Department of Physics

Manonmaniam Sundaranar University,

Tirunelveli – 12

M. Sc. (Physics)

Choice Based Credit System (CBCS)

Course Structure and Syllabus

(From the academic year 2019-2020 onwards)

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Objectives of the Course

The objective of the course is to create awareness in the field of physics and cultivate scientific approach and research aptitude among the graduate students in various subjects of physics and emerging extensions of research activities. The task includes preparation, enhancement etc. of human resources in strengthening the activities for the development of basic scientific knowledge, skills and application of scientific approach. An independent project and internship are included in the course so that the candidate knows about the flavor of research methodology in science.

Eligibility for Admission

A candidate who has passed B.Sc. Degree Examination with Physics or Applied Physics is eligible for this course. Admission to the M. Sc. course will be offered to those candidates who qualify for a common entrance test conducted at the level of the University.

Details of various core, elective and supportive course papers along with credits,marks and teaching hours for the students admitted from the academic year 2019 – 2020 onwards :

S.No.	Sem.	Subject	Credits	Teaching Hours / Week	Marks	
					Max.	Passing Min.
1	I	**C1:** Classical Mechanics	4	4	100	50
2	I	**C2:** Mathematical Physics - I	4	4	100	50
3	I	**C3:** Quantum Mechanics – I	4	4	100	50
4	I	**C4:** Electronics	4	4	100	50
5	I	**Elective I:** From Group - 1	3	3	100	50
6	I	**Practical I:** Optics and Lasers	2	4	100	50
7	I	**Practical II:** Electronics	2	4	100	50
8	II	**C5:** Mathematical Physics – II	4	4	100	50
9	II	**C6:** Quantum Mechanics – II	4	4	100	50
10	II	**C7:** Electromagnetic Theory	4	4	100	50
11	II	**Elective II:** From Group - 2	3	3	100	50
12	II	Supportive Course - I*	3	3	100	50
13	II	**Practical III:** Digital Electronics Application	2	4	100	50
14	II	**Practical IV:** Atomic and Nuclear Physics	2	4	100	50
15	III	Internship	2	**	100	50
16	III	**C8:** Thermodynamics and Statistical Mechanics	4	4	100	50
17	III	**C9:** Condensed Matter Physics - I	4	4	100	50
18	III	**C10:** Nuclear and Elementary Particle Physics	4	4	100	50
19	III	**Elective III:** From Group - 3	3	3	100	50
20	III	Supportive Course - II*	3	3	100	50
21	III	**Practical V:** Solid State Physics	2	4	100	50
22	III	**Practical VI:** Materials Science	2	4	100	50
23	IV	**C11:** Condensed Matter Physics - II	4	4	100	50
24	IV	**C12**: Spectroscopy	4	4	100	50
25	IV	**Elective IV:** From Group - 4	3	3	100	50
26	IV	Project and Viva – voce	10	20	100	50
TOTAL:			**90**	-	2500	-

C – Core.** 10 working days during summer vocation

***Semester II / III:** Papers 12 and 19 :

Supportive courses offered to the other departments (any one of the following papers either in semester II or III) through on-line (NPTEL): course syllabus is available in the NPTEL website. Continuous Internal Assessmentand External Examinations will be done by NPTEL course teacher and the mentor from the department will facilitate the student.

1. Solar Photovoltaics: Principles, Technologies and Materials
2. Nanotechnology in Agriculture

Elective Groups:

Elective courses (I, II, III, and IV) offered to the students of this Department are as given below in the four groups. One course shall be taken by each student from each group:

Group – 1

a) Critical Applications of Core Physics to problems – I
b) Advanced Computational Physics
c) General Relativity and Cosmology

Group – 2

a) Critical Applications of Core Physics to problems – II
b) Introductory Astronomy, Astrophysics & Cosmology
c) Quantum Field Theory

Group – 3

a) Material Processing and characterization Techniques
b) X-ray Crystallography
c) Data Analysis and Techniques

Group – 4

a) Thin film Physics
b) Density Functional Theory
c) Medical Physics

<u>Scheme of Evaluation:</u>

For evaluation of the theory papers (core, elective and supportive), practicals courses and project work, the continuous internal assessment and the external examination marks will be in the ratio of 25:75.

Core, Elective*, and Supportive papers :

(a) Continuous Internal Assessment (CIA):

The marks for the continuous internal assessment of 25 is split into three components, viz., 15 marks for the internal test, 5 for the Seminar and 5 for the Assignment activities. There is no passing minimum for the CIA components and for the CIA in total. There shall be no provision for improvement of CIA components. There shall be three compulsory periodical assessments in a semester. Each assessment carry a maximum of 25 marks and shall be converted for a maximum of 15 marks. The question paper pattern for each test of each of the theory papers is given below:

Section	Type of Questions	Max. Marks
Part A	MCQ Type -5 Qns.	05 X 01 = 05
Part B	2 out of 3 problems /Qns./ MCQ*	02 X 05 = 10
Part C	1 out of 2 Descriptive or Analytical Qns./MCQ*	01 X 10 = 10
Total Marks		25

*For the elective (Critical Applications of Core Physics to problems – I and Critical Applications of Core Physics to problems – II) the multiple choice question (MCQ) pattern shall be followed.

(b) External Examinations :

The duration of the University examination for each theory course is 3hours. The question paper pattern for the end-semester examination of each theory paper is givenbelow:

Section	Type of Questions	Max. Marks
Part A	MCQ Type -10 Qns. (2 from each units)	10 X 1 = 10
Part B	Unit-wise choice – Either (a) or (b)type – 5 Qns. Problems/ MCQ*	05 X 5 = 25
Part C	Unit-wise choice-Either (a) or (b)type – 5 Descriptive or analytical Qns./MCQ*	05 X 8 = 40
	Total Marks	75

There is a passing minimum of 50% in the University examinations in each theory course and there is a passing minimum of 50% in the overall component, i.e. out of the total marks in the CIA component and the University examination for each theorycourse.

*For the elective (Critical Applications of Core Physics to problems – I and Critical Applications of Core Physics to problems – II) the multiple choice question (MCQ) pattern shall be followed.

Practicals:

(a) Continuous Internal Assessment:

There is no passing minimum for the CIA components and for the CIA in total. For the practicals courses, the Course Faculty shall conduct one (or two) internal test(s) for a maximum of 100 marks. The maximum mark given by the Course Faculty is 25 % and the same comprises of the following components:

Experimental Performance (Max.)	Record (Max.)	Test (Max.)	Total (Max.)
15	5	5	25

(b) External Examinations :

At the end of each semester, external examinations will be conducted for practicals. The duration for the University examination for each Practical Course may be four hours. There is a passing minimum of 50% in the University examinations in each Practicals course and there is a passing minimum of 50% in the overall component, i.e. out of the total marks in the CIA component and the University examination for each Practicals course.

Internal Examiner rse Teacher) (Max.)	External Examiner (From outside the institution) (Max.)	Test (Max.)
37.5	37.5	75

Internship:

Each student shall carry out internship during summer vocation in any Science Department other than Physics Department / any University / any National Laboratory / any Registered Industry for duration of 10 working days with one department faculty member as mentor. Attendance shall be produced for the same from higher authority of the institution/industry. Student shall submit a report with a minimum of 10 pages during the first week of third semester and followed by an open presentation. Mentor will provide CIA marks (25 marks) and report evaluation (25 marks) while any other faculty member of the department /external member will evaluate the report and presentation (50 marks).

Project work:

The project work shall be based on research oriented topics both in the fields of theoretical and experimental physics under the guidance of a faculty member of the Department as a Project Supervisor. After completion of the project work by the end of semester IV, each student should submit two copies of the project report/thesis to the Department on or before the date notified for thesame.

CIA (Max.: 25 marks)				End – Semester Examination (Max.: 75 marks)				
Marks for Reviews (Average of the best two of the three compulsory Reviews) (Max.: 25 marks)				Marks for Thesis Evaluation (Max.: 25 marks)		Marks for Viva-Voce Exam (with the Dept. Faculty Member/ Course Students) (Max.: 50 marks)		Total (Max.)
iew I	view II	view III	Average of the best two (Max.)	Project Supervis or (Max.)	External (from outside the Institution) (Max.)	Project Supervisor (Max.)	External (from outside the Institution) (Max.)	
25	25	25	25	12.5	12.5	25	25	75

There is no passing minimum for the CIA components and for the CIA in total. There is passing minimum of 50% in the University examinations in Project course and there is a passing minimum of 50% in the overall component, i.e. out of the total marks in the CIA component and the University examination for each Projectcourse.

** Common regulations for all the Programmes - by 44th SCAA meeting held on 30.5.2016 - Annexure –C1.(http://www.msuniv.ac.in/BOS/Revised/Course%20Regulations.pdf)

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C1- CLASSICALMECHANICS

OBJECTIVES:

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

UNIT-I: LAGRANGIAN FORMULATION

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

UNIT –II: HAMILTON'S EQUATION AND CANONICAL TRANSFORMATION

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

UNIT-III: HAMILTON-JACOBI THEORY AND SMALL OSCILLATIONS

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

UNIT-IV: KINEMATICS OF RIGID BODY

Independent coordinates of rigid body-orthogonal transformation-properties of transformation matrix-Euler angle and Euler's theorem-infinitesimal rotation-Coriolis force-angular momentum and kinetic energy of motion about a point-moment of inertia tensor-Non-inertial frames and pseudo forces-Euler's equations of motion-torque free motion of a rigid body-heavy symmetricaltop.

