Department of Physics, CUH

Syllabus scheme for M.Sc. (Physics) under Choice Based Credit System (CBCS)

From Academic Session 2019 onwards

Course Type

- Core Course (CC)
- Generic Elective Course (GEC)
- Discipline Centric Elective Course (DCEC)

Total Credits : 104

Semester I

Course	Course Code	Credits	Course Type
Mathematical Methods in Physics-I	SPMS PHY 01 101 CC 3104	4	CC
Classical Mechanics	SPMS PHY 01 102 CC 3104	4	CC
Quantum Mechanics	SPMS PHY 01 103 CC 3104	4	CC
Semiconductor Devices	SPMS PHY 01 104 CC 3104	4	CC
Laboratory I	SPMS PHY 01 105 CC 00126	6	CC
Numerical Methods and Programming	SPMS PHY 01 101 GEC 3104	4	GEC*
Modern Optics	SPMS PHY 01 102 GEC 3104	4	GEC*
Introduction to Experimental Physics	SPMS PHY 01 103 GEC 3104	4	GEC*
Total Credits	4×4 (CC) + 6 + 4×1(GEC)	26	

Semester II

Course	Course Code	Credits	Course Type
Statistical Mechanics	SPMS PHY 01 201 CC 3104	4	CC
Classical Electrodynamics	SPMS PHY 01 202 CC 3104	4	CC
Mathematical Methods in Physics-II	SPMS PHY 01 203 CC 3104	4	**CC**
Laboratory II	SPMS PHY 01 204 CC 00126	6	CC
Latex for Science & Mathematics	SPMS PHY 01 201 GEC 2044	4	GEC*
Environmental Physics	SPMS PHY 01 202 GEC 3104	4	GEC*
Computational Physics	SPMS PHY 01 201 DCEC 3024	4	DCEC
Advanced Quantum Mechanics	SPMS PHY 01 202 DCEC 3104	4	DCEC
Analog Electronics	SPMS PHY 01 203 DCEC 3104	4	DCEC
Nonlinear Optics	SPMS PHY 01 204 DCEC 3104	4	DCEC
Seminar Presentation	SPMS PHY 01 205 CC 0202	2	CC
Total Credits	3×4 (CC) +4 (DCEC) + 6 + 4(GEC)+2 (S)	28	

Semester III

Course	Course Code	Credits	Course Type
Atomic, Molecular Physics and Laser	SPMS PHY 01 301 CC 3104	4	CC
Nuclear & Particle Physics	SPMS PHY 01 302 CC 3104	4	CC
Solid State Physics	SPMS PHY 01 303 CC 3104	4	CC
Laboratory III	SPMS PHY 01 304 CC 00126	6	CC
Physics of Electronic Material and Devices	SPMS PHY 01 301 DCEC 3104	4	DCEC
Electronic Communication	SPMS PHY 01 302 DCEC 3104	4	DCEC
Spectroscopy	SPMS PHY 01 303 DCEC 3104	4	DCEC
Physics of Nanomaterials	SPMS PHY 01 304 DCEC 3104	4	DCEC
Advanced Statistical Mechanics	SPMS PHY 01 305 DCEC 3104	4	DCEC
General Theory of Relativity	SPMS PHY 01 306 DCEC 3104	4	DCEC
Digital Electronics and Microprocessor	SPMS PHY 01 307 DCEC 3024	4	DCEC
Total Credits	**3×4 (CC) + 6 + 2×4(DCEC)**	26	

Semester IV

Course	Course Code	Credits	Course Type
Project	SPMS PHY 01 401 PROJ 00012	12	PROJECT
Nuclear Physics: Interaction and Detection	SPMS PHY 01 401 DCEC 3104	4	DCEC
Microprocessor and Microcontroller	SPMS PHY 01 402 DCEC 3104	4	DCEC
Nonlinear Dynamics	SPMS PHY 01 403 DCEC 3104	4	DCEC
Introduction to Astrophysics and Cosmology	SPMS PHY 01 404 DCEC 3104	4	DCEC
Thin Film and Integrated Devices	SPMS PHY 01 405 DCEC 3104	4	DCEC
Superconductivity: Conventional and High Temperature Superconductors	SPMS PHY 01 406 DCEC 3104	4	DCEC
Total Credits	12(P) + 3×4(DCEC)	24	

Note:

- This GEC* courses offered by the Department can only be taken by the students of other Departments. The students of the Physics Department will take GEC from other Departments.
- The Department may offer more than one discipline centric elective courses (DCECs) depending on specialization and strength of faculty members, and the students have to opt one of them for semester II.
- In semester III, students are required to opt two DCEC (courses) out of more than two courses offered by the Department, depending on the specialization and strength of the faculty.
- In semester IV, the students have to opt three DCEC (courses) out of options offered by the Department. Students need to do project also.

