean expressions.
(7) Atomic scattering power and geometrical structure factor.
(8) Effect of capacitance and load resistance on output of an amplifier.
(9) Integrated circuit timer familiarization.
(10) Op-amp differentiator.
(11) Multiplexor and De-multiplexor.
(12) Registers and counters.
(13) Coincidence circuits, counters, timers.

LAB B: PY L 105 AND PY L 205
(Computer Programming)

(Preferably six experiments to be performed by the students)

(1) Preparation of result of an examination.
(2) Mean standard deviation, coefficient of correlation and the equation of regression line for two variables.
(3) Least squares fit for a straight line.
(4) Least squares fit for a parabola.
(5) Solution of simultaneous equations.
(6) Solution of differential equations.
(7) Graphical depiction of expanding cube.
(8) Integration by Simpson's Rule.
(9) Integration by Gaussian Quadrature.
(10) Solution of partial differential equation.

TUTORIAL

(1) Different BASIC statements.
    (a) If (b) GOTO (c) GOSUB statement.
(2) Graphic statements in BASIC.
(3) GET-PUT and LOCATE statements.
(4) Newton Raphson iterative method for the solution of non-linear equations.
(5) What is meant by numerical integration? Derive Trapezoidal rule for numerical integration.
(6) Reading from a data file and writing on a data file in BASIC.

Note: Appropriate other experiments can be added based on the prescribed syllabus in both the Labs A & B

RANI DURGAVATI VISHWAVIDYALAYA, JABALPUR
SYLLABUS PRESCRIBED FOR THE EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN PHYSICS
THIRD AND FOURTH SEMESTERS (with effect from 2021-2022)
UNDER Choice Based Credit System (In Accordance with University Ordinance No – 222) AND LEARNING OUTCOME BASED CURRICULUM FRAMEWORK

M.Sc. THIRD SEMESTER PHYSICS

Theory Courses		Marking Scheme			
Paper Code	**Title of Paper**	**Credits**	**End Semester Exam.**	**CCE**	**Total**
PY C - 301	**Core Paper** **Quantum Mechanics – II**	**5**	**60**	**40**	**100**
PY C - 302	**Core Paper** **Nuclear and Particle Physics**	**5**	**60**	**40**	**100**
III & IV **PY SE – 301** **PY SE – 302** **PY SE – 303** **PY SE – 304**	**Special Elective Papers (Any two)** **A- Condensed Matter Physics - I** **B - Electronics - I** **C - Materials Science - I** **D - Computational Physics - I**	**5**	**60**	**40**	**100**
		5	**60**	**40**	**100**

Practical Courses		Credits	End Semester Exam.	CCE: Pract Record& Viva	CCE: Seminar related to Pract.	CCE: Total	Total
PY L – 301 **PY L – 302** **PY L – 303** **PY L – 304**	**Lab A**	**3**	**60**	**20**	**20**	**40**	**100**
	Lab B	**3**	**60**	**20**	**20**	**40**	**100**
PY S – 301	**Skill Development**	**2**					
Total		**28**	**360**	**240**			**600**

CORE PAPER – I
PYC 301 QUANTUM MECHANICS – II

60+40= 100 MARKS **5 CREDITS**

Course Objectives: To impart knowledge of advanced quantum mechanics for solving relevant physical problems.

1.	To learn how to apply Perturbation Theory (Time Independent) in non-degenerate and degenerate situations.
2.	To apply approximate method in Quantum Mechanics to treat molecules.
3.	To learn time dependent perturbation theory.
4.	To learn theory of scattering.
5.	To learn the basics of relativistic quantum Mechanics.

Course Outcomes: To equip with the techniques of quantum mechanics so that it can be used in understanding various branches of physics.

1.	Understand Approximation methods for bound states.
2.	Understand the Time Independent Perturbation Theory and its application.
3.	Understand theory of scattering, Born approximation and partial waves, Scattering by rigid sphere and spherically symmetric potential, Pauli spin matrices.
4.	Understand the central concept and principles of relativistic Quantum Mechanics.
5.	Understand Klein- Gordon equation, Dirac's relativistic equation, Zitterbewegung Dirac relativistic equation.

UNIT - I

Approximation method for bound states: Rayleigh-Schrodinger perturbation theory of non-degenerate and degenerate levels and their application to perturbation of an oscillator, normal Helium atom, and First order Stark effect in Hydrogen. Variation method and its application to ground state of helium, W.K.B. approximation method, connection formula, Ideas on potential barrier with applications to the theory of alpha decay.

UNIT-II

Time dependent perturbation theory: Method of variation of constants, constant and harmonic perturbation, transition probability, adiabatic and sudden approximation. Hamiltonian for a charged particle under the influence of external electromagnetic field, Absorption and induced emission, Transition probability in Electric dipole transition, Einstein's A and B coefficients.

UNIT - III

Theory of scattering, Physical concepts, Scattering amplitude, scattering cross section. Born approximation and partial waves. Scattering by a perfectly rigid sphere, complex potential and absorption, scattering by spherically symmetric potential. Identical particles with spin, symmetric and antisymmetric wave functions, Pauli's exclusion principle, Pauli's spin matrices.

UNIT – IV

Schrodinger's relativistic equation (Klein-Gordon equation), Probability and current density, Klein-Gordon equation in presence of electromagnetic field, Hydrogen atom, short comings of Klein-Gordon equation. Dirac's relativistic equation for a free electron, Dirac's matrices, Equation of motion for operators, position momentum and angular momentum; spin of an electron, Zitterbewegung Dirac's relativistic equation in electromagnetic field, negative energy states and their interpretation, Hydrogen atom, Hyperfine splitting.

UNIT - V

This unit will have four short questions based on tutorial problems covering all the four units. Students will have to answer any two questions out of four. Some sample problems are:

1. Normal Zeeman Effect.
2. Anomalous Zeeman Effect.
3. Vander Waals interactions.
4. Ionization of a hydrogen atom
5. Selection rules for single and many particle systems.

6. Optical theorem and Ramasuer- Townsend effect.
7. Scattering from standard simple potentials using partial wave analysis and Born Approximation.
8. Slater determinant.
9. Spin and statistics
10. Difference in collision process between classical and quantum identical particles.
11. Magnetic moment and spin of a Dirac's electron.
12. Covariance of a Dirac's equation.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books

- Quantum Mechanics : L. I. Schiff
- Quantum Mechanics : S. Gasiorowicz
- Quantum Physics : B. Craseman and J.D. Powell
- Quantum Mechanics : A.P. Messiah
- Modern Quantum Mechanics : J.J. Sakurai
- Quantum Mechanics : Mathews and Venkatesan
- Quantum Mechanics : A.K. Ghatak and Loknathan

CORE PAPER II
PY C – 302 NUCLEAR AND PARTICLE PHYSICS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The aim and objective of the course on Nuclear and Particle Physics is to familiarize with the basic aspects of Nuclear and Particle Physics

1.	To impart the knowledge regarding the fundamentals and basics of Nuclear interactions and Nuclear Reactions..
2.	To provide the knowledge of the Two-nucleus problem, concept of nuclear force.
3.	To acquire knowledge about the various nuclear models.
4.	To have an understanding of nuclear decay theories.
5.	To have an idea of elementary particles and their classification. Idea of basic nature and origin of Cosmic rays.

Course Outcomes: Students will have understanding of

1.	The method and analysis of Scattering process & understand structure and properties of nuclei, radioactive decay, and different types of nuclear reactions.
2.	Compare various nuclear models and properties of the nucleus & to study the nuclear structure properties.
3.	Various nuclear radiation detectors like Betatron and Synchrotron & describe various types of nuclear reactions and their properties.
4.	Nuclear decay processes and theory for beta and gamma decay.
5.	The nature, interaction etc. of the elementary particles and origin, nature of Cosmic rays. Bhabha-Heitler theory.

UNIT – I

Nuclear Interactions and Nuclear Reactions

Nucleon- nucleon interaction, exchange forces and tensor forces, meson theory of nuclear forces, nucleon, nucleon scattering, Effective range theory, spin dependence of nuclear forces, charge independence and charge symmetry of nuclear forces, Isospin formalism, and Yukawa interaction.

Direct and compound nuclear reaction mechanisms, cross sections in terms of partial wave amplitudes, compound nucleus, scattering matrix, Reciprocity theorem, Breit- Wigner one–level formula, Resonance scattering.

UNIT - II

Nuclear Models

Liquid drop model, Bohr–wheeler theory of fission, Experimental evidence for shell effects- shell model, spin, orbit coupling, magic numbers, Angular momenta and parities of nuclear ground states, Qualitative discussion and estimates of transition rates, magnetic moment and Schmidt lines, Collective model of Bohr and Mottelson .

UNIT – III

Nuclear Decay

Beta decay, Fermi theory of beta decay, Comparative half, lives, Parity violation, Two component theory of neutrino decay, Detection and properties of neutrino Gamma decay, Multipole transition in nuclei Angular momentum and parity selection rules Internal conversion, Nuclear isomerism.

General ideas of nuclear radiation detectors, linear acceleration, Betatron, Proton-synchrotron, Electron synchrotron.

UNIT - IV

Elementary particle physics

Types of interaction between elementary particles, Hadrons and leptons, Symmetry and conservation laws, Elementary ideas of : CP and CPT invariance, Classification of hadrons, lie algebra, SU(2) – SU (3) multiplets, Quark model, Gell Mann- Okubo mass formula for octet and decuplet hadrons, Charm, bottom and top quarks.

Cosmic Rays

Nature, composition, charge and energy spectrum of primary cosmic rays, production and propagation of secondary cosmic rays. Soft, penetrating and nucleonic components, Origin of cosmic rays, Rossi curve, Bhabha – Heitler theory of cascade showers.

UNIT – V

This unit will have four short questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are.