UNIT-V: CENTRAL FORCE PROBLEM AND THEORY OF RELATIVITY

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

BOOKS FOR STUDY:

1. Classical Mechanics -H. Goldstein, C. Poole and J. Safko,Pearson Education Asia, New Delhi, Third Edition,2002.
2. Classical Mechanics - G. Aruldhas, PHI Learning Private Limited, New Delhi,2015.

BOOKS FOR REFERENCE:

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

C2- MATHEMATICAL PHYSICS –I

OBJECTIVES:

- To develop knowledge in mathematical physics and itsapplications.
- To develop expertise in mathematical techniques required inphysics.
- To enhance problem solvingskills.
- To enable students to formulate, interpret and draw inferences frommathematical solutions.

UNIT-**I**: VECTOR ANALYSIS AND VECTOR SPACES

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

UNIT-**I**I: MATRICES

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

UNIT–III: TENSOR ANALYSIS

Definition of Tensors – Contravariant, covariant and mixed tensors – addition and subtraction of Tensors – Summation convention- Symmetry and Anti-symmetry Tensor – Contraction and direct product – Quotient rule- Pseudo tensors, Levi-Civita Symbol - Dual tensors, irreducible tensors-Metric tensors-Christoffel symbols – Geodesics.

UNIT-IV: COMPLEX VARIABLE

Functions of complex variable-Analytic functions-Cauchy- Riemann equations- integration in the Complex plane-Cauchy's theorem- Cauchy's integral formula-Taylor and Laurent expansions- Singular Points- Cauchy's residue theorem - poles - evaluation of residues - evaluation of definiteintegrals.

UNIT-V: GROUPTHEORY

Definition - Subgroups - Cyclic groups and abelian groups - Homomorphism and isomorphism of groups - Classes - Symmetry operations and symmetry elements - Representations of groups - Reducible and irreducible representations - Character tables for simple molecular types (C_{2v} and C_{3v} point groupmolecules).

BOOKS FOR REFERENCE:

1. Mathematical Physics, B.D. Gupta, Vikas Publishing House Pvt. Ltd,1995.
2. Mathematical Physics, B.S.Rajput, 20th Edition, Pragati Prakashan,2008.
3. Mathematical Physics, H.K. Dass and Rama Verma, S.Chand and Company Ltd,2010.
4. Mathematical physics, P.K. Chattopadhyay, Wiley Eastern Limited,1990.
5. Introduction to Mathematical physics, Charlie Harper, Prentice Hall of India Pvt.Ltd, 1993.
6. Applied Mathematics for Engineers and Physicists, L.A. Pipes and L.R. Havevill, McGraw Hill Publications Co., 3rd Edition,1971.
7. Theory and Problems of Laplace Transforms, Murray R. Spigel, Schaum's outline series, McGraw Hill,1986.
8. Matrices and Tensors in Physics, A.W. Joshi, Wiley Eastern limited, 3rd Edition,1995.

C3 – QUANTUM MECHANICS -I

OBJECTIVES**:**

- To study the fundamentals of wavemechanics.
- To study the stationary state and eigen spectrum of systems using timedependent Schrodingerequation.
- To solve the exactly soluble eigen valueproblems.
- To know the matrix formulation of quantum theory and how it can be used to understand the equation ofmotion.
- To understand the theory of identical particles and Angularmomentum.

UNIT-I: FOUNDATIONS OF WAVE MECHANICS

Postulates of wave mechanics -adjoint and self-adjoint operators-degeneracy-eigen value, eigen functions-Hermitian operator- parity - observables - Physical interpretation-expansion coefficients-momentum eigen functions-Uncertainty principle-states with minimum value-commuting observables .

Matter waves- Equation of motion- Schrodinger equation for the free particle – physical interpretation of wave function-normalised and orthogonal wave functions-expansion theorem-admissibility conditions- stationary state solution of Schrodinger wave equation - expectation values-probability current density- Ehrenferts theorem.

UNIT-II: STATIONARY STATE AND EIGENSPECTRUM

Time independent Schrodinger equation - Particle in a square well potential – Bound states – eigen values, eigen functions –Potential barrier – quantum mechanical tunnelling- alpha emission.

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

UNIT-III: EXACTLY SOLUBLE EIGENVALUE PROBLEMS

One dimensional linear harmonic oscillator – properties of stationary states- abstract operator method - Angular momentum operators- commutation relation- spherical symmetry systems - Particle in a central potential – radial wave function – Hydrogen atom: solution of the radial equation – stationary state wave functions – bound states-the rigid rotator: with free axis-in a fixed plane-3-Dimentional harmonicoscillator.

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

Quantum state vectors and functions- Hilbert space-Dirac's Bra-Ket notation-matrix theory of Harmonic oscillator –Equation of motions-Schrodinger, Heisenberg and Interaction representation.

Angular Momentum: Angular momentum -commutation relation of J_Z, J_+, J_- - eigen values and matrix representation of J^2, J_Z, J_+, J_- – Spin angular momentum – spin ½ , spin-1- addition of angular momenta- Clebsch-Gordan coefficients.

UNIT-V: SCATTERING THEORY

Kinematics of scattering process - wave mechanical picture- Green's functions – Born approximation and its validity –Born series – screend coulombic potential scattering from Born approximation.

Partial wave analysis: Asymptotic behavior – phase shift – scattering amplitude in terms of phase shifts – differential and total cross sections – optical theorem – low energy scattering – resonant scattering – non- resonant scattering-scattering length and effective range– Ramsauer-Townsend effect – scattering by square well potential.

BOOKS FOR STUDY:

1. A Text book of Quantum Mechanics – G. Aruldhas, Prentice Hall ofIndiaPvt., Ltd., 2002
2. Quantum Mechanics - Satya Prakash, Kedar Nath Ram Nath and Co. Publications, 2018.

BOOKS FOR REFERENCE:

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

C4 – ELECTRONICS

OBJECTIVES:

- The objective of the course is to impart in depth knowledge about Semiconductors, diodes, Transistors, Operational Amplifiers, Memories and converters etc., to the students.
- The theoretical knowledge gained in the class room can be experimented in the practical classes.

UNIT-I: SEMICONDUCTOR DIODES

Introduction to Semiconductor- PN Junction diode – Zener diode- Gunn diode- Tunnel diode- Photo diode - schottky diode – Impatt diode-Characteristics and Applications.

UNIT-II: TRANSISTOR BIASING AND OPTO ELECTRONIC DEVICES

Thevenin’s and Norton’s theorems - Transistor action- PNP-NPN transistors – Transistor biasing and stabilization- Need for biasing- DC load line- operating point- Bias stability-Two port Network - Hybrid model – h parameters — JFET – UJT-SCR.

UNIT-III: OPERATIONAL AMPLIFIER APPLICATIONS

Operational Amplifier- CMRR-Slew rate -Instrumentation amplifier – V to I and I to V converter - Op-amp stages- Equivalent circuits - Sample and Holdcircuits.

Applications of Op-Amp: Inverting, Non- inverting Amplifiers- circuits – Adder- Subtractor- Differentiator- Integrator- Electronic analog Computation solving simultaneous and differential equation –. Schmitt Trigger – Triangular wave generator – Sine wave generator – Active filters: Low, High and Band pass first and second order Butterworth filters – wide and narrow band reject filters.

UNIT-IV: SEMICONDUCTOR MEMORIES

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

UNIT-V: A/D AND D/A CONVERTER

Sampling theorem-Time division multiplexing – Quantization – DAC- Weighted resistor method – Binary Ladder network – ADC – successive approximation, Dual slope and Counter method – Voltage to Frequency conversion and Voltage to Time conversion.

BOOKS FOR REFERENCE:

1. Modern Digital Electronics – R.P. Jain – Tata McGraw Hill,2007.
2. Op-Amp and linear integrated circuits - R.F. Coughlin and F.F, Driscol, Prentice Hall of India, New Delhi,1996.
3. Op-Amps and Linear Integrated Circits -Ramakant A. Gayakwad, Pearson Education: Fourth Edition,2015.
4. Electronic Principles- Albert Malvino, David J Bates, 7 th Edition, McGraw Hill,2007.
5. Principles of Electronics- V.K.Mehta, 6 th Revised Edition, S.Chand and Company, 2001.
6. Electronic Devices and Circuits- David A. Bell, 4^{th} Edition, Prentice Hall.2007

Elective I
(Group – 1)

a. CRITICAL APPLICATIONS OF CORE PHYSICS TO PROBLEMS – I

OBJECTIVES:

- To consolidate the concepts and important relations without derivations and descriptions
- To apply the concepts and to use the relations for solving physics problems relevant to CSIR-NET, JEST and GATE

UNIT – I: CLASSICAL MECHANICS

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics- moment of inertia tensor. Non-inertial frames and pseudoforces.