Mathematical Methods in Physics I

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Mathematical Methods in Physics I</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 101 CC 3104</td><td>Prerequisite: None</td><td colspan="4">Total hours = 60</td></tr>
<tr><td colspan="5">Semester I</td></tr>
</table>

COURSE OBJECTIVE : This course has been developed to introduce students to some topics of mathematical Physics which are directly relevant in different papers of Physics course. It includes elements of matrices and group theory, introduction to tensor algebra, function of a complex variable and calculus along with an introduction to computational techniques and statistical measures used in physics Course.

UNIT I

Matrices and Group Theory
Linear vector spaces, matrix spaces, linear operators, eigenvectors and eigenvalues, matrix diagonalization, special matrices. Symmetries and groups, multiplication table and representations, permutation group, translation and rotation groups, O(N) and U(N) groups.

UNIT II

Tensors Analysis
Coordinate transformations, scalars, contravariant and covariant vectors, mixed and covariant tensor of second rank, addition, subtraction and contraction of tensors, quotient rule. Christoffel symbols, transformation of Christoffel symbols, Covariant differentiation, Ricci's theorem, divergence, Curl and Laplacian tensor form, Stress and strain tensors, Hook's law in tensor form.

UNIT III

Complex Variables Functions of complex variable, Limits and continuity, differentiation, Analytical functions, Cauchy-Riemannn conditions, Cauchy Integral theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville's theorem. Power series Taylor's theorem, Laurent's theorem. Calculus of residues–poles, essential singularities and branch points, residue theorem, Jordan's lemma, singularities on contours of integration, evaluation of definite integrals.

UNIT IV

Computational Techniques and Probability Theory Root of functions, interpolation, extrapolation, Integration by trapezoid and Simpson's rule,solution of first order differential equation : using Runge-Kutta method and Finite difference methods. , Preliminary Concepts : mean values, standard deviation, various moments; Random walk problem, Binomial distribution, Poisson distribution, Gaussian distributions, Lorentz distribution, Central Limit Theorem.

Learning outcome: After completion of the course, students would be able

- To use matrices for solving linear algebraic equations and to use group theory for understanding of crystallography.
- To use tensor transformation and related algebra in physics
- To solve real definite integrals in theoretical Physics.
- To find roots of a given polynomial and understand the properties of a statistical distribution of point particles.

References:

1. **George Arfken and Hans J Weber**, Mathematical Methods for Physicists, Elsevier Academic Press. 7th Edition 2012
2. **L. A. Pipe**, Applied Mathematics for Engineers and Physicists, Dover Publication Inc., 3rd Edition 2014.
3. **Merle C. Potter and Jack Goldberg**, Mathematical Methods, SCHAND (Prentice Hall of India). 2nd Edition, 1987
4. **Fredrick W. Byron and Robert W. Fuller**, Mathematics of Classical and Quantum Physics, Dover Publications., Vol1 &2, 1970
5. **E.Kreyszig**, Advanced Engineering Mathematics, John Wiley & Sons. 10th Edition, 2015,
6. **K.F.Riley, M.P. Hobson, and S.J.Bence,** Mathematical methods for Physicists and Engineers, SCHAND (Cambridge University Press)., 3rd edition, 2018.
7. **V. BALAKRISHNAN :** Mathematical Physics with Applications, Problems and Solutions, Ane Books, 1st Edition , 2018

Classical Mechanics

Scheme Version: 2019	Name of the subject: Classical Mechanics	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 102 CC 3104	Prerequisite: None	Total hours = 60			
	Semester I				

Course Objective: This course aims at providing knowledge of Classical Mechanics to the students so that they are able to understand the Lagrangian & Hamiltonian mechanics of systems of particles interacting with various forces and also their applications in various branches of Physics.

UNIT I

Lagrangian Formulation and Central Force Problem:
Newtonian mechanics of one and many particle systems, Virtual work, Constraints: holonomic and non-holonomic, D'Alembert's Principle and Euler-Lagrange Equations of motion, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton's Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Conservation theorems and Symmetry Properties, Noether's theorem.
Two body central force problem: Reduction to equivalent one body problem, equation of motion and first integrals, Equivalent one-dimension problem and classification of orbits. Coriolis force.