1. Scattering Matrix.
2. Nucleon- Nucleon phase Shifts.
3. Double Scattering Experiment to measure polarization.
4. Ground state spectroscopic configuration of nuclei on the basis of single particle shell model.
5. The Q – Equation.
6. Calculation of Absorption Cross Section.
7. Nuclear Quadrapole moment.
8. Kurie Plot
9. Selection Rules for β and γ decay.
10. Parity Violation Experiment.

11. Neutrino Helicity.
12. Isospin Symmetry.
13. Lie Algebra.
14. Origin of cosmic rays.
15. Bhabha-Heitler theory.

In addition to above the tutorial will also consist of solving problems given in the Text and Reference books.

Text and Reference Books

- Kenneth S. Kiane. Introductory Nuclear Physics, Wiley New York 1988..
- H.A. Enge, Introduction to Nuclear Physics, Addison- Wesley, 1975.
- G.E.Brown and A.D. Jackson, Introduction to Nuclean nucleon Interaction, North – Holland, Amsterdam, 1976.
- Y.R. Waghmare, Introductory Nuclear Physics, Oxford-IBH Bombay,1981
- I. Kaplan, Nuclear Physics, 2” Ed. Narosa, Madras, 1989
- R.D.Evans, Atomic Nucleus, McGraw Hill, New York, 1955.
- B.L. Cohen, Concepts of Nuclear Physics, TMGH, Bombay, 1971.
- R.R. Roy and B.P. Nigam Nuclear Physics, Wiley- Eastem Ltd, 1983.
- Bruno Rossi, Cosmic Rays
- B.N. Shrivastava, Basic Nuclear Physics and Cosmic Rays
- M.P. Khanna, Particle Physics, Prentice Hall
- Burcham, Nuclear Physics

PAPERS III &IV: SPECIAL ELECTIVE PAPERS
(ANY TWO OF THE FOLLOWING)
PY SE – 301
(A) CONDENSED MATTER PHYSICS – I

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of the course is to develop specialization skill with advance knowledge in the subject.

1.	To become familiar with the effect of defects and deformation behavior of solids. Nature of Dislocations and their multiplication
2.	To become familiar with the interaction of dislocations, Partial dislocations and stacking faults in crystal structures. Experimental techniques to observe dislocations and stacking faults.
3.	To be familiar with thin films and their surface topography and electrical behavior.
4.	To become familiar with the lattice dynamics of monatomic and Diatomic lattice.
5.	To understand the different optical processes and photo-physical properties of solids.

Course Outcomes: Students will have understanding of

1.	Mechanism of plastic deformation, Dislocations and their stress and strain fields, Multiplication, Dislocations in different types of lattices.
2.	Concept of Dislocation interaction and partial dislocations, Demonstrate techniques of microscopy for their observation. About elementary concepts of surface crystallography.
3.	Idea about thin films, their surface topography & electrical properties of thin films.
4.	Optical properties of solids, direct and indirect transitions, phonon absorption, skin effect.
5.	Able to define the concepts of Phonons and to understand the lattice dynamics of mono and diatomic lattices, Debye-Waller factor, UmKlapp process, interaction of electron and phonons with photon.

UNIT - I

Imperfection in Crystals

Mechanism of plastic deformation in solids, stress and strain field of screw and edge dislocations. Elastic energy of dislocations. Forces between dislocations. Stress needed to operate Frank-Read source, dislocations in fcc, hcp and bcc lattices.

UNIT - II

Partial dislocations and stacking faults in closed packed structures. Experimental methods of observing dislocations and stacking faults. Electron microscopy, kinematical theory of diffraction contrast and lattice imaging.

Elementary concepts of surface crystallography. Scanning tunneling and atomic force microscopy.

UNIT - III

Films and Surface

Study of surface topography by multiple-beam interferometry, conditions for accurate determination of step height and film thickness (Fizeau Fringes). Electrical conductivity of thin films, difference of behavior of thin films from bulk, Boltzmann transport equation for a thin film (for diffused scattering), expression for temperature coefficient of resistivity of thin films.

UNIT – IV

Lattice Dynamics

Lattice Dynamics of monatomic and Diatomic lattice, Optical phonons and dielectric constants. Mossbauer Effect, Debye – Waller factor Anharmonicity, Thermal expansion and thermal conductivity. Umklapp process, Interaction of electrons and phonons with photons.

Optical Properties of Solids

Direct and indirect transitions. Absorption in insulators, polaritons, one phonon absorption, optical properties of metals, skin effect and anomalous skin effect.

UNIT – V

This unit will have four short questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are.

1. Consider two parallel dislocations lying on the same slip plane. Their Burgers vectors lie parallel to the slip plane but are not parallel to each other. Their magnitudes are equal. Find all possible orientations of the Burgers vectors for which the component of the force between the dislocations that acts parallel to the slip plane is zero.
2. Prove that the stress σ_{ZZ} never exerts a force on a dislocation in which burgers vector lies parallel to the x direction regardless of the orientation of the dislocation line.
3. Derive Taylor’s relation between dislocation density and applied stress.
4. Discuss the working of atomic force microscope
5. Bring out the essential differences between diffuse and specular electron scattering from the conventional solid: bulk and films by taking the specific property of electrical conductivity.

6. What are thin and thick film? With reference to electronic conduction which films can be referred to as thin and which as thick taking into account the mean free path as a reference parameters.
7. Estimate for 300 K the root mean square thermal dilation AV/V for a primitive cell of sodium. Take the bulk modufus as 7×10^{10} erg cm^{-3}. Note that the Debye temperature 158 K is less than 300 K so that the thermal energy is of the order of K_BT. Use this result to estimate the root mean square thermal fluctuation $\Delta a/a$ of the lattice parameter.
8. Consider a classical harmonic oscillator with small anharmonic terms so that the potential energy is $V(x) = ax^2 + bx^3 + cx^4$. Using the partition function approach shows that the mean energy (ξ) and mean thermal displacement from equilibrium (x) are:

$$(\xi) = K_BT\ [15b^2/16a^2 - 3c/4a^2]\ (K_BT)^2$$
$$(x) = -(3b/4a^2)\ K_BT$$

The former leads to a high temperature contribution to the specific heat that is linear in temperature. The latter is an indication of the origin of thermal expansion (and the proper sign of the coefficient)

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books

- X-ray crystallography : Azaroff
- Elementary Dislocation Theory : Weertman & Weertman
- Crystallography for Solid State Physics : Verma & Srivastava
- Solid State Physics : Kittel
- The Powder Method : Azaroff & Buerger
- Crystal Structure Analysis : Buerger
- Transmission Electron Microscopy : Thomas
- Multiple Beam Interferometry : Tolansky
- Thin films : Heavens:
- Physics of thin film : K.L.Chopra
- Introduction to Solid State Theory : Medlung
- Quantum Theory of Solid State : Callaway
- Physical Metallurgy Principles : Robert E-Read
- Materials Science and Processes : S.K. Hajra Choudhary
- Introduction to Dislocations : D.Hull
- Dislocations and Plastic Deformation : I.Koracs and L.Zsotdos

SPECIAL ELECTIVE PAPER III & IV (B)
PY SE – 302
ELECTRONICS - I

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of the course is to develop specialization skill with advance knowledge in the subject.

1.	Information about communication electronics and types of modulation and demodulation processes.
2.	Contains information about Microwave electronics and Satellite communication.
3.	Knowledge about Micro-wave passive components and methods to measure various microwave

	parameters. Idea about Radars and its communication.
4.	Introduces architecture and functioning of 8085 Microprocessor.
5.	Idea of programmable interface devices and converters.

Course Outcomes: At the end of the course, the student will be able to

1.	Know the basic phenomenon of communication, modulation and demodulation and their types. Knowledge of microwave transmission and parameters affecting along with Satellite communication and geostationary system.
2.	Gain knowledge about working, design and application of microwave devices and systems. Idea of Radar and Antenna system and related parameters.
3.	Enrich the learner about Microwave transmission lines and waveguides. Through it students would be able to understand the propagation of microwave through transmission lines and Waveguides.
4.	Get knowledge of 8085 microprocessor architecture and its functioning and ability to understand and design the microcontroller and microprocessor based systems.
5.	Know the principle and working concepts of Interfacing devices like 8155/8255 and 8257 DMA and 8279 systems. Methods for digital and analog conversions.

UNIT - I

Communication Electronics

Amplitude modulation- Generation of AM waves- Demodulation of AM waves DSBSC modulation. Generation of DSBSC waves, Coherent detection of DSBSC waves, SSB modulation, Generation and detection of SSB waves. Vestigial sideband modulation. Frequency division multiplexing (FDM).

Microwave

Advantages and disadvantages of microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading sources, detectors, components, antennas used in MW communication systems.

Introduction to satellite communication, geostationary satellite, orbital patterns, satellite systems link modules.

UNIT-II

Microwave and Radar

Klystrons, Magnetrons and Travelling Wave Tubes, Velocity modulation, Basic principles of two cavity Klystrons and Reflex Klystrons, principles of operation of magnetrons. Helix Travelling Wave Tubes, Wave Modes.

Radar block diagram and operation, radar frequencies, pulse considerations. Radar range equation, minimum detectable signal, derivation of radar range equation, Antena parameters, system losses, propagation losses, Rader transmitters- receivers, display.

UNIT-III

Introduction to Intel 8085 microprocessor, instruction for 8085, and addressing modes, Data Transfer, Arithmetic, Logical and branch group of instructions. Stack, I/O and machine control group. (Examples related to each group of instructions). Timing and operation status, Memory read write, I/O read, I/O write, register move, and move immediate, Timing diagrams.

Interrupts: Various interrupts handling facilities of inlet 8085 vector and non vectored interrupt Maskable and non maskable interrupts.