UNIT – II: CLASSICAL MECHANICS

Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Special theory of relativity- Lorentz transformations, relativistic kinematics and mass–energy equivalence.

UNIT – III: MATHEMATICAL PHYSICS

Vector algebra and vector calculus- line integral – surface and volume integrals -Gauss, Greens and Stokes theorem. Linear algebra, Matrices, Cayley-Hamilton Theorem, Eigenvalues and eigenvectors, Symmetric matrix, antisymmetric matrix, Pauli Matrix, Hermitian, anti-hermitian matrix, orthogonal matrix, Unitary Matrix, Linear ordinary differential equations of first & second order, Special functions (Hermite polynomial, Bessel function, Laguerre and Legendre polynomial). Fourier series, Fourier transform, Fourier spectrum, Laplace and inverse Laplace transform of simple functions, Dirac delta function.

UNIT – IV: QUANTUM MECHANICS

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors.

UNIT – V: ELECTRONICS

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs).

BOOKS FOR STUDY:

1. Classical Mechanics -H. Goldstein, C. Poole and J. Safko, Pearson Education Asia, New Delhi, Third Edition, 2002.
2. Classical Mechanics -J. C. Upadhaya, Himalaya Publishing House Pvt. Ltd, Bangalore, Second edition, 2017.
3. Theory and Problems of Advanced Mathematics, Schaum's outline series - Murray R. Spiegel, (1983)
4. Quantum Mechanics: Concepts and Applications - Nouredine Zettli, Second Edition, John Wiley & sons (2009).
5. Electronic Devices – Thomas L. Floyd, Tenth Edition, Pearson Education (2017)

b. ADVANCED COMPUTATIONAL PHYSICS

OBJECTIVES:

- To provide the core tools and methodology of computationalphysics
- The emphasis is on gaining practical skills and a key objective isthatthe students gain the techniques and the confidence to tackle a broad range of problems inphysics.
- To provide a broad basis of skills and each is illustrated by application to physical system Usingmatlab.
- To provide knowledge about various mathematicalmethods.

UNIT I: NUMERICAL DIFFERENTIATION

Finding Roots of a Polynomial-Bisection Method-Newton Raphson Method- Solution of Simultaneous Linear Equation by Gauss Elimination Method- Solution of Ordinary Differential Equation by Euler, Runge-Kutta Fourth Order Method for solving first order Ordinary DifferentialEquations

UNIT II: NUMERICAL INTEGRATION

Newton’s cotes formula-Trapezoidal rule-Simpson’s 1/3 rule- Simpson’s 3/8 rule- Boole’s rule-Gaussian quadrature method-(2 point and 3 point formulae)- Giraffe’s root square method for solving algebraicequation.

UNIT III: MATLAB FUNDAMENTALS

Introduction - Matlab Features-Desktop Windows: Command, Workspace, Command History, Array Editor and Current Directory - Matlab Help and Demos- Matlab Functions, Operators and Commands. Basic Arithmetic in Matlab-Basic Operations with Scalars, Vectors and Arrays-Matrices and Matrix Operations- Complex Numbers- Matlab Built-In Functions-IllustrativeExamples

UNIT IV: MATLAB PROGRAMMING

Control Flow Statements: if, else, else if, switch Statements - for, while LoopStructures-break Statement- Input/Output Commands-Script “m‟ Files -Function “m‟ Files-Controlling Output

UNIT V: MATLAB GRAPHICS

2D Plots-Planar Plots, Log Plots, Scatter Plots, Contour Plots-Multiple Figures, Graph of a Function-Titles, Labels, Text in a Graph- Line Types, Marker types, Colors-3D Graphics-Curve Plots-Mesh and Surface Plots-IllustrativeExamples

BOOKS FOR STUDY:

1. Numerical methods in Science and Engineering- M.K. Venkataraman- National Publishing Co. Madras,1996.

2. Getting Started With Matlab-RudraPratap-Oxford University Press-New Delhi.

BOOKS FOR REFERENCE:

1. Engineering and Scientific Computations Using Matlab- Sergey E. Lyshevski-JohnWiley&Sons.
2. A Guide to Matlab for Beginners & Experienced Users-Brian Hunt, Ronald Lipsman, Jonathan Rosenberg-Cambridge UniversityPress.
3. Matlab Primer-Timothy A. Davis & Kermit Sigmon-Chapman & Hall CRC Press-London.
4. Matlab Programming-David Kuncicky-PrenticeHall.
5. An Introduction to Programming and Numerical Methods in MATLAB- S.R. Otto and J.P.Denier-Springer-Verlag-London.
6. Numerical Methods Using Matlab-John Mathews &Kurtis Fink-PrenticeHall-New Jersey,2006.
7. Introductory Methods of Numerical Analysis- S.S. Sastry-Prentice Hall,2005.

c. GENERAL RELATIVITY AND COSMOLOGY

OBJECTIVES:

- To expose the students to Tensors, General Relativity and Cosmology.

UNIT-I: TENSORS PRELIMINARIES

Tensors in index notation - Kronecker and Levi Civita tensors - inner and outer products - contraction - symmetric and antisymmetric tensors - quotient law - metric tensors - covariant and contravariant tensors - vectors - the tangent space - dual vectors - tensors - tensor products - the Levi-Civita tensor - tensors in Riemann spaces - Vector-fields, tensor-fields, transformation of tensors - gradient and Laplace operator in general coordinates - covariant derivatives and Christoffel connection.

UNIT-II: GENERAL RELATIVITY

Elasticity: Field tensor - field energy tensor - strain tensor - tensor of elasticity- curvature tensor The spacetime interval - the metric - Lorentz transformations - spacetime diagrams - worldlines

- proper time - energy-momentum vector - energy-momentum tensor - perfect fluids - energy-momentum conservation - parallel transport - the parallel propagator - geodesics - affine parameters.

UNIT-III: APPLICATIONS TO EINSTEIN'S THEORY

The Riemann curvature tensor - symmetries of the Riemann tensor - the Bianchi identity - Ricci and Einstein tensors - Weyl tensor - Killing vectors - the Principle of Equivalence - gravitational redshift - gravitation as spacetime curvature - the Newtonian limit - physics in curved spacetime- Einstein's equations - the Weak Energy Condition - causality - spherical symmetry - the Schwarzschild metric - perihelionprecession.

UNIT-IV: SOME MODELS OF THE UNIVERSE

Expansion of the Universe - thermal history - and the standard cosmological model –Friedmann - Robertson-Walker type models of the Universe - Primordial inflation and the theory of cosmologicalfluctuations.

UNIT-V: COSMOLOGY

Theory and observations of the cosmic microwave background and of the large-scale structure of the Universe - Dark matter and dark energy - theoretical questions and observationalevidence - inflation - origin of galaxies and other openproblems.

BOOKS FOR REFERENCE:

1. M. R. Spiegel, Vector Analysis, Schaum’a outline series, McGraw Hill, NewYork, 1974.
2. James Hartle, Gravity: An introduction to Einstein's general relativity, SanFrancisco, Addison-Wesley,2002
3. Sean Carroll, Spacetime and Geometry: An Introduction to GeneralRelativity, (Addison-Wesley,2004).
4. Jerzy Plebanski and Andrzej Krasinski, An Introduction to General Relativity and Cosmology, Cambridge University Press2006
5. Meisner, Thorne and Wheeler: Gravitation W. H. Freeman & Co., San Francisco 1973
6. Schutz: A First Course in GeneralRelativity.
7. J V. Narlikar, General relativity and cosmology, The Macmillan Company ofIndia Ltd.,1978
8. Robert M Wald, General Relativity, Univ. of Chicago Press.(1984)
9. Robert M. Wald: Space, Time, and Gravity: the Theory of the Big Bang and Black Holes, Univ. of ChicagoPress.
10. J. V. Narlikar, Introduction to Cosmology, Jones & Bartlett1983
11. Steven Weinberg, Gravitation and Cosmology, New York, Wiley,1972.
12. Jerzy Plebanski and Andrzej Krasinski, An Introduction to General Relativityand Cosmology, Cambridge University Press2006.
13. R Adler, M Bazin& M Schiffer, Introduction to GeneralRelativity.
14. A K Raichoudhury, TheoreticalCosmology.
15. A Papapetrou, Lectures in GeneralRelativity.

Practical I – OPTICS AND LASERS

(Any 8 Experiments from the following list**)**

1. MichelsonInterferometer
2. Cauchy’s constant by curve fittingmethod
3. Hartmann’s dispersionrelation
4. Elliptic fringes - q, n, σdetermination
5. Hyperbolic fringes - q, n, σdetermination
6. Airwedge
7. Cleavage step height of crystal by multiple Fizeauefringes
8. Study of Laser beam parameters(Coherent)
9. Fraunhofer diffraction usingLaser
10. Determination of wavelength ofLaser
11. Haidinger’s fringes in a wedgeplate
12. Faraday’s rotation usingLaser
13. Fabry - PerotEtalon
14. Constant DeviationSpectrometer
15. Any other experiment usinglaser

Practical II – ELECTRONICS

(Any 8 Experiments from the following)

1. OP AMPCharacteristics
2. OP AMP : Addition &Subtraction
3. OP AMP : Differentiation &Integration
4. OP AMP : Wave formgenerator
5. Schmitt trigger using IC
6. D/Aconverter
7. A/Dconverter
8. SCRCharacteristics
9. FETCharacteristics
10. UJTCharacteristics
11. OPAMP Comparator
12. OPAMP Analogcomputation
13. Any other experiments withIC's

C5 – MATHEMATICAL PHYSICS –II

OBJECTIVES:

- To develop knowledge in mathematical physics and itsapplications.
- To develop expertise in mathematical techniques required inphysics.
- To enhance problem solvingskills.
- To enable students to formulate, interpret and draw inferences frommathematical solutions.