UNIT II

Hamilton's Equations of Motion:
Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical equation from Hamilton's variational principle. The principle of least action.

UNIT III

Canonical Transformation and Hamilton-Jacobi Theory:
Canonical transformation, integral invariant of Poincare, Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem. Hamilton-Jacobi equation and its application. Action angle variable: adiabatic invariance of action variable,the Kepler problem in action angle variables.

UNIT IV

Small Oscillations and Rigid Body Motion:
Stable and unstable equilibria; Theory of small oscillations in Lagrangian formulation, normal coordinates and its applications, Free vibrations of linear triatomic oscillator. Orthogonal transformation, Eigenvalues of the inertia tensor, Euler equations, Eulerian angles, moment of Inertia.

Learning outcome: Students will be able to

- understand the mechanics of system of particles, D'Alembert's principle, Principle of least action and Lagrangian mechanics
- learn rigid body dynamics including problems &Euler's equation of motion.
- understand classical mechanics of Special theory of relativity, various transformation equations and Lagrangian and Hamiltonian of a relativistic particle in interaction with various force fields.
- learnCanonical Transformations &Hamilton-Jacobi theory.

References:

1. **Herbert Goldstein, Charles Poole, John Safko,** Classical Mechanics, Pearson Education, 3rd Edition, 2011.
2. **L.D. Landau and E.M. Lifshitz,** Mechanics, Butterworth-Heinemann, 2nd Edition, 2012.
3. **N.C. Rana and P.S. Joag,** Classical Mechanics, Tata McGraw Hill, 1st Edition, 2015.
4. **Ronald L. Greene,** Classical Mechanics with Maple, Springer, 2nd Edition, 2000.
5. **A.Sommerfeld,** Mechanics, Academic Press, 1st Edition, 1952.
6. **I. Percival and D. Richards**, Introduction to Dynamics, Cambridge University Press, 1st Edition1982.

Quantum Mechanics

Scheme Version: 2019	Name of the subject: Quantum Mechanics	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 103 CC 3104	Prerequisite: None	Total hours = 60			
	Semester I				

Course Objective: The aim of the course is to enable the students to understand the basic techniques & methods of quantum mechanics, so that they may apply these methods in various fields of research and development. Axioms of quantum mechanics are introduced; matrix representation of quantum mechanics is discussed together with approximate methods

UNIT I

Origin and Structure of Quantum Mechanics (QM)

Review of chronological developments of quantum mechanics. Linear spaces and Operators: Vector spaces, Linear independence, Bases, Dimensionality. Linear Transformations, Similarity Transformations; Eigen values and Eigen vectors. Inner product, Orthogonality and Completeness; Gramm Schmidt Orthogonalization Procedure.

Structure of Quantum Mechanics**:** Postulates of QM, Hilbert space; Hermitian and Unitary Operators; Orthonormality, Completeness and Closure. Dirac's bra and ket notation. Matrix Representation and Change of Basis. Operators and Observables, Significance of eigenvector and eigenvalues, Commutation relation; Uncertainty principle for two arbitrary Operators.

UNIT II

Quantum Dynamics:

Problem in one dimension (1D) with different types of potential functions such as particle in box, barrier potential, harmonic oscillator: analytical and algebraic methods. 3 D problems: Hydrogen Atom.

UNIT III

Angular Momenta &Approximate Analysis:

Orbital angular momentum, angular momentum algebra, raising and lowering operators; Matrix representation for j = 1/2 and j = 1; Spin angular momentum; Addition of two angular momentum, Clebsch-Gordan (CG) Coefficients.

UNIT IV

Time-dependent Perturbation Theory& Scattering Theory:

Perturbation Theory: Time-independent non-degenerate and degenerate cases, Time-dependent Perturbation theory; variational methods, and WKB method.

Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering.

Learning outcome: The students will learn

- the Schrodinger and Heisenberg pictures of time evolution, which play an important role in the quantum mechanical studies of any dynamical system.
- the quantum mechanical theory of angular momentum, Commutation relations for angular momentum operators, applications to Hydrogen atom, Coupling of angular momenta for multi-particle systems, Tensor operators.
- to apply the Time dependent and Time independent perturbation theories for non-degenerate and degenerate systems up to second order perturbation, with applications to harmonic oscillator and hydrogen atom.
- Basic of scattering theory.