UNIT-IV

Programmable Interface devices:

Internal Architecture and pin out diagrams of 8155 and 8255 programmable interface. Programmable interrupt controller Intel 8259, Direct memory access and 8257 DMA controller 8279 display/ key board controller.

Interfacing with D/A and A/D converters

Elementary method of digital to analog conversion. Working of DAC 0808 and programme for interfacing with 8255 in 8085 based system. Basic technique for analog to digital conversion. Internal block diagram of ADC 809 and working. Interfacing of IC 809 with 8085 based system.

UNIT – V

This unit will have four short questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

1. Effect of frequency and phase error in detection of DSBSC and SSBC signals.
2. Frequency considerations in satellite communication.
3. Make a clear distinction between velocity modulation and current modulation. Show how each occurs in Klystron amplifier, and explain how current modulation is necessary if the tube is to have significant power gain.
4. Different type of Radar system.
5. Timing diagrams for 8085 microprocessor instruction for fetch and execute machine cycles and calculation of T states used.
6. Program with flow chart to take in ten data samples of one microsecond interval and store them in memory.
7. Interfacing of 8255 with 8085 in MOD 0 and MOD 1.
8. Program for a interrupt driven clock using 50 Hz mains as an interrupting source.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books

- Vacuums Tubes : Karl R. Spangenberg McGraw Hill
- Communication System : Taub and Schilling McGraw Hill
- Communication Electronics : John Kennedy
- Microprocessor Architecture : Ramesh S. Gaonkar
- Programming &Application
- with 8085MICROPROCESSORS : B. RAM
- Microcomputer : Malvino
- Microwaves : K.L. Gupta
- Advance Electronics Communication System : Wayne Tamasi

SPECIAL ELECTIVE PAPER III & IV (C)

PY SE – 303

MATERIALS SCIENCE – I

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of the course is to develop specialization skill with advance knowledge in the subject

1.	To understand the correlation between bonding and structure, and bonding and properties & the physical origin and demonstrate the correlation between structure and properties of materials.
2.	The meaning of phases, and the different types of phase transformations.
3.	To introduce common crystal defects and to understand their role in materials behavior & time-dependent and time-independent diffusion in solids.
4.	To introduce with the preparation of materials and concept of crystal structure, and the myriad of structures possible in metals and ceramics, as well as crystalline polymers, including crystal planes and diffraction.
5.	Characterization of microstructure using optical microscope.

Course Outcomes: Students will have understanding of

1.	Able to qualitatively describe the bonding scheme and its general physical properties, as well as possible applications.
2.	Given a binary phase diagram, what microstructures can be obtained by suitable thermal treatments? examples for near-equilibrium and far-from-equilibrium processing.
3.	Able to identify phases (and their abundance), phase rule, and invariant reactions, as well as identify simple microstructures that can occur (including possible effects on mechanical response).
4.	Demonstrate techniques of microscopy for investigation on the nanometer and atomic scales
5.	Ability to know the basic instruments in materials science and engineering to characterize the structural properties.

UNIT - I

Introduction to Materials Science

A brief introduction to general engineering materials (Metals, alloys, glasses, ceramics, polymers, composites), General classification based on structure and properties, Fusion and crystallization, glass transition, significant difference between crystalline and non-crystalline materials.

Atomic bonding and Coordination

Individual atoms and ions, molecules, macromolecules, three dimensional bonding, interatomic distances, Generalizations based on atomic bonding, crystalline phases, cubic structures, non-cubic structures, imperfection in crystalline solids, grains and grain boundaries, non-crystalline materials, order and disorder in polymers, solid solutions, solid solutions in ceramic and metallic compounds and polymers.

UNIT - II

Phase Equilibrium and Reaction Rates

Introduction, phase diagram (Qualitative) chemical compositions of equilibrated phases, phase rule, quantities of phases in equilibrated mixtures, Invariant reactions, Deferred reactions (Glasses), Segregation during solidification, Nucleation.

Diffusion in Materials

Introduction to kinetics and diffusion, Atomic Vibration, Atomic Diffusion, mechanism of diffusion, macroscopic and microscopic view points, Ficks laws of diffusion, Einstein's relation, (relation between diffusivity and mobility) solution of Ficks second law and its application, Kirkendall effect, diffusion tensors experimental determination of diffusion coefficient.

UNIT - III

Preparation of Materials

Growth of single crystals; vapour – solid, liquid – solid, solid - solid and zone refining process. Preparation of polymers, ceramics, composites and nanomaterials. Introduction to preparation of thin films.

Characterization of materials using x-ray diffraction

Measurement of diffraction pattern of crystals, Inter planar spacing, Diffraction analysis, Determination of Lattice constant.

UNIT IV

Micro Structures

Single phase materials, Grains, ASTM Grain size numbers, Grain growth, phase distributions (Precipitates) - precipitation rates, inter-granular and intra-granular precipitation; phase distribution (Eutectoid Decomposition)- Pearlite, Hypo and Hyper eutectoid microstructures, Isothermal Decomposition of Austenite; modification of microstructures- coalescence, Spheroidization, Martensite, Tempered Martensite; Microstructures within polymers-crystallinity in polymers, polyblends.

Optical and Thermal Characterization Techniques

Electron microscopy, scanning and transmissions, optical microscopy and topography by multiple beam interferometry, brief introduction to Auger, ESCA, FIM and AFM, DTA, DSC and TGA techniques.

UNIT – V

The unit will have four short questions based on the tutorial problems covering all the four units. The students will have to answer any two questions. The samples problems are:

1. Which part has the greater stress : (a) a rectangular aluminum bar of 24.6 mm × 1.21 in) in cross section, under a load of 7640 kg and therefore a force of 75,000 N (16,800 lb); or (b) a round steel bar whose cross sectional diameter is 12.8 mm (0.505 in), under a 5000 - kg (11,000 lb) load ?
2. How much energy is required, + (or, released, -) if 2.6 kg of acetylene C_2H_2, react with hydrogen to produce ethylene, C_2H_4 ?.
3. A plastics molding company buys a phenol formaldehyde raw material that is only two thirds polymerized; that is there is an average of only two - CH_2 bridges joining each phenol rather than the maximum three.

   (a) How many g of additional formaldehyde are required per kg of the above raw material to complete the network formation (that is, to make the phenols fully trifunctional ? (b) How many g of water will be formed in this thermosetting step?
4. For Ag-Cu system. (a) Locate the liquidus and solidus (b) How many phases are present where the two meet?

5. To produce a p-type semiconductor, the third column element boron is doped in pure silicon. The doping is done through a B_2 O_3 vapour phase of partial pressure equal to 1.5 Nm^{-2}. This atmosphere is equivalent to surface concentration of 3 × 10^{26} boron atoms per m3. Calculate the time required to get a boron content of 10^{23} atoms per m^3 at a depth of 2μm. The doping temperature is $1100^{o}C$ and In-Si at this temperature is 4 × 10^{-17} m^2 S^{-1}.

6. At 500 ^{o}C (7773 k) a diffusion experiment indicates that one out of 10^{10} atoms has enough activation energy to jump out of its lattice site into an interstitial position. At 600 ^{o}C (873 k), this fraction is increased to 10^{-9} (a) what is the activation energy required for this jump? (b) What of the atoms has enough energy at 700 ^{o}C (973 k)?

7. Discuss the method of preparation of (one)
   (i) Alkali halide crystal using Kyropolous technique,
   (ii) $BaTiO_3$ using solid state ceramic method
   (iii) Polymer blends.

8. A diffraction pattern of a cubic crystal of lattice parameter a 3.16 Å is obtained with a monochromatic X-ray beam of wavelength 1.54 Å. The first four lines on this values :

Line	θ (in degrees)
1	20.3
2	29.2
3	36.7
4	43.0

   Determine the inter planner spacing and the auller indices of the reflecting planes.

9. From a powder diameter 114.6mm, using X-ray beam of wavelength 1.54 Å, the following 5 values in mm are obtained for a material:
   86, 100, 148, 180, 188, 232 and 272.
   Determine the structure and the lattice parameter of the material.

10. Calculate the density of fully crystalline poly ethylene whose chains are aligned longitudinally. The unit cell is orthorhombic with 90^{o} angles. The unit cell parameters are 0.740 nm, 0.493 nm and 0.253 nm.

11. What do you understand by ASTM Grain size numbers? Explain the procedure to obtain it giving examples.

12. Discuss the application of DTA, DSC and TGA techniques in the development of material.

In addition to above the tutorial will also consist of solving problems given in the text and reference books.

Text and Reference Books

- Elements of Materials Science and Engineering (Sixth Edition)-Lawrence H., Van Vlacle, Addition Wesley (1989).
- Elements of Solid State Physics-J.P. Shrivastava- Premtice Hall India (2001).
- Materials Science and Engineering-V. Raghwan-Fourth Edition-Prentice Hall (2000).
- The Structure and Properties of Materials Vol. I, II, III, and IV –John Wulff et al. Wiley Eastern Limited.
- Physical Metallurgy Principles Robert E-Reed-Hill, East West Press New Delhi.
- Introduction to Solid-A Zroff.

- Materials Science and Processes– Hajra Choudhry Indian Book Distribution co.
- Materials Science and Engineering- William D. Callister Jr, John Wiley (2001).
- Experiments in Materials Science- E.C. Subbarao, L.K. Swghal, D. Chakraborty, M.F. Merriam and V.Raghavan, Tata McGraw Hill, New Delhi.

SPECIAL ELECTIVE PAPERIII & IV (D)
PY SE – 304
COMPUTATIONAL PHYSICS – I

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of the course is to develop specialization skill with advance knowledge in the subject.