UNIT-I: DIFFERENTIAL EQUATIONS

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

UNIT-II: SPECIAL FUNCTIONS – I

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

UNIT-III: SPECIAL FUNCTIONS – II

Hermite differential equation – Generating functions – Hermite polynomials - Recurrence relations – Rodrigue’s formula - Orthogonality: Laguerre differential equations – Generating functions - Laguerre polynomials - Recurrence relation - Rodrigue’s formula – Orthogonality.

UNIT-**I**V: PARTIAL DIFFERENTIAL EQUATIONS

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

UNIT - V: INTEGRAL TRANSFORMS

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

BOOKS FOR REFERENCE:

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

C6 – QUANTUM MECHANICS -II

OBJECTIVES**:**

- To learn about the approximation methods for time independent and time dependent perturbationtheory.
- To understand the kinematics of scattering process and partial waveanalysis.
- To study the theory of relativistic quantum mechanics and fieldquantization.
- To study the quantum theory of atomic and molecularstructures.

UNIT-I: APPROXIMATION METHODS FOR TIME INDEPENDENT PROBLEMS

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

UNIT-II: APPROXIMATION METHODS FOR TIME DEPENDENT PERTURBATION THEORY

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

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

UNIT-III: VARIATION METHOD

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

UNIT–IV: QUANTUM THEORY OF ATOMIC AND MOLECULAR STRUCTURE

Central field approximation: Residual electrostatic interaction-spin-orbit interaction-Determination of central field: Thomas Fermi statistical method-Hartree and Hartree-Fock approximations (self consistent fields) – Atomic structure and Hund's rule. Molecules : Born-Oppenheimer approximation – Anapplication: the hydrogen molecule Ion (H_2^+) – Molecular orbital theory: LCAO- Hydrogen molecule.

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

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

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

BOOKS FOR STUDY:

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

BOOKS FOR REFERENCE:

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

C7 – ELECTROMAGNETIC THEORY

OBJECTIVES:

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

UNIT -I:ELECTROSTATICS

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

UNIT- II: MAGNETOSTATICS

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

UNIT-III: ELECTROMOTIVE FORCE

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

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

UNIT-IV: ELECTROMAGNETIC WAVES

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

UNIT-V: APPLICATION OF ELECTROMAGNETIC WAVES

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

BOOK FOR STUDY:

1. Introduction to Electrodynamics – David J. Griffiths, 4th Edition,Pearson.
2. Electromagnetic Theory and Electrodynamics, SathyaPrakash, KedarNath RamNath and Co,2017.
3. Electromagnetics, B.B Laud, Wiley Eastern Company,2000.
4. Fundamentals of Electromagnetic, Wazed Miah, Tata Mc Graw Hill,1980.
5. Basic Electromagnetics with Application, Narayana rao, (EEE) Prentice Hall,1997.

BOOKS FOR REFERENCE:

1. Fundamentals of Electromagnetic Theory, Third edition, Narosa Publishing House, New Delhi – John R.Reitz, Frederick J Milford and Robert W.Christy,1998.
2. Classical Electrodynamics – J.D. Jackson, II Edition, Wiley Eastern Limited,1993.
3. Electromagnetic Fields and Waves – P.Lorrain andD.Corson.
4. Electromagnetics , B.B Laud, Wiley Eastern Company,2000

Elective II

(Group – 2)

a. CRITICAL APPLICATIONS OF CORE PHYSICS TO PROBLEMS – II

OBJECTIVES:

- To consolidate the concepts and important relations without derivations and descriptions
- To apply the concepts and to use the relations for solving physics problems relevant to CSIR-NET, JEST and GATE

UNIT – I: ELECTRONICS

Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters. Microprocessor and microcontroller basics. Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting.

UNIT-II: QUANTUM MECHANICS

Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time-independent perturbation theory and applications. Variational method. Time-dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection.

UNIT-III: MATHEMATICAL PHYSICS

Elements of complex analysis, analytic functions; Cauchy integral theorem, Taylor & Laurent series; singular points, poles, residues and evaluation of integrals. Elementary probability theory, random variables, Poisson statistics, binomial, Poisson and normal distributions. Central limit theorem, Group theory-SU(2), SU(3), Partial differential equations, elementary ideas about tensors: covariant and contravariant tensor, Levi-Civita and Christoffel symbols

UNIT – IV: ELECTROMAGNETIC THEORY

Electrostatics: Gauss’s law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction.

UNIT – V: ELECTROMAGNETIC THEORY

Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields.

BOOKS FOR STUDY

1. Theory and Problems of Advanced Mathematics, Schaum's outline series - Murray R. Spiegel, (1983)
2. Quantum Mechanics: Concepts and Applications - Nouredine Zettli, Second Edition, John Wiley & sons (2009).
3. Electronic Devices – Thomas L. Floyd, Tenth Edition, Pearson Education (2017)
4. Principles of Electronic – V.K. Mehta and Rohit Mehta, S. Chand & Co (2017)
5. Fundamentals of Quantum Mechanics, Statistical mechanics & Solid State Physics – S.P. Kuila, S.Chand & Co (2016)

b. INTRODUCTORY ASTRONOMY, ASTROPHYSICS &COSMOLOGY OBJECTIVES

OBJECTIVES

- ToDevelopanalyticalskillsandtheabilitytounderstandtheastronomical situation.
- To Achieve a good understanding of physical laws andprinciples.
- To Gain experience with measurement techniques and equipment, and develop the ability to assess uncertainties andassumptions.

UNIT - I : HISTORY OF ASTRONOMY

Introductory History of Astronomy-Ptolemy"s Geocentric Universe-Copernicus" Heliocentric Universe-Tycho Brahe and Galileo"s Observations-Kepler"s Laws ofPlanetary Motion-Newtonian Concept Of Gravity-Highlights of Einstein"s Special and General Theory Of Relativity-Curved Space Time-Evidence of Curved Space Time-Bending Of Light-TimeDilation

UNIT - II : STARS & GALAXIES

Stars and Galaxies-Distances-Trigonometric Parallax-Inverse Square Law- Magnitude of Stars-Apparent Magnitude-Absolute Magnitude and Luminosity- Color and Temperature-Composition of Stars-Velocity, Mass and Sizes of Stars-Types of Stars- Temperature Dependence-Spectral Types-Hertzsprung- Russell (HR) Diagram- SpectroscopicParallax

UNIT - III : LIVES AND DEATH OF STARS

Stellar Evolution-Mass Dependence-Giant Molecular Cloud-Protostar-Main Sequence Star-Subgiant, Red Giant, Supergiant-Core Fusion-Red Giant (Or) Supergiant- Planetary Nebula(Or) Supernova-White Dwarfs-Novae And Supernovae- Neutron Stars-Pulsars- Black Holes-Detecting Black Holes-The Sun- Its Size and Composition- Sun"s Interior Zones-Sun"sSurface-Photosphere-Chromosphere-Corona-Sun’s Power Source- Fusion ReactionMechanism.

UNIT -IV : COSMOLOGY I

Introduction to Cosmology-Basic Observations and implications-Olbers" Paradox - Expanding Universe-Gravitational Redshift-Doppler Effect-Hubble"s Law and the Age of the Universe - Cosmological Principle-The Perfect Cosmological Principle- Observation and interpretation of Cosmic Microwave background Radiation (CMBR)- Evidence Supporting the General Big Bang Theory-Salient features of SteadyStateTheory.

UNIT – V : COSMOLOGY II

Fate of the Universe-Dependence on Mass (Curvature of Space)-Critical density-Open Universe-Closed Universe-Homogenous and Isotropic Freidman-Robertson-Walker Universes-Deriving the Geometry of the Universe from the Background Radiation- Flatness Problem-Horizon Problem-Inflation and its effect on the universe-The Cosmological Constant.

BOOKS FOR REFERENCE:

1. Lectures on Astronomy, Astrophysics, And Cosmology-Luis A.Anchordoqu-
2. Lecture Notes of Department of Physics, University ofWisconsin-Milwaukee
3. Astrophysics of the Solar System -K.D.Abhayankar
4. An Introduction to Planetary Physics - Kaula.W.M.
5. Astrophysics of the Sun - HaroldZirin.

c. QUANTUM FIELDTHEORY

OBJECTIVES

- To given an exposure to Quantum Field Theory, which combines Quantum Mechanics and Special Relativity.
- This Advanced level course is a pre-requisite to studies in Advanced Nuclear Physics and Elementary ParticlePhysics

UNIT-I: CLASSICAL FIELDS

Lagrangian and Hamiltonian Formulations; Variational principle; Euler-Lagrange equations; Invariance of action and Conservation laws (Noether's theorem); Space-time translations; Lorentz transformations and conservation of energy-momentum and angular momentum tensor; Internal symmetries and associated conservation laws; Global and local gauge invariance; Lagrangians with Abelian and non-Abelian gaugeinvariance.