References:

1. **Ashok Das and A. C. Melissinos,** Quantum Mechanics, Gordon and Breach Science Publishers, 1st Ed., 1987.
2. **B.H. Bransden & C.A. Joachim**, Quantum Mechanics, Pearson Publication, 2nd Ed., 2012.
3. **P. A. M. Dirac,** Lectures on Quantum Mechanics, Snowball Publishing, 1st Ed., 2012.
4. **R. Shankar,** Principles of Quantum Mechanics, Springer, 2nd Ed., 2011.
5. **Albert Messiah,** Quantum Mechanics, Dover Publications, 1st Ed., 2014.
6. **L.I. Schiff,** Quantum Mechanics, McGraw Publications, 4th Ed., 2017.
7. **Claude Cohen,** Quantum Mechanics, Wiley, 1st Ed., 1991.
8. **J.J. Sakurai,** Modern Quantum Mechanics, Pearson Education, 2nd Ed., 2013.
9. **E. Merzbecher,** Quantum Mechanics, John Wiley, 3rd Ed., 1998.
10. **Nouredine Zettili,** Quantum Mechanics: Concepts and Applications, Wiley, 2nd Edition, 2016.

Semiconductor Devices

Scheme Version: 2019	Name of the subject: Semiconductor Devices	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 104 CC 3104	Prerequisite: None	Total hours = 60			
	Semester I				

Course Objective: The objective of the course on Semiconductor Devices is to introduce semiconductor physics, physical principle of devices and their basic applications.

UNIT I

Semiconductors: Energy Band and Charge Carriers: Energy bands in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration equilibrium, Temperature dependence of carrier concentration, Compensation and charge neutrality. Conductivity and mobility, Effect of temperature, Doping and high electric field, Hall effect.

UNIT II

Junctions: p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener and Avalanche breakdown. Capacitance of p-n junction, Schottky barriers; Schottky barrier height, C-V characteristics, current flow across Schottky barrier: thermionic emission, Rectifying contact and Ohmic contact.

UNIT III

Field Effect Transistors: JEFT amplifying and switching, Pinch off and saturation, Gate control, I-V characteristics. MOSFET, Operation, MOS capacitor, Debye screening length, Effect of real surfaces; Work function difference, Interface charge, Threshold voltage and its control, MOS C-V analysis and time dependent capacitance. Output and transfer characteristics of MOSFET.

UNIT IV

Bipolar Junction Transistors (BJT): Fundamentals of BJT operation. Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio, Ebers-Moll equations, Charge control analysis. BJT switching: Cut off, Saturation, Switching cycle,. LED: Radiative transition, Emission spectra, Luminous efficiency and LED materials, Solar cell and photodetectors: Ideal conversion efficiency, Fill factor, Equivalent circuit, V_{oc}, I_{sc} and Load resistance, Spectral response. Reverse saturation current in photodetector.

Learning Outcome: Students will be able to

- get knowledge about various topics related to Semiconductors Physics such as intrinsic & extrinsic semiconductor, mobility, hall effect.
- learn about the semiconductor devices (principle & working)
- learn about photonic devices

References:

1. **P. Horowitz and W. Hill,** The Art of Electronics, Cambridge University Press, 3rd Edition 2015.
2. **J.J. Cathey,** Schaum's Outline of Electronic Devices and Circuits, McGraw Hill, 2nd Edition 2002.
3. **Millman and Halkias** ,Integrated Electronics : (Tata McGraw Hill), 2nd Edition 2009.
4. **A.P. Malvino**, Electronic Principles : (Tata McGraw, New Delhi), 7th Edition, 2009.
5. **J.H. Moore, C.C. Davis and M.A. Coplan**, Building Scientific Apparatus, Addison Wesley, 4th Edition 2009.
6. **R.L. Boylestad and L. Nashelsky**, Electronics Devices and Circuit Theory, Prentice Hall of India, 11th Edition, 2013.
7. **B. Streetman and S. Banerjee**, Solid State Electronics, Prentice Hall India, 6th Edition, 2006.

Laboratory I

Scheme Version: 2019	Name of the subject: Laboratory I	L	T	P	C
	Applicable to Programs: M.Sc. Physics	0	0	12	6
Subject Code: SPMS PHY 01 105 CC 00126	Prerequisite: None	Total hours = 180			
	Semester I				

Course Objective: The objective of the lab I is to train students to perform various practicals associated with Electronics, Quantum physics, Waves mechanics and Spectroscopy.