1.	To become familiar with the numerical methods used in computation and programming using any high level language such as C^{++}, so that they can use these in solving simple physics problems.
2.	To give comprehensive exposure to the students regarding associated digital electronics for implementation of computational techniques.
3.	To apply computational methods to solve problems in physics with representative examples.
4.	To gain knowledge on integral equations & also to gain familiarity with the numerical solutions of partial differential equations.
5	To apply computational methods to solve various problems of Electronics with representative examples.

Course Outcomes: Students will have understanding of

1.	General concepts and structure of C^{++} programming for developing computational methods.
2.	Review of instruments and related electronics used in computer controlled instrumentation. Idea of 8085 and 8086 based microcomputer system their programming and interface.
3.	Computation and the evolution of phase space as various parameters are changed.
4.	Solving problems related to propagation of elastic waves in solids, Phase trajectory of chaotic pendulum, Poincare section etc. Using computational techniques.
5.	To explore application of computational physics in frontier areas of Electronics such as electromagnetic oscillation in LC circuit, Fourier analysis in harmonic waves, circuits having LCR, acceleration of charged particle in cyclotron etc.

UNIT – I

Introduction to C^{++}

General concepts, structure of C^{++} program, variables and constants, operators and expression, Flow of control, conditional and unconditional loops, Data types, Array, functions, standard Library functions, Programming methodology, type of errors, scientific programmes with examples, organization and handling of files in C^{++}.

UNIT – II

Interfacing and computer controlled Laboratory, Brief review of instruments used in computer controlled instrumentation : Logic Gates (AND, OR, NOT, NAND, NOR, EXCLUSIVE-OR) and their truth tables, Flip-flops (SR. JK, Master-slave, JK, D,T) counters shift registers, encoders, decoders, multiplexing, demultiplexing, General ideas of 8-bit microprocessors (8085), 8086 based microcomputer system, programming and interfacing with ADC, and DAC, use of IEEE 488 OR RS 232 interfaces with application.

UNIT – III

Computer Application to problems in Physics - I : (1) propagation of elastic waves in crystalline solid, (2) Bifurcation points of one- dimensional logistic maps using Newton's method, (3) Phase Trajectory of chaotic pendulum, (4) Study of poincare section, (5) Study of motion of charged particle in an Electric field.

UNIT – IV

Computer Application to problems in Physics - II: (1) Study of Electronic configuration of any Element, (2) Study of Electromagnetic Oscillation in LC circuit, (3) Study of Fourier Analysis of Harmonic wave, (4) Study of circuit with Inductors, capacitors and Registers, (5) Acceleration of a charged particle in cyclotron.

UNIT - V

This unit will have four short question based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

1. (a) Write a programme to calculate and print roots of a quadratic $ax^2+bx+c = 0$ ($a\neq 0$).
   (b) Write a programme to add and multiply two matrices.
2. Illustrate the use of function by a program.
3. Explain the meaning of latches and multiplexing.
4. Using a block diagram explain the computer interfacing of a spectrum analyzer.
5. Modeling and simulation of predator and prey problem.
6. Charged particle in a magnetic field.
7. Study of convection of fluids.
8. Discuss Lorentz system and Lorentz attractors.

In addition to above the tutorial will also consist of solving problems given in the text and reference books.

Text and Reference Books

- Computational Physics - R.C. Verma, P.K. Ahluwalia and K.C. Sharma, New Age Publishers (1999)
- Programming in ANSI C, - E. Balaguruswami Tata Mc Graw Hill (1994)
- Numerical Recipes in FORTRAN - Press W.H., Teukolsky S.A. Vellerling W.T. and Flannery B.P. (Cambridge Univ. Press 1992)
- Simulation using Personal Computers - Carroll, J.M. (Prentice Hall, 1987)
- FORTRAN-77 with applications for Scientists and Engineers - Rama, M. Reddy and Carola, Ziegler.

M.Sc. PHYSICS FOURTH SEMESTER

Theory Courses		Marking Scheme			
Paper Code	**Title of Paper**	**Credits**	**End Semester Exam.**	**CCE**	**Total**
PY C - 401	**Core Paper** **Atomic and Molecular Physics**	**5**	**60**	**40**	**100**
PY E – 401 **PY E – 402** **PY E – 403**	**Elective (Any One of the following)** **A - Physics of Lasers and Laser Applications** **B - Non-linear Dynamics** **C - Physics of Nano-materials**	**5**	**60**	**40**	**100**
PY SE – 401 **PY SE – 402** **PY SE – 403** **PY SE – 404**	**Special Elective Papers (Any two)** **A - Condensed Matter Physics - II** **B - Electronics - II** **C - Materials Science - II** **D - Computational Physics - II**	**5**	**60**	**40**	**100**
		5	**60**	**40**	**100**

Practical Courses		Credits	End Semester Exam.	CCE			Total
				Pract Record. & Viva	**Seminar related to Pract**	**Total**	
PY L – 401 **PY L – 402** **PY L – 403** **PY L – 404**	**Lab A**	**3**	**60**	**20**	**20**	**40**	**100**
	Lab B	**3**	**60**	**20**	**20**	**40**	**100**
PY PW– 401	**Project Work**	**2**	**60**	**40**			**100**
PY S - 401	**Skill Development**	**2**					
Total		**30**	**420**	**280**			**700**

CORE PAPER – I

PY C - 401

ATOMIC AND MOLECULAR PHYSICS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: Objective of this course is to learn the fundamentals of atomic and molecular spectroscopy key for Physics problems.

1.	To learn about the intricacies of spectra of Hydrogen-like atoms and alkali metals. Concepts of molecular quantum mechanics.
2.	To understand the details of rotational, spectra of diatomic molecules and elements of microwave spectroscopy.
3.	To know about the vibrational spectra of molecules and elements of IR spectroscopy..
4.	To equip them with the knowledge of other spectroscopies like UV, Visible, Raman.

5.	To learn about PES, PAS, NMR and Mossbauer spectroscopy instrumentation.

Course Outcomes: At the end of the course, the student will be

1.	Able to deal with problems related to Hydrogen-like atomic spectra and alkali metals. Understand coupling schemes and hyperfine structures.
2.	Able to know the features of molecular quantum mechanics such as Thomas Fermi model, Hartree and Hartree-Fock methods.
3.	Able to understand the basics of microwave spectroscopy with rotation of diatomic molecules.
4.	Able to understand the basics of IR spectroscopy with vibrating diatomic molecules and vibrating –rotator molecule.
5.	Understand the behavior of atomic and molecular spectra with UV, Visible, Raman, Photo-electron, Photo- acoustic, NMR and Mossbauer spectroscopies.

UNIT –I

Quantum states of one electron atoms Atomic orbitals, Hydrogen spectrum, Pauli's principle. Spectra of alkali elements, spin orbit interaction and line structure of alkali spectra, Methods of molecular Quantum Mechanics, Thomas Fermi Statistical Model, Hartree and Hartree Fock Method. Two electron system, interaction energy in LS and JJ coupling, Hyperfine structure (qualitative), line broadening mechanisms (general ideas).

UNIT – II

Types of molecules, Diatomic linear, symmetric top, asymmetric top and spherical top molecules, Rotational spectra of diatomic molecules as a rigid rotator, Energy level and spectra of non-rigid rotator, intensity of rotational lines.

UNIT – III

Vibrational energy of diatomic molecule, diatomic molecule as a simple harmonic oscillator, Energy levels and spectrum, Morse potential energy curve, Molecules as vibrating rotator, vibration spectrum of diatomic molecule PQR branches IR spectrometer (qualitative).

UNIT – IV

Introduction to ultraviolet, visible and infra-red spectroscopy, Raman spectroscopy: Introduction, Pure rotational and vibrational spectra, Techniques and instrumentation, Stimulated Raman spectroscopy, Experimental techniques: Photo electron spectroscopy, Elementary idea about photo acousticspectroscopy, Mossbauer spectroscopy and NMR Spectroscopy.

UNIT –V

This unit will have four short questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

1. Write all possible term symbols for the following electron configurations

   (a) [Be]2p3p (b) [He]2s2p (c) [Be]2p3d

   2. Normal and anomalous Zeeman effect

   3. Paschen Back effect, Stark effect.

4. The measured value of the first line (J = 0) in the rotational spectrum of carbon monoxide is 3.84235 cm^{-1}. Determine the moment of inertia and bond length of the molecule.

5. The data for the $^{1}H^{35}Cl$ molecule are :
   Bond length = 127.5 pm
   Bond force constant = 516.3 Nm^{-1}
   Atomic masses: $^{1}H = 1.673 \times 10^{-27}$kg, $^{35}Cl = 58.066 \times 10^{-27}$ kg
   Determine the following
   (a) The energy of fundamental vibration ν_o.
   (b) The rotational constant B.
   (c) The wave numbers of the line $P_{(1)}$, $P_{(2)}$, $R_{(0)}$, $R_{(1)}$ and $R_{(2)}$.
   (d) Sketch the expected vibration-rotation

6. How many normal models of vibration are possible for the following molecules : HBr, 0_2, OCS (linear), SO_2 (bent), BCl_3, HC ≡ CH, CH_4, CH_3I, C_6H_6?

7. With which type of spectroscopy would one observe the pure rotational spectrum of H_2? If the bond length of H_2 is 0.07417 nm. What would be the spacing of the lines in the spectrum?

8. Raman Spectrum of Chloroform, $CHCl_3$, molecule shows that Raman lines appear at 262, 366, 668, 761, 1216 and 3019 cm^{-1} on low frequency side of exciting line. Comment of the spectrum.