UNIT-II: QUANTISATION OF RELATIVISTIC FREE FIELDS

Quantisation of scalar, Dirac and electromagnetic fields; Number operator, States; Invariant Green's functions.

UNIT-III: INTERACTING QUANTUM FIELDS AND PERTURBATION THEORY

The interaction picture; Time evolution operator; Covariant perturbation theory; Normal product; Time ordered product and Wick.s theorem; Invariant amplitude and Feynman rules; Scattering cross section.

UNIT-IV: QUANTUM ELECTRODYNAMICS

Feynman rules for spinor electrodynamics; Simple applications; Basic ideas of renormalistion.

UNIT-V: GAUGE THEORIES

Elementary ideas on spontaneous symmetry breaking; Goldstone theorem (without proof); Spontaneously broken gauge theory and Higgs-Kibble mechanism; Standard model for electro-weak interactions(Glashow-Salam-Weinberg).

BOOKS FOR STUDY
1. J D Bjorken and S Drell: Relativistic QuantumMechanics
2. J D Bjorken and S Drell: Relativistic Quantum Field Theory
3. L R Ryder: Quantum FieldTheory

BOOKS FOR REFERENCE :
1. T P Cheng and L F Li : Gauge Theories of ElementaryParticles
2. T D Lee : Particle Physics And Introduction To FieldTheory

PRACTICAL III –DIGITAL ELECTRONICS APPLICATION

(Any 8 Experiments from the following)

1. Registers
2. Counters
3. RC active Filters
4. 8 bit and 16 bitAddition- MICROPROCESSORS
5. 8 bit and 16 bitSubtraction - MICROPROCESSORS
6. Multiplication- MICROPROCESSORS
7. Division- MICROPROCESSORS
8. Sum of nnumbers- MICROPROCESSORS
9. Square of anumber- MICROPROCESSORS
10. Sorting a series ofdata- MICROPROCESSORS
11. Square root of anumber- MICROPROCESSORS
12. BCDaddition- MICROPROCESSORS
13. Hexadecimal to Nibbles- MICROPROCESSORS
14. Name display- MICROPROCESSORS
15. Stepper-motorinterface- MICROPROCESSORS
16. A/D and D/Aconversion- MICROPROCESSORS
17. Simple programs in 8051 Assembly code and theirexecution - MICROCONTROLLERS
18. Manipulation, arithmetic operations, branching operations, logical operations and testing condition of bit in abyte- MICROCONTROLLERS
19. Code conversionprograms - MICROCONTROLLERS
20. Timer and counter programming- MICROCONTROLLERS
21. Serial mode operation- MICROCONTROLLERS
22. Interfacing DACmodule- MICROCONTROLLERS
23. Interfacing Traffic signalcontrol- MICROCONTROLLERS
24. Interfacing 7-segmentdisplay- MICROCONTROLLERS
25. Interfacing Stepper motorcontrol- MICROCONTROLLERS
26. Familiarity with MCBX51 board and writing programs for MCBX51.Program for Blinking of LEDs- MICROCONTROLLERS
27. Real timeclock- MICROCONTROLLERS
28. Arrayoperations

Practical IV – ATOMIC AND NUCLEAR PHYSICS

(Any 8 Experiments from the following list)

1. G.M. Counter Characteristics
2. G.M. Counter: Dead time & Inverse squarelaw
3. GM Counter: Linear & Mass attenuationcoefficient
4. Estimation of efficiency of the GMdetector
5. Feather's analysis – Range of betarays
6. Fermi – Kurie plot
7. Scintillation counter characteristics
8. Mass attenuation coefficient of solid materials for gammarays
9. Study of Cs^{137} and Co^{60} spectrum and calculation of full width at half maximum and resolution for the scintillationdetector
10. Energy calibration of gamma ray spectrometer (Study ofLinearity)
11. Variation of gamma intensity as a function of distance (verification of inverse square law)
12. Planck Constantmeasurement
13. Electron SpinResonance

C8 – THERMODYNAMICS AND STATISTICALMECHANICS

OBJECTIVES

- To provide a phenomenological introduction to thermodynamicsthrough thermodynamics postulates, quantities andrelations.
- Studying the micro and macroscopic properties of the mater through thestatistical probability laws and distribution ofparticles.
- Understanding the classical and quantum distribution laws and theirrelations.
- Studying transport properties, different phases of maters, equilibrium and non-equilibriumprocess.

UNIT- I: THERMODYNAMICS, MICROSTATES AND MACROSTATES

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

UNIT-II: MICROCANONICAL, CANONICAL AND GRAND CANONICAL ENSEMBLES

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

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

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

UNIT-IV: TRANSPORT AND NON-EQUILIBRIUM PROCESSES

Derivation of Boltzmann transport equation for change of states without and with collisions – Boltzmann equation for quantum statistics – Equilibrium distribution in Boltzmann equation –

Transport processes; One speed and one dimension - All speeds and all directions - Conserved properties - Distribution of molecular velocities – Equipartition and Virial theorems – Random walk - Brownian motion - Non-equilibrium process; Joule-Thompson process - Free expansion and mixing - Thermal conduction - The heat equation.

UNIT-V: HEAT CAPACITIES, ISING MODEL AND PHASE TRANSITIONS

Heat capacities of heteronuclear diatomic gas – Heat capacities of homonuclear diatomic gas – Heat capacity of Bose gas –One-dimensional Ising model and its solution by variational method – Exact solution for one-dimensional Ising model - Phase transitions and criterion for phase transitions – Classification of phase transitions by order and by symmetry – Phase diagrams for pure systems – Clausius-Clapeyron equation – Gibbs phase rule

BOOKS FOR REFERENCE:

1. Fundamentals of Statistical and Thermal PhysicsPaperback, Reif, Sarat Book Distributors(2010).
2. Fundamentals of Statistical Mechanics Paperback, B.B. Laud , New Age International Private Limited, Jan 2012.
3. Elementary Statistical Physics, C.Kittel, John Wiley & Sons,2004.
4. Statistical and Thermal Physics, F.Reif, McGraw Hill, Fifth Edition,2010.
5. Statistical Mechanics, Gupta & Kumar, 20^{th} Edition, Pragati Prakashan, Meerut,2003.
6. Statistical Mechanics, B.K.Agarwal and M.Eisner, Second Edition, New Age International Private Limited, Delhi,2016.
7. Statistical Mechanics and Properties of Matter (Theory and Applications), E.S.R.Gopal, Ellis Horwood Ltd,1974.

C9 – CONDENSED MATTER PHYSICS –I

OBJECTIVE

- To give strong foundation in the conceptual understanding of the development of solid state physics with appropriate theoreticalbackground.

UNIT-1: CRYSTAL PHYSICS: CRYSTAL STRUCTURE

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

Crystal Binding*:* Interactions in inert gas crystals and cohesive energy – Lennard – Jones potential - Interactions in ionic crystals and Madelung energy - Covalent bonding – Heitler – London Theory – Hydrogen bonding – metallic bonding.

UNIT-2: DIFFRACTION OF WAVES AND PARTICLES BY CRYSTALS

X-rays and their generation - Moseley's law – Absorption of X-rays (Classical theory) – Absorption Edge – X-ray diffraction – The Laue equations – Equivalence of Bragg and Laue equations – Interpretation of Bragg equation – Ewald construction - Reciprocal lattice – Reciprocal lattice to SC, BCC and FCC crystals- Importance properties of the Reciprocal lattice - Diffraction Intensity - The Powder method – Powder Diffractometer - The Laue method -The Rotating Crystal method - Neutron Diffraction - Electrondiffraction.

UNIT-3: CRYSTAL IMPERFECTIONS AND ORDERED PHASES OF MATTER

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

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

UNIT-4: LATTICE DYNAMICS

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

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

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

UNIT-5: THEORY OF ELECTRONS

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

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

BOOKS FOR STUDY:

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

BOOKS FOR REFERENCE:

1. J. Blakemore, Solid State Physics, 2nd Edition, W. B. Saunders Co, Philadelphia,1974.
2. C. M. Kachhava, Solid State Physics, Tata Mcgraw Hill, New Delhi,1990.
3. N. W. Aschroft and N. D., Mermin, Solid State Physics, Rhinehart and Winton, New York.1976.
4. M. Tinkham, Introduction to Superconductivity, Tata Mcgraw Hill, New Delhi,1996.
5. K.K.Chattopadhyay, A.N.Banerjee, Introduction to Nanoscience and Nanotechnolog, PHI Learning private Ltd., Delhi2014.
6. A. J. Dekker, Electrical Engineering Materials, Prentice Hall of India,1975.
7. S.O. Pillai, Problems and Solutions in Solid State Physics, New Age international Publishers, New Delhi,1994.
8. A.K. Bain, P. Chand, Ferroelectrics, Wiley,2017.
9. Kwan Chi Kao, Dielectric phenomena in solids with emphasis on physical concepts of electronic processes, Elsevier Academic Press,2004
10. Alexander O. E. Animalu, Intermediate Quantum Theory of Crystalline solids, Prentice Hall of India, New Delhi,1978.