1. Hall Effect
2. Four Probe Method to find band gap of semiconductor
3. Electron Spin Resonance
4. Frank-Hertz experiment
5. PN Junction characteristics
6. Solar cell characteristics
7. Velocity of ultrasonic wave in liquids
8. Characteristics of MOSFET
9. Diode as voltage regulator
10. Ionization potential of mercury
11. Planck's constant using LED
12. Law of Malus
13. Zener diode characteristics

Introduction to C Programming :

14. Write a Program to calculate and display the volume of a CUBE having its height, width and depth.
15. Write a C program to perform addition, subtraction, division and multiplication of two numbers
16. Write a program to input two numbers and display the maximum number.
17. Write a program to find the largest and smallest among three entered numbers and also display whether the identified largest/smallest number is even or odd.
18. Write a program to find the roots of quadratic equation.
19. Write a program to check whether the entered year is leap year or not (a year is leap if it is divisible by 4 and divisible by 100 or 400.)
20. Write a program to find the factorial of a number.
21. Write a program to check number is Armstrong or not.
22. Write a program to find GCD (greatest common divisor or HCF) and LCM (least common multiple) of two numbers
23. Write a program to generate Fibonacci series.

Students assigned the general laboratory work will perform at least ten (10) experiments of the above mentioned list of Physics experiments and further 8 experiments from the C programming section.. Experiments of equal standard may be added. Workshop soldering and designing of experiments should be included.

Learning outcome: Students will learn various Physics aspects by performing the experiments related to electronic devices, atomic and molecular physics, light wave, sound waves etc.

Reference:

1. Worsnop and Flint, Experimental Physics, Littlehampton Book Services Ltd, 9th Edition, 1951.
2. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, 2nd Edition, 2003.
3. Lab manuals.

Numerical Methods and Programming

Scheme Version: 2019	Name of the subject: Numerical Methods and Programming	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 101 GEC 3104	Prerequisite: Mathematics during B.Sc./BCA	Total hours = 60			
	Semester I				

Course Objective: To make student expert in numerical methods and programming the physics problems related to various phenomena

UNIT I

C/C++:

Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

UNIT II

Numerical Methods of Analysis:

Solution of algebraic and transcendental equations: Iterative, Bisection and Newton-Raphson methods; Solution of simultaneous linear equations: Matrix inversion method; Interpolation: Newton and Lagrange formulas; Numerical differentiation, Numerical Integration: Trapezoidal, Simpson and Gaussian quadrature methods; Least-square curve fitting: Straight line and polynomial fits; Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods.

UNIT III

Simulations:

Generation of uniformly distributed random numbers, Statistical tests of randomness, Monte-Carlo evaluation of integrals and error analysis, Non-uniform probability distributions, Importance sampling, Rejection method, Metropolis algorithm, Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation.

UNIT IV

Short introduction to Programming using C and Psi Lab, class projects may be implemented in any language.

Learning Outcome: Students will be able to learn

- About solutions of linear and non-linear equations, and the convergence of the solutions, along with solutions of simultaneous linear equations.
- Numerical differentiation and integration.
- Monte Carlo methods

References:

1. **S. S. M. Wong,**Computational Methods in Physics and Engineering, World Scientific, 2nd Edition, 1997.
2. **V. Rajaraman,**Computer Oriented Numerical Methods, Prentice Hall of India, 4th Edition, 2015.
3. **V. Rajaraman,**Computer Programming in FORTRAN 90/95, Prentice Hall of India Pvt Ltd, 1st Edition, 2015.
4. **C. F. Gerald,** Applied Numerical Analysis, Pearson/Addison Wesley, 7th Edition, 2003.
5. **Landau and Binder,** A Guide to Monte Carlo Simulations in Statistical Physics, Cambridge University Press, 3rd Edition, 2013.
6. **Teukolsky, Vetterling and Flannery,**Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, 3rd Edition 2007.

Modern Optics

Scheme Version: 2019	Name of the subject: Modern Optics	L	T	P	C
	Applicable to Programs: UG & PG	3	1	0	4
Subject Code: SPMS PHY 01 102 GEC 3104	Prerequisite: B.Sc. with Physics	Total hours = 60			
	Semester I				

Course objective: The course Modern optics has focus on the Geometrical and wave optics, thin films, Holography, optical fibre, liquid crystals, LED and Photonic band gap crystals.

UNIT I

An overview of Geometrical and Wave Optics: Laws of Reflection, Refraction, Total Internal Reflection; Ideas of Interference, Diffraction, Polarisation, Dispersion.