9. The strongest lines in the Infra-red and Raman spectra of nitrous oxide are shown in the table

Vcm^{-1}	Infra-red	Raman
589	Strong; PQR contour	-
1285	Very strong; PR contour	Very strong; polarized
2224	Very strong; PR contour	Strong; depolarized

   Comment on the spectra.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books

- Introduction to Atomic Spectra : H.E. White
- Fundamentals of molecular spectroscopy : C.B. Banwell
- Spectroscopy vol.I, II & III : Walker and Stanghen
- Introduction to molecular spectroscopy : G.M. Barrow
- Spectra of diatomic molecules : Herzberg.
- Molecular spectroscopy : Jeanne L. Mc Hale
- Molecular spectroscopy : J.M.Brown
- Spectra of atoms and molecules : P.F.Bemath.
- Modern spectroscopy : J.M. Halian

PAPER - II
ELECTIVE PAPERS (ANY ONE TO BE OPTED)
PY E - 401
II (A): PHYSICS OF LASERS ITS APPLICATIONS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The course aims at imparting knowledge about principle and working of Lasers, and fiber-optic communication

1.	To identify conditions for lasing phenomenon and properties of the laser.
2.	To classify different types of lasers with respect to design and working principles.
3.	Laser florescence and Raman scattering and applications.
4.	To know about Optical fibers and use of Lasers in optic communication.
5.	To illustrate various aspects of crystal optics and propagation of light.

Course Outcomes: At the end of the course, the student will be

1.	Evaluate conditions for lasing phenomenon and properties of the laser.
2.	To understand various types of Lasers and their applications.
3.	To know about Laser fluorescence and Raman scattering and their applications.
4.	To understand the Optical fibers and use of Lasers in light wave communication along with the engineering and medical applications.
5.	To understand the basics of crystal optics and propagation of light ,electro- optical effects, laser induced multiphoton processes, parametric generation, optical stability etc.

UNIT –I

Working principle of laser, threshold condition characteristics of laser, Gaussian beam and its properties, optical Resonators, longitudinal and transverse modes of laser cavity, mode selection, gain in a Regenerative Laser cavity.

Rate equations and threshold for 3 and 4 level systems. Q switching, mode locking and obtaing altrashort pulses. Spectral narrowing.

UNIT – II

Ruby laser, He-Ne laser, Nd based lasers, semiconductor lasers, Nitrogen laser, CO_2 laser, ionlaser Dye laser, chemical laser, excimer laser, Higher power laser systems.

UNIT –III

Laser fluorescence and Raman scattering and their use in ranging and pollution studies; ultra high resolution spectroscopy with laser, and its application in isotope separation, single atom detection and rotational and vibrational level of molecules. Optical fibers, use of lasers in light waves communication. Qualitative treatment of medical and engineering applications of lasers.

UNIT – IV

Crystal optics, propagation of light in a medium with variable refractive index, Electro, optical effect. Non-linear interaction of light with matter, laser induced multiphoton processes, second harmonic generation phase matching, third harmonic generation optical mixing, Parametric generation of light self focusing of light, Frequency mixing in gases and vapours, Optical bistability and optical phase conjugation, Frequency up coversion.

UNIT – V

This unit will have four short questions based on tutorial problems covering all the four units. The students will have to answer any two questions some sample problems are:-

1. Calculation of threshold population inversion for laser action in a cavity of given parameters.
2. Calculation of gain coefficient.
3. Determining line width of laser line.
4. Determining line pulse duration in case of Q switched or mode locked laser.

5. Calculation of power of the laser output in case of certain laser system.
6. Tuning of laser in order to obtain- a particular wave length
7. Finding distance of an object by laser range finder.
8. Determining vibrational levels of molecule by scattering of laser light.
9. Calculation of intensity of second harmonic and third harmonic generated by non-linear interaction of laser light with matter.
10. Calculate the wave length separation between the longitudinal modes of a 1530 nm semiconductor laser in which the active layer in 0-2 μm long and has a refractive index of 4.0.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Book

- Svelte : Lasers
- Yariv : Optical Electronics.
- Demtroder : Laser spectroscopy
- Letekhov : Non-Linear Laser spectroscopy
- Lasers : A.L. Siegman
- Optical Electronics : K.Tyagrajan & A.K. Ghatak.

PY E - 402
II (B) NONLINEAR DYNAMICS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The aim and objective of the course is to familiarize with the basics of the field of dynamics of nonlinear systems.

1.	Introduction to Dynamical systems.
2.	Introduction to Dissipative systems.
3.	Introduction to Hamiltonian systems.
4.	Introduction to some advanced topics like Solitons and their types.
5.	To identify nonlinear optical phenomenon for applications in optical devices.

Course Outcomes: At the end of Course students will be able to

1.	Understand basic knowledge of nonlinear dynamical systems, their equations, bifurcations, Poincare section.
2.	Understand dissipative systems, noninvertible maps, attractors, intermittency, Lyapunov exponents, Henon map and Fractals and their geometry.
3.	Learn skills by solving problems on solving nonlinear problems using numerical methods.
4.	Understand Hamiltonian Systems, Integrability, Liouvill's theorem, perturbation techniques, Concept of Chaos and stochasticity.
5.	Understand advanced topics like Solitons, Sine Gordon and Kartweg devries, Baclund transformation, magnetic monopole and Vortex solitons.

UNIT – I

Introduction to Dynamical Systems

Physics of nonlinear systems, dynamical equations of motion, phase space, fixed points, stability analysis, bifurcations and their classifications, Poincare section and iterative maps.

UNIT- II

Dissipative Systems

One-dimensional noninvertible maps, simple and strange attractors, iterative maps, period doubling and universality, intermittency, invariant measure, Lyapunov exponents, higher-dimensional systems, Henon map, Lorenz equation. Fractal geometry, generalized dimensions, examples of fractals.

UNIT – III

Hamiltonian Systems

Inerrability, Liouville's theorem, action-angle variables, introduction to perturbation techniques, KAM theorem, area presserving maps, concepts of chaos and stochasticity.

UNIT- IV

Advanced Topics

Completely integrable systems, Solitons solution, Sine-Gordon and Kartweg devries solitons, Perturbation of solitons, Baclund transformation, Solitons like solutions, ϕ^4 theories with both signs, Magnetic monopole and vortex solutions.

UNIT - V

This unit will have four short questions based on tutorial problems covering all the four units. Students will have to answer any two questions out of four. Some sample problems are:

1. Saddle Points, solitons and homoclinic orbits.
2. Limit cycles.
3. Rosssten's equations and strange attractors.
4. Mandelbrot set.
5. Sine Gordon solutions
6. Lorentz equations and strange attractor
7. Logistic map, period doubling and Lypunov exponents
8. Backlund transformations
9. Davydov soliton

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books

- Introduction to Dynamics : Percival and D. Richards
- Nonlinear Dynamics I & II : E.A. Jackson
- Introduction to Dynamical Systems : R.L. Devaney
- Chaos : Hao Bai-lin
- Regular and Stochastic Motion : A.J. Lichtenberg and M.A. Lieberman
- CHAOS IN CLASSICAL AND : M.C. GUTZWILLR, E. Ott, M. Tabor

PY E - 403
II (C) PHYSICS OF NANOMATERIALS

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The aim and objective of the course on Physics of Nano-materials is to familiarize with the various aspects related to preparation, characterization and study of different properties of the nanomaterials.

1.	Define Nanotechnology and outline the various properties of nano materials and their fabrication techniques.
2.	Able to know the various methods of synthesis of nanoparticles & describe the physical properties.
3.	To learn about the techniques of fabrication of MQW & SL structures.
4.	To equip them with the optical properties and thereby find the nano-size of the experimental samples.
5.	To learn about the electrical & magnetic properties of nano materials and their applications in different field of science.

Course Outcomes: At the end of Course students will able to

1.	Understand concept of quantum confinement, electron confinement in deep square well and two and three dimensions, idea of quantum well, dot and wires.
2.	Understand quantum well and super lattices, techniques of fabrication of MQW and SL structures.
3.	Acquire knowledge of basic approaches like Bottom up and Top down to synthesize inorganic colloidal nanoparticles and their self-assembly in solution and surfaces, Physical properties of nanoparticles.
4.	Understand and describe the use of unique optical properties of nanoscale metallic structures using Luminescence and Raman scattering.
5.	Understand electrical properties, magnetic materials and stability of nano structures, Various applications and perspectives of nanotechnology in the development of value added new products and devices

UNIT-I

Concept of Quantum Confinement

Free electron theory (qualitative ideas) and its features. Idea of band structure, Metals, insulators and semiconductors, Density of states in bands, Variation of density of states with energy.

Electron confinement in infinitely deep square well, confinement in two and three dimension, Idea of quantum well, quantum wire and quantum dots, classification of nanostructured materials.

UNIT-II

Quantum wells and Super lattices

Energy levels and density of states in quantum wells. Band structure in quantum well, coupling between the wells, multiple quantum well structure, super lattice dispersion relation and density of states, Band structure in super lattice, Types of super lattices.

Techniques of Fabrication of MQW and SL structures (MBE, MOCVD, LPE etc).

UNIT-III

Nanoparticles

Synthesis of nanoparticles: Bottom up: cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques; and Top up: Ball milling.

Physical properties of nanoparticles: Impurities and composition surface roughness, structure, thermodynamic properties. Determination of particle size by width of XRD peaks.

UNIT-IV

Characteristics of Nanoparticles

Optical properties: Absorption spectra, luminescence, Raman scattering, spectral response. Determination of particle size by shift in photoluminescence peaks.

Electrical properties of nanoparticles, nanostructured magnetic materials, stability of nanocrystals. Application of nanostructured materials.