C10 – NUCLEAR AND ELEMENTARY PARTICLE PHYSICS

OBJECTIVES:

- To introduce students to the fundamental principles and concepts governing nuclear and particlephysics.
- To know about nuclear physics' scientific and technological applications as wellas their social, economic and environmentalimplications.
- To understand the concept of elementaryparticles.

UNIT-I: NUCLEAR FORCES

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

UNIT-II: NUCLEAR MODELS

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

UNIT-III: NUCLEAR REACTIONS

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

UNIT-IV: RADIOACTIVEDECAYS

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

UNIT-V: ELEMENTRY PARTICLE PHYSICS

Classification of elementary particles - Types of interaction between elementary particles – Hadrons and leptons – Symmetry and conservation laws – Strangeness and associate production - CPT theorem – classification of hadrons – Quark model - Isospin multiples - SU(2)- SU(3) multiplets- Gell-

Mann - Okubo mass formula for octet and decuplet hadrons – Phenomenology of weak interaction hadrons and leptons - Universal Fermi interaction – Elementary concepts of weakinteractions.

BOOKS FOR STUDY:

1. Concepts of Nuclear Physics, B. B. Cohen, TMGH, Bombay,1971.
2. Introductory Nuclear Physics, K. Krane, Wiley, New York,1987.
3. Nuclear Physics, V. Devanathan, Narosa Publishinghouse.
4. Introduction to Elementary Particles, D. Griffiths, 2nd Ed., Wiley-Vch,2008
5. Nuclear Physics, S.N. Ghoshal, S. Chand and Co., II edition,1994.
6. Nuclear Physics, D.C. Tayal, Himalaya Publishing House Pvt., Ltd., V edition,2018.
7. Nuclear Physics, Irving Kaplan, Narosa Publishing House,2012.
8. Basic Nuclear Physics and Cosmic Rays, B.N. Srivatsava, Pragati Prakashan publications, Meerut, Edition: XVII,2016.
9. Elements of Nuclear Physics, M.L. Pandya and P.R.S Yadav, Kedar Nath RamNath publications, Meerut,2016.

BOOKS FOR REFERENCE:

1. R. D. Evans, "Atomic Nucleus", Mcgraw-HillNY.1955.
2. J. M. Blatt and V. F. Weisskopf, "Theoretical Nuclear Physics". Berlin1979.
3. H. Enge, " Introduction to Nuclear Physics Addision-Wesley" .Reading MA.1975
4. R. R. Roy and B. P. Nigam, "Nuclear Physics", Wiley Eastern,Madras1993.
5. D.C. Tayal „NuclearPhysics"
6. A. Bohr and B. R. Mottelson, "Nuclear Structure" Vol. I (1969) and Vol.II(1975), Benjamin Reading.

Elective III

(Group -3)

a. MATERIALS PHYSICS AND PROCESSING TECHNIQUES

OBJECTIVES:

- To impart knowledge on various materials growth, synthesis and processingtechniques
- To learn the structural, morphology, and surface characterizationtechniques.

UNIT-I: CRYSTAL GROWTH

Significance of crystal growth-Naturally occurring crystal growth processes-Crystal growthprocesses in laboratory and industrial scale- Classification of crystal growth methods-Growthfrom solutions -Nucleation: Homogeneous and heterogeneous, Solubility phase diagram-Saturation-Supersaturation- Metastable zone width-Slow evaporation and slow cooling methods,Growth from gel-Growth from flux-Growth from melt- Bridgeman-Stockbarger method-Czochralski pulling method- Growth from vapour-Sublimation method.

UNIT-II: PLASMA PROCESSING

Basics of plasma: Introduction, Types of plasma; Properties of plasma; V-I characteristics;Advantages of plasma processing.Thermal plasma: Principles of generation DC plasma torches; AC plasma torches;RF plasma torches, Plasma spraying; plasma Structure of sprayed deposits, Plasma spheroidization;Plasma decomposition; Treatment of hazardous wastes – Synthesis of ultrafine/nanopowders. Plasma melting and remelting.Non-thermal plasma: Glow discharge plasma, Plasma reactors for surface treatment: Corona& DBD atmospheric pressure surface treatment reactors

UNIT-III:VACUUMTECHNIQUES

Units and range of vacuua – Formulas for important quantities – Qualitative description of pumpingprocess – Surface processes and outgassing – Gas flow mechanism – Classification of pumps :Positive displacement pumps – Kinetic pumps – Entrapment pumps - Classification of pressuregauges : Total pressure gauges –Hydrostatic pressure gauges - Thermal conductivity gauges –Ionization gagues – Vacuum system : simple rotary, diffusion, turbo molecular, ultra-high vacuumand cryo-pumpedsystems.

UNIT-IV: GROWTH TECHNIQUE OF THINFILMS AND NANOMATERIALS

Plasma arc discharge-sputtering-chemical vapour deposition-pulsed laser deposition-molecular beam epitaxy-Electrochemical deposition- SILAR method; Solid-State Reaction - Sol-Gel Technique - Hydrothermal growth - Ball Milling – Combustion synthesis – Sonochemical method - Microwave synthesis – Coprecipitation.

UNIT-V: CHARACTERIZATION TOOLS

Working principles and instrumentation – XRD – XPS – AES- SIMS - RBS– LEED - AFM – SEM - STM

BOOKS FOR REFERENCE:

1. Maissel and Glange, Handbook of Thin Film Technology, McGraw Hill, First Edition, 1970.
2. A. Roth, Vacuum Technology, North Holland, Third Edition, 1990
3. Pipko A, Pliskosky V, Fundamentals of VacuumTechniques, MIR Publishers, First Edition, 1984
4. K. L. Chopra, Thin Films Phenomena, McGraw Hill,First Edition, 1969
5. D. K. Avasthi, A. Tripathi, A.C. Gupta, Ultra High VacuumTechnology, Allied Publishers, Private Limited, 2002
6. Kasturi Lal Chopra, SuhitRanjan Das, Thin Film Solar Cells, Plenum Press,New York, 1983
7. A.Chambers, R.K.Fitch and B.S.Halliday, Basic Vacuum Technology, IOP Publishing Ltd ,2ND Edition ,1998
8. A.Roth, Vacuum Technology, Elsevier Science, 3rd Edition, 1990
9. Edited by C. Suryanarayana, Non-equilibrium processing ofmaterials (Chapter – 6)Pergamon, 1999
10. P.V. Ananthapadmanabhan and N. Venkataramani, Thermal plasma processingPergamonmaterials series Vol 2, 1999
11. J. Reece Roth, Industrial plasma engineering - Applications to Nonthermal plasma processing (Vol. 2)Institute of Physics Publishing,Bristol, 2001
12. Maher I.Boulos, PierreFauchais and EmilPfender, Thermal plasmas– Fundamentals andApplications (Vol. 1), Springer Science, NY, 1994
13. Edited by Rainer Hippler, Sigismund P fau, MartinSchmidt, KarlH. Schoenbach, Low temperature plasma physics, Wiley-Vch, Berlin, 2001

b. X-RAYCRYSTALLOGRAPHY

OBJECTIVES:

- To study the production of X-rays, crystals and its symmetry and theirproperties.
- To understand the X-ray intensity data collection techniques, data reduction and structure solution and refinement from crystallographicmethod.

UNIT - I: X-RAYS

X-rays sources – conventional generators-construction and geometry-sealed tube–rotating anode generators–choice of radiation-Synchrotron radiation – X-ray optics: filters– monochromators–collimators-mirrors- safety.

Diffraction of X-rays: Lattice–Lattice planes-Miller indices–X-ray diffraction reciprocal lattice–relation between direct and reciprocal space–Bragg's law in reciprocal lattice–sphere of reflection – limiting sphere.

Symmetry of crystals: Crystal systems and symmetry – unit cell – space lattices- nonprimitive lattices – point groups– space groups–screw axes–glide planes-equivalent positions–matrix representation of symmetry- intensity weighted reciprocal lattice – analysis of space group symbols.

Crystals and their properties: Crystallization – growing crystals – choosing a crystal –mosaic structure-absorption- crystal mounting–alignment – measurement of crystal properties.

UNIT – II: DATA COLLECTION TECHNIQUES FOR SINGLE CRYSTALS

Laue method–single crystal diffraction cameras: rotation and oscillation method – Ewald construction – Weissenberg method – Precession method. Single crystal diffractometers and data collection strategy: Instrument geometry–crystal in a diffracting position–determination of unit cell–orientation matrix–Intensity Data collection–Unique data–equivalent reflections – selection of data–Intensity measurement methods: Film methods–counter methods: Point detector–Area detectors–CCD's–Image plates–Low temperature single crystaldiffractometry.

UNIT – III: DATA REDUCTION

Integration of intensity–Lorenz and Polarization corrections – absorption–deterioration or radiation damage–scaling – Interpretation of Intensity data.

Structure factors and Fourier syntheses: Structure factor – Friedel's Law – exponential and vector form – generalized structure factor – Fourier synthesis –Fast Fourier transform –

Anomalous scattering and its effect– Calculation of structure factors and Fourier syntheses.