UNIT-V

This unit will have four short questions based on tutorial problems covering all the four units. The student will have to answer any two questions out of four. Some sample examples are:

(1) Density of state function in 1D, 2D and 3D systems.
(2) Calculation of energy levels and change in band gap in a quantum well of given dimensions.
(3) Energy difference between two levels in a double QW.
(4) Variation of specific heat with size of crystal.
(5) Calculation of crystal size from XRD peaks.
(6) Calculation of crystal size from PL peaks.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and References Books

- Nanotechnology Molecularly designed material by Gan-Moog, Chow , Kenneth. E Gonsalves, AmericanChemical Society.
- Quantum dot Heterostructure by D. Bimerg, M. Grundmann and N.N. Ledentsov John Wiley and sons 1998.
- Nanotechnology: Molecular Speculations on global abundance by B.C. Gran dall MIT Press 1996.
- Physics of low dimensional semiconductors by John W. Davies, Cambridge Univ. Press 1999.
- Physics of semiconductor nanostructures by K.R. Jain Narosa 1999
- Nano-fabrication and bio-systems: Integrating materials science engineering Science and biology by Harvey C. Hoch, Harold G. Craighead and Lynn Jelinski, Cambridge Univ. Press- 1996.
- Nano particles and nano structured films: Preparation, characterization and application, Ed. J. H. Fendler, Jhon Wiley and sons 1998.
- Wave mechanics applied to semiconductor heterostructures by Gerald Bastard.

PAPERS III & IV

SPECIAL ELECTIVE PAPERS (ANY TW0 TO BE OPTED)
PY SE - 401

III & IV (A) CONDENSED MATTER PHYSICS – II

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of the course is to develop specialization skill with advance knowledge in the subject.

1.	To get familiarized with the different parameters associated with superconductivity and the theory of superconductivity, idea of high temperature superconductivity.
2.	Able to understand point defects, and color centers.
3.	To differentiate the structure and symmetries of liquids, idea of quasi crystals.
4.	To equip them with the knowledge of types of CNT's and its applications.
5.	To learn about disordered and amorphous solids, Atomic correlation function and structural descriptions of glasses and liquids.

Course Outcomes: After the completion of this course, students will be

1.	Able to differentiate between type-I and type-II superconductors and their theories and explain the behavior of superconductors, applications and high temperature superconductivity.
2.	Understand the point defects, shallow impurity states and color centers.
3.	Understand structure and symmetries of liquid crystals, quasi crystals, Penrose lattice.
4.	Understand the physical and chemical properties of carbon nanotubes, methods of synthesis of nano structures, quantum size effect.
5.	Understand the crystalline, non- crystalline materials, disorder in condensed matter, atomic correlation, glasses and liquids, Anderson model, and amorphous semiconductors.

UNIT – I

Interaction of electrons with acoustic and optical phonons, polarons, Superconductivity: Manifestations of energy gap, Cooper pairing due to phonons, BCS theory of superconductivity, Ginsburg –Landau theory and application to Josephson Effect: d-c-Josephson effect, a-c Josephson Effect, macroscopic quantum interference. Vortices and type II superconductors, high temperature superconductivity (elementary).

UNIT – II

Point defects: Shallow impurity states in semiconductors. Localized lattice vibrational states in solids, vacancies, interstitial and color centers in ionic crystals.

Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonaccy sequence, penrose lattice and their extension to 3-dimensions.

UNIT – III

Special carbon solids; fullerenes and tubules, formation and characterization of fullerenes and tubules. Single wall and multi -wall carbon tubules. Electronic properties of tubules. Carbon nanotubes based electronic devices. Definition and properties of nanostructured materials. Methods of synthesis of nanostructures materials. Special experimental techniques for characterization of nanostructured materials. Quantum size effect and its applications.

UNIT - IV

Disorder in condensed matter, subsitutional, positional and topographical disorder, short and long range order, Atomic correlation function and structural descriptions of glasses and liquids.

Anderson model for random systems and electron localization, mobility edge, qualitative application of the idea to amorphous semiconductors and hopping conduction.

UNIT - V

This unit will have four short question based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

1. Draw diagrams showing some possible two-phonon processes in which a neutron enters with momentum p and leaves with momentum P'. In labeling the diagrams take due account of the conservation law.
2. The average rate of dissipation of energy for an electromagnetic wave is W = < E.J.> where the average is over a complete cycle. Show that

$$W = (\omega\varepsilon_2/ 8\pi)\ Eo2 = \sigma\ E_o^2/2 = \sigma_1 E^2$$

3. How do the (2l+1) fold degenerate energy levels of a free atom split up in a crystal field invariant to all proper rotations which transform a cube into itself? The free atom is invariant to operations of the (infinite) rotation group. The characters of the irreducible representations of this group are

$$\lambda^{(l)}(\varphi) = \sin (l + ½)\ \phi / \sin \phi/2$$

The point group of the crystal field has 24 elements in five classes and hence also five irreducible representations. Set up character table for this group

4. (a) Show whether periodicity can exist together with a periodicity in a structure (b) What is golden mean ratio? How it is relevant to quasi crystals.
5. Band structure formula for crystals is not quite valid for Nanostructure, why?
6. Distinguish between crystalline, amorphous solids and liquids.
7. What are onion carbon structures? How are they related with fullerene?
8. Calculate the lifetime of electrons and holes in a semiconductor with recombination centers (acceptors with levels E_R in the energy gap) treat explicitly the limits of large and small defect concentration n_r. Discuss the recombination mechanism in both cases. Compare the two possible definitions: $\delta n(t) – \exp(-t/\tau)$ (decay time) and $\delta n = G\tau$ (steady state).
9. The carbon nanotubes can be both semiconducting and metallic why?

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and References Books

- Crystal Structure Analysis : Burger
- The Physics of Quasicrystals, : Eds.Steinhardt and Ostulond
- Hand Book of Nanostructured Materials : Ed. Hari Singh Nalwa
- And Nanotechnology (Vol. l to 4)
- Quantum Theory of Solid State : Callaway
- Theoretical Solid State Physics : Huang
- Quantum Theory of Solids : Kittle

- Introduction to Solid State Theory : Madelung
- Solid State Physics : J.P. Shrivastava
- X-ray Crystallography : Azaroff
- Elementary Dislocation theory : Weertman and Weertman
- Crystallography for Solid State Physics : Verma and Shrivastava
- Solid State Physics : Kittel
- Elementary Solid State physics : M. Ali Omar
- Structure and Properties of Liquid Crystals : Lev M.Blinov
- Solids : H.C. Gupta

SPECIAL ELECTIVE PAPER
PY SE - 402
III & IV (B) ELECTROINCS – II

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of the course is to develop specialization skill with advance knowledge in the subject.

1.	To introduce with various aspects of digital communication,
2.	To introduce with noise in digital communication systems.
3.	To introduce with computer communication systems.
4.	To introfuce with 8086 microprocessor and assembly language programming.
5.	To learn about 8086 connection timings, Interrupts, Digital and Analog interfacing.

Course Outcomes: At the end of Course students will be able to

1.	Understand digital communication systems such as PM, PAM, PCM, Delta modulations.
2.	Understand digital modulation techniques like BPSK, DPSK, QPSK, PSK FSK etc.
3.	Understand noise in pulse code and delta modulation systems, various noise parameters, signal to noise ratio.
4.	Understand computer communication systems, types of networks, design of networks, mobile and satellite network.
5.	Understand 8086 architecture and functioning, its assembly language programming, 8086 connection timings, Interrupts, digital and analog interfacing, elementary idea of Pentium processors.

UNIT-I

Digital Communication

Pulse-Modulation Systems: Sampling theorem- Low pass and Band pass Signals, PAM, Channel Bandwidth for a PAM signal, Natural sampling, Flat-Top sampling, Signal recovery through Holding, Quantization of signal, Quantization, Differential PCM, delta Modulation, Adaptive Delta Modulation, CVSD.

Digital Modulation techniques: BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK.

UNIT-II

Noise in pulse code and Delta modulation systems: PCM transmission, calculation of Quantization noise, output-signal power, Effect of thermal noise, Output signal to noise ratio in PCM,DM, Quantization noise in DM, output signal power, DM output-signal –to Quantization- noise ratio. Effect of thermal noise in Delta modulation, output signal- noise ratio in DM.

Computer communication systems: Types of networks, Design of a communication network, examples TYMNET, ARPANET, ISDN, LAN.

Introduction to Mobile radio and satellites: Time division multiple Access (TDMA), Frequency Division Multiple Access (FDMA), ALOHA, Slotted ALOHA, Carrier Sense Multiple Access (CSMA) Poisson distribution, protocols.

UNIT-III

Introduction to 8086, Microprocessor chip, Internal Architecture, Introduction (Basics of) to Programming of 8086 and Assembly language. Programme development steps. Construction of machine code for 8086 Instructions, writing a programme for use with assembler, Assembly language program development tools.

Assembly Language Programming Technique: Simple sequence programmes. Basic idea of flags and jumps, While – Do, IF- THEN, IF –THEN-ELSE structure based simple programs. Writing and using Assembler Macros.

UNIT – IV

8086 System Connection Timings : 8086 Hardware Review, Addressing Memory and ports in microcomputer system , Basic Idea about Timing parameters, Minimum mode waveform and calculation for access time.

Interrupts: 8086 Interrupts and Interrupts response with some hardware applications.

Digital and Analog Interfacing of 8086: Methods of parallel data transfer, single Handshake I/O, Double Handshake Data transfer. 8255 Handshake applications:Lathe control and speech synthesizer. Display and keyboard interfacing with 8279, D/A interfacing with microcompiler, A/D interfacing (introduction)

Elementary Idea about 80816, 80286, 80386 to Pentium processors.

UNIT - V

This unit will have four short question based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

1. Explain the meaning of pulse code modulation. Draw one complete cycle diagram. Draw one complete cycle of some irregular waveform and show it is quantized using eight standard pulses.
2. Efficiency of PCM
3. Noise in PCM system
4. Signal to noise ratio in time division multiplexed PAM systems.
5. Program for creating a delay loop using 16 bit register pair.
6. Program for 8086 in Assembly Language using IF-THEN-ELSE structure.
7. Debugging Assembly Language Programs for 8086 μp with simple examples.
8. Assembly Language for interrupts procedure in 8086.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and References Books

- Principles of communication system : Taub & Schilling (1994) II Edition
- Communication systems : Simon Haylein III Ed.
- Microprocessors and Interfacing : Douglas Hall 2nd Ed. (1992)
- Programming and Hardware

- The Intel Microprocessor 8086/8088/ : Brey & Brey
- 80186/80286/80386/80486 Pentium and
- Pentium ProProcessor Architecture
- Programming and Interfacing

SPECIAL ELECTIVE PAPER

PY SE - 403

III & IV (C) MATERIALS SCIENCE – II

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of the course is to develop specialization skill with advance knowledge in the subject.

1.	To know about the mechanical properties of materials, factors governing mechanical behavior.
2.	Able to know the various dielectric properties of materials and its implementation in different applications. Properties of Polymer Electrets
3.	Idea of piezo, pyro, and ferro electric materials, their theory and applications.
4.	To understand thin films, their preparation, size effect, magnetic and optical properties.
5.	To know about ceramics, glasses and modern materials.

Course Outcomes: At the end of Course students will be able

1.	To understand various mechanical properties and mechanism responsible for it. Failure of materials.
2.	To understand the dielectric behavior and polarization mechanism of materials.
3.	To understand the Polymer electrets and their applications, mechanism like Poole Frenkel, Richardson Schottky, tunneling and hopping inside the materials.
4.	To understand piezo, pyro, and ferro electric materials and their applications, to know about thin films, their deposition techniques, and electrical conduction, their magnetic and optical properties.
5.	To understand ceramics, glasses, and modern materials, their preparation and applications, modern materials like, liquid and quasi crystals, fullerenes, GMR materials, composite materials, bio polymers and conducting polymers.

UNIT – I

Mechanical Properties of Materials

Elastic, visco-elastic and plastic deformation. Deformation mechanisms; slip and twinning, origin and multiplication of dislocations, Frank-Read Source, Intersection of dislocations, Fracture, Introduction to hardness and toughness.

Performance of materials in service failure, Corrosion and its control, Delayed fracture, fatigue performance of material at high temperatures, creep, service performance of polymers and ceramics.

UNIT - II

Dielectric Properties of Materials

General theory of dielectric relaxation, cooperative dipolar relaxation in polymers single and multiple dielectric relaxation processes in solids, temperature dependence of electrical properties, Polarization mechanism, dipolar and space charge polarization, thermally stimulated depolarization processes.

Polymers and Electrets

Aspects of molecular characterization, molecular weight its distribution and determination, glass transition temperature, Elastic strain, flow, polymer viscosity, visoelastic deformation, processing of polymers-Addition, fillers, plasticizers, mixing, shaping, molding, spinning. Ionic and electronic conduction in polymers, space charge conduction, charge transport in polymers. Poole Frenkel, Richardson Schottky, tunneling and hopping. Charge storage in polymers electret effect.

UNIT – III

Brief Introduction of piezo, pyro and ferroelectric materials- Idea of theory of ferroelectricity and their applications.

Brief review of diamagnetism, paramagnetism, ferromagnetism and ferri-magnetism, magnetic moments due to electron spin, Domain structure, The hysteresis loop, soft magnetic materials, hard magnetic materials, square loop magnetic materials.

Thin Films

Vacuum deposition, Ion - plasma deposition. Elementary idea about hot - metal spraying, metallization by fusion, chemical deposition, thermochemical and plasma-chemical methods and electrolytic deposition. Electrical conduction in continuous metal films. Theories of size effect, size effect anisotropy ,TCR of continuous films. Galavanomagnetic size effects - Magnetoresistance and Hall effect in thin films. Anomalous skin effect, Eddy current.

Optical properties of thin films, reflectance, transmittance and other optical constant of thin films, absorbing films, Elementary idea about the application of thin films.

UNIT – IV

Ceramics, Glasses and Modern Materials

General introduction to Ceramic materials, Preparation (solid state and wet chemical methods), Processing and sintering, Electronics ceramics, Cermaics structures, Glass, Glass ceramics, Application of ceramics as sensors, I-R and gas sensors, Ferro electric devices, heating elements, optical, Electro-optic ceramic.

Introduction to some of the modern materials like : liquid crystals, quasi crystals, fullerenes, nanostructured materials, Transparent materials, high T_c superconductivity materials, GMR materials, composite materials, Biopolymers and conducting polymers.

UNIT – V

The unit will have four short questions based on the tutorial problems covering all the four units. The students will have to answer any two questions. The samples problems are:

1. (a) The activation volume for dislocation motion in a crystal in $20b^3$, where b is the Burgers vector of the moving dislocation b = 2 Å. The P-N stress for this crystal is 1000 Mn m^{-2}. For a specified rate of dislocation motion, the activation energy Q = 40 kT. Calculate the stress required energy the dislocation at (i) 0 K (ii) 100 K (iii) 300 K and (iv) 500 K.

(b) The length of a dislocation line between two tie points is on an average equal to the reciprocal of the square root of the dislocation density in a crystal. Calculate the dislocation density in copper, work hardened to a stage where slip occurs at a shear stress of 35MN m^{-2} (Given shear modulus of copper is 44 GN m^{-2})

2.(a) A stress of 11 MP a (1600 psi) is required to stretch a 100 mm rubber band to 140 mm. After 42 days at 20^{o}C in the same stretched position, the band exerts a stress of only 5.5 Mpa. (800 psi) (i) what is the relaxation time ? (ii) What stress would be exerted by the band in the same stretched position after 90 days ?

(b) The relaxation time at 25^{o}C is 50 days for the rubber band in above problem. What will be the stress ratio s/so, after 36 days at 30 ^{o}C.

3. Assume that all energy required to produce scission in a polyethylene molecule comes from a photon (and that none of the energy is thermal).
   (a) What is the maximum wavelength that can be used?
   (b) How many eV are involved?

4. Calculate the polarization of a $BaTiO_3$ crystal. The shift of the titanium ion from the body centre is 0.06 Å. The oxygen anions of the side faces shift by 0.06 Å, while the oxygen anions of the top and bottom faces shift by 0.08 Å, all in a direction opposite to that of the titanium ion.

5. The relative dielectric constant for polyvinyl chloride (PVC) are 6.5, 5.6, 4.7, 3.9, 3.3, 2.9, 2.8, 2.6, and 2.6 at frequencies 10^2, 10^3, 10^4, 10^5, 10^6, 10^7, 10^8, 10^9 and 10^{10} Hz respectively. The values of relative dielectric constants at the above frequencies for polytetrafluoroethylene (PTFE) are 2.1.
   (a) Plot the capacitance versus - frequency curves for three capacitors with 3.1 cm × 10.2 cm effective area separated by 0.025 mm of (i) vacuum (ii) PVC and (iii) PTFE.
   (b) Account for the decrease in the relative dielectric constant of PVC with increased frequency, and for the constancy in the relative dielectric constant of PTFE.

6. The glass-transition temperature of a thermoplastic polymer is 95^{o}C. The viscosity at 110 ^{o}C is four times too great for a particular molding process.
   (a) What temperature is required ? Assume that the temperature cannot be controlled to closer than ± 1 ^{o}C.
   (b) What viscosity variation might by expected ?

7. Deduce the magnetic moment for formula of the following ferrites :
   Fe_3O_4, $NiFe_2O_4$, $CoFe_2O_4$ and $MnFe_2O_4$. In Fe_3O_4, the ferric ions are antiferromagnetically coupled. All the divalent cations have lost their 4S electrons. Compare the deduced values with the listed values and explain any discrepancy.

8. Discuses Mangnetoresistance and Hall effect in thin films.

9. Describe the preparation of solid solutions.

10. Discuss the preparation of nanomaterials

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books

- Elements of Materials Science and Engineering Sixth Edition-Lawrence H., Van Vlacke, Addition Wesley.
- Elements of Solid State Physics-J.P. Shrivastava- Prentice Hall India.

- Materials Science and Engineering-V. Raghwan-Fourth Edition-Prentice Hall.
- The Structure and Properties of Materials Vol. I, II, III, and IV –John Wulff et al. Wiley Eastern Limited.
- Physical Metallurgy Principles Robert E-Reed-Hill, East West Press New Delhi.
- Introduction to Solid-A Zroff.
- Materials Science and Processes– Hajra Choudhry Indian Book Distribution co.
- Materials Science and Engineering- William D. Callister Jr, John Wiley (2001).
- Experiments in Materials Science- E.C. Subbarao, L.K. Swghal, D. Chakraborty, M.F. Merriam and V.Raghavan, Tata McGraw Hill, New Delhi.

SPECIAL ELECTIVE PAPER
PY SE - 404
III & IV (D): COMPUTATIONAL PHYSICS – II

60+40= 100 MARKS **5 CREDITS**

Course Objectives: The objective of the course is to develop specialization skill with advance knowledge in the subject.

1.	To know the basics of Mathematica programming.
2.	To equip with the application of Computers for problem solving in quantum mechanics.
3.	Implement optimization techniques to solve the problems related to condensed matter physics.
4.	To provide the concept on computation of free energies of solids and how to obtain them numerically.
5.	Introduction to computer simulation techniques.

Course Outcomes: At the end of Course students will understand and apply computational skills for understanding and describing the various problems of Physics. They will be able to

1.	Get a wide knowledge of Mathematica programming, its commands, numerical calculations like Factorial, exponential etc. Factorial, exponential & polynomials, Plots of data functions.
2.	To solve quantum mechanical problems in computational methods, like Schrodinger equations
3.	Solve propagation of free waves and through one dimensional well.
4.	Use computational methods to simulate phonon dispersion, density of states, two dimensional free electrons.
5.	Use simulation techniques to solve molecular dynamics with random oscillations, Monte Carlo and Ising model, magnetic susceptibility.