UNIT – IV: PHASE PROBLEM

Methods of solving Phase Problem: Direct methods – Patterson methods – Heavy atom methods – molecular replacement- search methods – completing thestructure.

UNIT – V: REFINEMENT OF CRYSTAL STRUCTURES

Weighting – Refinement by Fourier syntheses – Locating Hydrogen atoms- identification of atom types – Least squares – goodness of fit– Least square and matrices-correlation coefficients– Relationship between Fourier and Least squares – Practical consideration in least squaresmethods.

Errors and Derived results: Random and systematic errors–derived results – molecular geometry – absolute configuration– thermal motion.

BOOKS FOR REFERENCE:

1. X-ray Structure Determination – G.H. Stout and L.H.Jensen, John WileyPublications, Second Edition,1989.
2. Fundamentals of Crystallography - C. Giacovazzo, Oxford Press, Second Edition,2011.
3. Structure Determination by X-ray Crystallography - Ladd and Palmer, Plenum Publishing Corporation, Second Edition,2013.
4. X-ray Crystallography - Woolfson, Cambridge University Press Publications. Second Edition, 1997.
5. Elements of X-ray Crystallography - Leonid V. Azaroff, , McGraw Hill Publications, 1968.
6. Crystal Structure analysis for Chemist and Biologist – J.P. Glusker, M. Lewis and M. Rossi, VCH Publishers Inc,1994.
7. Crystal, X-ray and Proteins – D. Sherwood, and J. Cooper, Oxford University Press, 2010.
8. An Introduction to Crystallography – F.C. Phillips, John Wiley Publications,1971.
9. International table forCrystallography.

c. DATA ANALYSIS ANDTECHNIQUES

OBJECTIVES**:**

- To learn the importance of error analysis, and various methods to analyseerror
- To effectively learn statistical tools needed for dataanalysis.
- To understand the behaviour of distribution ofdata

UNIT-I: ERRORS AND ITS IMPORTANCE

Approximate numbers and Significant Figures – Rounding of Numbers – Absolute, Relative and Percentage errors – Relation between Relative error and the significant figures – The general formula for errors – Formulas to the fundamental operations of arithmetic and logarithms – Accuracy in the evaluation of a Formula – Accuracy in the Determination of arguments from a tabulated function – Accuracy of Series approximations – Errors in Determinants.

UNIT-II: ERRORS AND CURVE FITTING

Errors of Observations and Measurement – The law of accidental errors – The probability of errors lying between given limits – The probability equation – The law of error of a linear function of independent quantities – The probability integral and its evaluations – Theprobability of hitting a target – The principle of least squares – Weighted observations – Residuals – The most probable value of a set of direct measurements – Law of error for residuals – Agreement between theory andexperience.

UNIT-III: PROBABILITY BASICS

Chance Experiments and Events – Definition of Probability – Basic Properties: Addition and multiplication laws of Probability – Conditional Probability, population, variants, collection, tabulation and graphical representation of data– Some General Probability Rules – Estimating Probabilities Empirically using Simulation -frequency distributions, averages or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standarddeviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis.

UNIT-IV: PROBABILITY DISTRIBUTIONS

Random variables – Probability distribution of discrete random variables – Probability distribution for continuous random variables – Mean and Standard deviation of a random variable - Binomial and geometric distribution – Normal distributions - Poisson distribution - Gaussian distribution, exponential distribution – additive property of normal variants, confidence limits, Bi-varite distribution, Correlation and Regression, Chi-Squaredistribution.

UNIT-V: ERRORS IN MEASUREMENTS

Measurement, Direct and Indirect – Precision and Accuracy – Measures of Precision – Relations between the Precision measures – Geometric significance of μ, r and η – Relation between probable error, and the probable errors of the arithmetic and weighted means – Computation of the precision measures from the residuals – The combinations of sets of measurements when the P.E.'s of Sets are given – The probable error of any function of independent quantities whose P.E.'s are known – The two fundamental problems of indirect measurements – Rejection of observations andmeasurement.

BOOKS FOR REFERENCE:

1. Numerical Mathematical Analysis, J. B. Scarborough, Oxford and IBH Publishing Company, 6th Edition, 1990
2. Introduction to Statistics and Data Analysis, R. Peck, C. Olsen and J.L. Devore, Cengage Learning, 5th Edition, 2014

Practical V – SOLID STATE PHYSICS

(Any 8 experiments from the following list)

1. Dielectric Constant ofliquid
2. HysterisLoop
3. Four ProbeMethod
4. Determination of Bandgap
5. Halleffect
6. GuoyBalance
7. Quincke'smethod
8. Ferroelectric Phasetransition
9. UltrasonicInterferometer
10. Ionic conductivitymeasurement
11. Etching process: Specimenpreparation
12. Determination of Specific heat of a material
13. Any other relatedexperiments

Practical VI – MATERIALS SCIENCE

(Any 8 experiments from the following list)

1. Solar cellcharacteristics
2. Fuel cellcharacteristics
3. Thin films- Electrodeposition
4. Thin films- Solutiongrowth
5. Measurement of lattice parameters of powder XRD data
6. Taue plot- Determination of bandgap
7. SEM/TEM- Particle sizeanalysis
8. SAED pattern analysis- Indexing thespots/rings
9. Raman/FTIR- Functional groupidentification
10. TG-DTA dataanalysis
11. Determination of particle size and strain from powder XRDdata
12. Analysis of any other characterizationdata

C11 – CONDENSED MATTER PHYSICS –II

OBJECTIVE:

- To develop analytical thinking to understand the phenomenon that decide various properties of solids thereby equip students to pursue higher learningconfidently.

UNIT – I: THEORY OF DIELECTRICS

Dipole moment – Polarization – The electric field of a dipole – Local electric field at an atom – Clausius –Mosotti equation - Dielectric constants and its measurements - Polarizability – The Classical theory of electronic polarizability – Ionic polarizabilities - Orientational polarizabilities

- The polarizability catastrophe - Dipole orientation in solids - Dipole relaxation and dielectric losses – Debye Relaxation time - Relaxation in solids - Complex dielectric constants and the loss angle - Frequency and temperature effects on Polarization – Dielectric breakdown and dielectric loss

UNIT – II: THEORY OF FERROELECTRICS AND PIEZO ELECTRICS

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

UNIT – III: MAGNETIC PROPERTIES OF MATERIALS

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

UNIT – IV: SUPERCONDUCTIVITY

Occurence of super conductivity - Destruction of super conductivity by magnetic fields - Meissner Effect – Type I and Type II Super conductors - Heat Capacity - Energy gap - Microwave and infrared properties - Isotope effect - Thermodynamics of the superconducting transition - London equation - Coherence Length - BCS theory of superconductivity, BCS groundstate-Fluxquantisationinasuperconductionring-Durationofpersistencecurrents-Single particle tunnelling - DC Josephson effect - AC Josephson effect - Macroscopic quantum interference – High temperature super conductors – Applications.

UNIT – V: PHYSICS OF NANOSOLIDS

Definition of nanoscience and nanotechnology – Preparation of nanomaterials – Surface to volume ratio – Quantum confinement – Qualitative and Quantitative description – Density of states of nanostructures – Excitons in Nano semiconductors – Carbon in nanotechnology – Buckminsterfullerene – Carbon nanotubes – Nano diamond – BN nano tubes – Nanoelectronics - Single electron transistor – Molecular machine – nanobiometrics.

BOOKS FOR STUDY:

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

BOOKS FOR REFERENCE:

1. J. Blakemore, Solid State Physics, 2nd Edition, W. B. Saunders Co, Philadelphia,1974.
2. C. M. Kachhava, Solid State Physics, Tata Mcgraw Hill, New Delhi,1990.
3. N. W. Aschroft and N. D., Mermin, Solid State Physics, Rhinehart and Winton, New York.1976.
4. M. Tinkham, Introduction to Superconductivity, Tata Mcgraw Hill, New Delhi,1996.
5. K.K.Chattopadhyay, A.N.Banerjee, Introduction to Nanoscience and Nanotechnolog, PHI Learning private Ltd., Delhi2014.
6. J. Dekker, Electrical Engineering Materials, Prentice Hall of India,1975.
7. S.O. Pillai, Problems and Solutions in Solid State Physics, New Age international Publishers, New Delhi,1994.
8. A.K. Bain, P. Chand, Ferroelectrics, Wiley,2017.
9. Kwan Chi Kao, Dielectric phenomena in solids with emphasis on physical concepts of electronic processes, Elsevier Academic Press,2004
10. Alexander O. E. Animalu, Intermediate Quantum Theory of Crystalline solids, Prentice Hall of India, New Delhi,1978.

    A. Eleftherios N. Economou, The Physics of Solids – Essentials and Beyond,Springer, 2010.

C12 – SPECTROSCOPY

OBJECTIVES**:**

- To give advanced knowledge about the interactions of EM radiation with matter and their applications in spectroscopy like IR, RAMAN, NMR, ESR, NQR and Mossbauerspectroscopy.