UNIT – I

Basic of Mathematica Programming

Introduction, commands and variables, numerical calculations with examples such as Factorial, Exponential etc. Symbolic calculations : polynomials, equations calculus (differential and integrals) Manipulations with matrices, Eigen values and Eigen vectors, Plots of data and functions.

UNIT – II

Computer Applications to problem solving in Quantum Mechanics

Solving one dimensional Schrodinger equation for stationary states, solution of time independent Schrodinger equation for linear harmonic osillator. Radial solution of

Schrodinger equation for three dimensional harmonic oscillator potential, The propagation of free wave packets, study of wave packet propagation through a one-dimensional well.

UNIT – III

Computer Application to problems in Condensed Matter Physics

Simulation of phonon dispersion curves and density of states, The reciprocal lattice and Harrison construction(2D), One dimensional phonon propagation, Two dimensional Lattice vibrations, Two dimensional nearly free electrons.

UNIT – IV

Introduction to Computer Simulation

Molecular Dynamic Simulation Gas with random collisions, N body gas, Monte Carlo simulations, The 2-D Ising model for interacting spins, specific heat, average energy, Magnetization, susceptibility.

UNIT - V

This unit will have four short questions based on tutorial problems covering all the four units. The students will have to answer any two questions out of four. Some sample problems are:

1. General ideas of computer algebra software viz Mathematica, Matlab.
2. Use of Mathematical graphics with examples.
3. Discuss the numerical solution of the Schrodinger equation for an harmonic oscillator potential $v(x) = \frac{1}{2}x^2 + bx^4$. Choose b of different magnitudes and check how the grounds state wave function depends on this.
4. Develop a program to find energy Eigen value for a general power law potential. $V(r) = a\,r^n$, $n > 0$.
5. In a linear monatomic chain of four atoms, the end atoms are fixed, considering only the nearest neighbor interaction and assuming that the force between any two atoms is proportional to their relative displacement, set up the equation of motion for longitudinal vibrations of the free atoms. Solve this equation numerically and verify that the frequencies of the two normal modes are related as $w_1^2 = 3w_2^2$.
6. In a one-dimensional nearly free electron model, solve the Schrodinger equation and plot the periodic occurrence of the parabolic energy curves of a free electron in one-dimensional reciprocal space.
7. Simulation of (i) travelling pulse (2) standing wave.
8. Simulation of radioactive decay and random walk.

In addition to above the tutorial will also consist of solving problems given in the text and reference books.

Text and Reference Books

- Computational Physics - R.C. Verma, P.K. Ahluwalia and K.C. Sharma, New Age Publishers (1999)
- Programming in ANSI C, - E. Balaguruswami Tata Mc Graw Hill (1994)
- Numerical Recips in FORTRAN - Press W.H., Teukolsky S.A. Vellerling W.T. and Flanney B.P.

(Cambridge Univ. Press 1992)

- Simulation using Personal Computer - Carroll, J.M. (Prentice Hall, 1987)

ABILITY ENHANCEMENT AND SKILL DEVELOPMENT PRACTICAL COURSES SEMESTER III & IV

M.Sc. (Physics) III & IV Semester:

Note: Appropriate other experiments can be added based on prescribed syllabus in both labs A and B

SPECIAL ELECTIVE PAPER LABORATORY COURSE PY L 301/PY L 302/PY L 303/ PY L 304 & PY L 401/PY L 402/PY L 403/ PY L 404

(A) CONDENSED MATTER PHYSICS I & II

PY L 301 & PY L 401

(Preferably six experiments to be performed by the students)

1. Measurements of lattice parameters and indexing of powder photographs.
2. Interpretation on transmission Laue photographs.
3. Determination of orientation of a crystal by back reflection Laue methods.
4. Rotation/Oscillation photographs and their interpretation.
5. To study the modulus of rigidity and internal friction in metals as a function of temperature.
6. To measure the cleavage step height of a crystal by Multiple Fizeau fringes.
7. To obtain Multiple beam Fringes of Equal Chromatic Order. To determine crystal step height and study birefringence.
8. To determine magnetoresistance of a Bismuth crystal as function of magnetic field.
9. To study hysterisis in the electrical polarization of a TGS crystal and measure the Curie temperature.
10. To measure the dislocation density of a crystal by etching.
11. Solution of some problems in spherical geometry using stereographic wulffnet.
12. Study of symmetry of crystal models.
13. Measurement of Hall coefficient.
14. Determination of Lande’s ‘g’ factor using ESR.
15. Determination of Energy band gap
16. Study of Lattice dynamics.
17. Measure of resistivity using four probe.
18. Hysteresis Loop tracer.
19. Study of Luminescence.

Tutorial: Laboratory /Practical Course CONDENSED MATTER PHYSICS

1. Study of X-ray diffraction from liquid, amorphous materials.
2. Determination of dislocation density by Reflection X-ray topography.

3. To take Burger Precession photograph of a crystal and index the reflections.
4. To measure the superconductivity transition temperature and transition width of high-temperature superconductors.
5. To determine the optical constants of a metal by reflection of light.
6. Model evaluation of dispersion curves of one-dimensional lattice.
7. Creation of low pressure and measurement.
8. Thin film deposition and operation of vacuum coating unit.
9. Data analysis using computers.
10. Operation of Spectrophotometer.
11. NMR Instrumentation.
12. Surface structural study of materials using Carl Zeiss microscope.

(B) ELECTRONICS I & II PY L 302 & PY L 402

Preferably six experiments to be performed by the students

1. Amplitude Modulation and Demodulation.
2. TDM PULSE Amplitude Modulation and Demodulation.
3. Study of PCM Receiver and Transmitter.
4. Study of satellite – C Band Receiver.
5. Study of AM – FM Receiver set.
6. Pulse position/ Pulse width Modulation and Demodulation.
7. FSK Modulation.
8. Microwave characterization and measurement.
9. Study of Motor speed control Interface and programming.
10. Temperature control using 8086.
11. Programs for Addition, Division, Subtraction, & Multiplication with 8085 μp system.
12. Programs for (a) To find Largest Number.
    (b) To find Smellers Number
13. Programme for Addition, Subtraction, Multiplication and Division with 8086.
14. Dielectric measurement of Solid/Liquids using Microwave.
15. SWR Reflection Coefficient Measurement.
16. Study of E Plane, H Plane, Magic Tees Bends.
17. Frequency Guide wavelength measurement.

Tutorials: Laboratory/Practical course
ELECTRONICS

1. Digital Communication.
2. Cellular Communication
3. Mobile Communication via satellite
4. Trouble shooting in 8086 Microprocessor System.
5. 8086 Instruction Description
6. Microprocessor based process control system
7. Trouble shooting in 8085 based system
8. Trouble shooting AM based Radio Receiver

(C) MATERIALS SCIENCE - I & II PY L 303 & PY L 403

(Preferably six experiments to be performed by the students)

PREPARATION AND CHARACTERIZATION

1. Growth of single crystals from solution
2. X-ray diffraction study of crystal structure and indexing (a) Laue photograph (b) Rotating Crystal and (c) Powder

MICROSTRUCTURE AND IMPERFECTIONS

3. Preparation of specimen for metallographic examination measurment of grain size and amount of constitutional phase.
4. Study of dislocations and measurement of dislocation density by etching technique.
5. Application of Fizeau fringes for measurment of step height.
6. Application of FECO for study of pilling-up and sinking- in.

TRANFORMATION AND KINETICS

7. To study the kinetics of crystallization of polyethylene
8. Study of microstructure of metals and alloys after various phase transformations
9. To demonstrate the electrochemical nature of aqueous corrosion and to study electrochemical methods of corrosion control
10. Effect of recovery, recrystallization and grain growth on microstructure and mechanical properties of commercially pure copper.

MECHANICAL PROPERTIES

11. To study Griffith flaws in glass.
12. Tensile testing of Aluminium, Copper, Steel etc.
13. Study of hardness of different materials by Vicker's pyramid hardness tester
14. Fatigue testing of materials

ELECTRICAL PROPERTIES

15. Study of short circuit TSC
16. Measurement of Transient charging and Discharging current
17. Study of Hall effect and measurement of Hall coefficient
18. Study of dielectric behaviour of barium titanate
19. Determination of energy band gap
20. Determination of Resistivity using four probe methods.
21. Hysteresis loop of ferroelectric.

DEVICES

22. Study of Solar Cell
23. Preparation of thermo-electret and measurement of initial surface charge density
24. To measure the piezoelectric coefficient/P-E curve of barium titanate.

Tutorials: Laboratory/practical course

1. Creation of low pressure and measurement.
2. Thin film deposition and operation of vacuum coating unit.
3. Data Analysis using computer.
4. NMR Instrumentation
5. Preparation of nanomaterials.
6. Preparation of polymer blends materials.
7. Fabrication of high temperature furnaces.

8. Operation of Spectrometer.

(D) COMPUTATIONAL PHYSICS – I & II PY L 304 & PY L 404

(Preferably six experiments to be performed by the students)

1. Monte Carlo simulation of Radio Active Decay.
2. Determination of Phonon Dispersion Relation.
3. Wave packet propagation through square well potential.
4. Monte Carlo simulation of two dimensional Ising model.
5. Graphic representation of 3D object.
6. Gas of point particles with Random Elastic collision.
7. Motion of a satellite around a planet.
8. Phase Trajectory of a chaotic pendulecan.
9. Electromagnetic Oscillation of LC Circuit.
10. Motion of charged particle in Electric field.
11. Diffusion as a random walk problem.
12. Simulation of Brownaian motion
13. Lyapunov Exponents and Bifurcation.

Tutorial : Laboratory/ Practical Course

COMPUTATIONAL PHYSICS

Setting up of new experiments will form tutorial for this laboratory course.