UNIT-I: MICROWAVE SPECTROSCOPY

Rotation of Molecules – Rigid Rotor (Diatomic Molecules) – Expression for the Rotational Constant - Intensity of Spectral Lines – Effect of Isotopic Substitution - Molecular Parameters (Bond Length, Bond Angle, Dipole Moment) from Rotation Spectra – Techniques and Instrumentation.

UNIT II: INFRARED SPECTROSCOPY

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

UNIT III: RAMAN SPECTROSCOPY

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

UNIT IV: NUCLEAR MAGNETIC AND ELECTRON SPIN RESONANCE SPECTROSCOPY

Basic principles – Quantum theory of NMR - magnetic resonance – relaxation processes – chemical shifts – spin-spin coupling - Spectra and molecular structure – Fourier Transform NMR - Instrumentation – Applications.

Basic principles – Quantum theory - g-factor – Nuclear Interaction and Hyperfine structure – Relaxation effects - Hyperfine interaction – line widths – ESR spectrometer – Instrumentation – applications.

UNIT V: NUCLEAR QUADRUPOLE RESONANCE ANDMOSSBAUER SPECTROSCOPY

Basic theory - Nuclear Electric quadrupole interaction – Energy levels – Transition frequency – Excitation and Detection – Effect of magnetic field – Instrumentation – applications.

Mossbauer effect - recoilless emission and absorption - hyperfine interaction - chemical isomer shift - magnetic hyperfine and electric quadruple interactions – ` Instrumentation – applications.

BOOKS FOR REFERENCE:

1. Colin N. Banwell, Elaine M. McCash, Fundamentals of Molecular Spectroscopy (Fourth Edition), Tata McGraw-Hill Publishing Company Ltd,1995.
2. J.D. Graybeal, Molecular Spectroscopy, McGraw-Hill, New York,1988.
3. Hollas, Michael, Modern Spectroscopy (Fourth Edition) John Wiley, NewYork, 2004.
4. R.P Straughen, S.Walker, Spectroscopy Vols.I,II and III, Chapman & Hall, London, 1976.

Elective- IV
(Group -4)

a. THIN FILM PHYSICS

UNIT I: VACCUM PUMPS

Kinetic theory of gases – Molecular Velocities – Pressure – Gas impingement on surfaces – Gas flow regimes – Conductance – Pumping speed – Vacuum pumps – Rotary mechanical pump – Roots pump – Diffusion pump – Turbomolecular pump – Cryopumps – Sputter ion pumps

UNIT II: MEASUREMENT OF VACCUM

Vacuum systems – Components and operation – System pumping considerations – Vacuum leaks – Direct pressure gauges: Manometeres, Mechanical gauge – Indirect Pressure gauges: Pirani gauge, Ionisation gauge, Penning gauge – Physics and chemistry of evaporation – Film thickness uniformity – Electrically heated evaporationsources

UNIT III: PHYSICAL VAPOUR DEPOSITION

Substrate preparation – Thermal evaporation method – Electron beam evaporation – Pulsed laser deposition – Web coating – Ion beam assisted evaporation – DC sputtering – RF sputtering method – Magnetron sputtering

UNIT IV: CHEMICAL METHOD

Solution growth of thin films – Spray pyrolysis – Electrodeposition of semiconducting and polymer films -Chemical vapour deposition: Pyrolysis, Reduction, Oxidation, Compound formation, Disproportionation – Thermodynamics of CVD: Reaction feasibility, Conditions ofequilibrium.

UNIT V: CHARACTERIZATION OF THIN FILMS

Thickness measurement: Gravimetric method, Quartz crystal thickness monitor, Fizeau method – Electrical properties: Two probe method, Four probe method and Van der Pauw technique – Structural properties: X-ray diffraction, line position, line width, line profile and line area analysis – Rutherford Back Scattering(RBS)

BOOKS FOR STUDY:
1. Milton Ohring – Materials Science of Thin Films – Academic Press, Second Edition,2002.
2. A. Goswami – Thin Film Fundamentals – New Age International,1996.

BOOKS FOR REFERENCES:
1. LI.Maissel and R.Gland – Handbook of thin film technology – McGraw Hill book company, New York 1983.
2. A.Chambers, R.K.Fitch, B.S.Halliday – Basic Vacuum Technology – Overseas Press, New Delhi, 2005.

b. DENSITY FUNCTIONAL THEORY

OBJECTIVES:

- Account for the fundamental background of Density Functional Theory(DFT)
- Understand the difference between DFT and other many bodyapproaches
- Explain how electron correlations are approximated withinDFT
- Explain the difference between different functionals such as LDA,GGA

UNIT-1: INTRODUCTION TO MANY ELECTRON PROBLEMS

Hartree-Fock (HF) theory - Configuration Interaction (CI) – Fundamental concept – Variational theorem – Variational theorem for ground state – reducing the CI space – DeterminantCI

UNIT-2: FOUNDATION OF DFT

The Thomas-Fermi model: precursor to modern DFT - Functional and functional derivatives, Euler Lagrange equation – Hohenberg-Kohn Theorem – degenerate ground state - N and υ representability of densities – Current Density FunctionalTheory.

UNIT-3: KOHN-SHAM (KS) EQUATION

Effective exact single particle method to the many body problem – Exchange and correlation energies – Interpretation of KS eigenvalues: Koopman's theorem, Ionization energy, Fermi surface, bandgap

UNIT-4: APPROXIMATION TO FUNCTIONALS

Local approximation: local density approximation(LDA)–Semi-localapproximation:generalizedgradientapproximation(GGA)- Non- local approximation: hybrid functional – Self interactionCorrection

UNIT-5: INTRODUCTION TO TIME DEPENDENT DFT

Runge-Gross Theorem - Time-Dependent Kohn- Sham Equations - Practical implementation of DFT methods: General scheme for solving Kohn-Sham - Full potential and pseudo potential methods - Basis functions: Gaussian, LAPWequation

BOOKS FOR STUDY:

1. http://vergil.chemistry.gatech.edu/notes/ci.pdf (UnitI)
2. Density Functional Theory: An Advanced Course, Eberhard Engel and Reiner M. Dreizler, Springer-Verlag,2011, Unit 2: chapter 2 and Unit 3: chapter 3 (relevant sections only) Unit5: Chapter 7, Section 7.1, 7.2
3. http://www.lct.jussieu.fr/pagesperso/toulouse/enseignement/introduction_dft.pdf Unit 4: relevantsections
4. https://www.springer.com/cda/content/document/cda_downloaddocument/9780387287805-c2.pdf?SGWID=0-0-45-326611-p86705782 (Unit 5, relevantsections)

BOOKS FOR REFERENCE:

1. Computational Physics, J. M. Thijssen, Cambridge University Press,1999
2. Introduction to Computational Chemistry, Frank Jensen, John Wiley and Sons,2017
3. Computational Materials Science: An Introduction, Second Edition, June Gunn Lee, CRC Press, Taylor and Francis Group,2017.

c. MEDICAL PHYSICS

OBJECTIVES:

- To understand the general concepts in radiation and its interaction anddose measurement.
- To apply the physics concepts in clinicaltrials.
- To educate scientifically the principles of radiation and its effect in the medicalfield.
- To emphasize the significance of various medical techniques andtherapy.

UNIT – I

Basic concepts in Radiation Dosimetry: Definitions of Dosimetric Quantities-units and relationship between DQ- linear energy transfer- tissue weighting factor-charged particle equilibrium-biological effects ofradiation.

UNIT –II

Interaction of gamma rays and X-rays with matter: Introduction- typesof interaction with matter – over all interaction of photons with matter.

UNIT – III

Treatment planning in radiation therapy: photon beam treatment planning-electron beam treatmentplanning.

UNIT – IV

Image-Guided radiation therapy: Introduction – Rationale of IGRT- current available IG techniques – traditional IGRT technologies –real time tracking systems – image registration and correction strategies – image guided Adaptive treatment (IG-ART) - management of respiratorymotion.

UNIT –V

Magnetic Resonance Imaging (MRI): MRI – contrasts in MRI – Physiological and functional MRI – MRI safety – future MRI applications. CT and MRI Radiotherapy: CT based treatment simulation and planning – MRI in Radiotherapy.

BOOKS FOR STUDY**:**

1. Introduction to Medical Physics – Muhammad Maqbool – Springer International Publishing (2017).

BOOKS FOR REFERENCE:

1. Attix FH (1986) An introduction to radiological physics and radiation dosimetry,Wiley.
2. Bortfeld T, Biirkelbach J, Boesecke R, SchlegelW(1990a) Methods of image reconstruction from projections applied to conformation radiotherapy. Phys Med Biol35(10):1423–1434.
3. Adler JR Jr et al (1997) The Cyberknife: a frameless robotic system for radio Surgery StereotactFunct Neurosurg69:124–128.
4. Antonuk LE et al (1996) Megavoltage imaging withalarge-area,flat-panel, amorphous silicon imager. Int J Radiat Oncol Biol Phys36:661–672.
5. Baltzer PA, Dietzel M, Kaiser WA (2012) MR-spectroscopy at 1.5 tesla and 3 tesla. Asystematic review and meta-analysis. Eur J Radiol 81(Suppl 1):S6–S9
6. Hendee WR, Ritenour ER (2002) Medical imaging physics, 4th edn. Wiley-Liss. xix, NewYork.