UNIT II

Fresnel Relations: Conductors, Thin Films: Reflection Model, Matrix Formalism, Coating Design, Fourier Optics: Wave Propagation, Fraunhofer Diffraction, Fresnel Diffraction, Spatial Filtering, Holography and Holograms.

UNIT III

Coherence, Interference and Visibility, Laser Physics: Overview, Gain Saturation, Light-Atom Interactions, Optical Gain and Pumping Schemes, Output Characteristics, Light Shifts and Optical Forces, Atom-Photon interactions.

UNIT IV

Fiber Optics: Mode Analysis, Single mode and multimode optical fiber, Loss and Dispersion, Photonics Band-gap Crystals, Liquid crystals, Introduction of LED.

Learning outcome: After completion of this course, students would be able to

- hold the modern concepts like optical fibre, Holography, liquid crystals which have various applications.

References:

1. **Pedrotti,** Introduction to Optics, Pearson.3rd Ed, 2006.
2. **A. Ghatak,** Optics, Tata McGraw-Hill, 6th Ed, 2017.
3. **G. R. Fowles,** Introduction to Modern Optics, Dover Publication, 2nd Ed, 1989
4. **B. E. A. Saleh and M. C. Teich,** Fundamentals of Photonics, Wiley, 2nd Ed, 2012.
5. **E. Hecht,** Optics, Addison Wesley, 4th Ed, 2001.
6. **J. T. Verdeyen,** Laser Electronics, Prentice-Hall, 3rd Ed, 1995.
7. **A. E. Siegman,** Lasers, University Science Book, Revised Edition, 1986.

Introduction to Experimental Physics

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Introduction to Experimental Physics</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 103 GEC 3104</td><td>Prerequisite: B.Sc. with Physics</td><td colspan="4">Total hours = 60</td></tr>
<tr><td colspan="5">Semester I</td></tr>
</table>

Course Objective: To expose students to various experimental techniques to study different phenomena of physics.

UNIT I

Science of Experimental Physics: Background, Objectives, Error Analysis, Graphical Analysis, Writing about Experiments, Design of Experiments.

UNIT II

Probability and Statistics in Experimental Physics: Basic Concepts, Specific Discrete Distributions, Normal Distribution and other Continuous Distributions, Monte-Carlo Method, Inverse Probability: Confidence Limit.

UNIT III

Curve-Fitting Methods: Methods for Estimating Parameters, Regression Analysis, The Regularization Method, Interpolating Functions and Unfolding Problems, Fitting Data with Correlations and Constraints.

UNIT IV

Some Fundamental Experiments in Physics: Frequency of Oscillations in Simple Pendulum, Single, Double and N slits Diffraction Experiments, Relation between Refractive Index and Wavelength: Hartmann Formulae, Hall Effect, Ionization Potential of Mercury, Oscillations in Compound Pendulum, more experiments of similar nature may also be discussed.

Learning Outcome: The students will learn

- about error analysis
- curve fitting methods, monte carlo method
- case study of Physics experiments.

References:

1. **D.W. Preston and E.R. Dietz,** The Art of Experimental Physics, John Wiley & Sons, 1st Edition, 1991.
2. **C. Cooke,** An Introduction to Experimental Physics, University College London, 1st Edition, 1996.
3. **B.P. Roe,** Probability and Statistics in Experimental Physics, Springer-Verlag New York, 1st Edition, 2001.

Statistical Mechanics

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Statistical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 201 CC 3104</td><td>Prerequisite: Mathematical Methods in Physics I and Quantum Mechanics I</td><td colspan="4">Total hours = 60</td></tr>
<tr><td colspan="5">Semester II</td></tr>
</table>

Course Objective: This course provides a platform to develop concepts in classical laws of thermodynamics and their applications. Course will enable the students learn basic concepts regarding classical statistical mechanics and quantum statistical mechanics, phase transition and theory of probability.

UNIT I

Elementary Probability Theory:
Preliminary Concepts: mean values, standard deviation, various moments; Random walk and Brownian motion, Diffusion equation, Binomial distribution, Poisson distribution, Gaussian distributions, Central Limit Theorem.

UNIT II

Review of Thermodynamics:
Extensive and intensive variables, laws of thermodynamics, entropy for different systems, Boltzmann relation for Entropy, Legendre transformations and thermodynamic potentials, Maxwell relations, applications of thermodynamics to (a) ideal gas, (b) magnetic material, and (c) dielectric material.

UNIT III

Classical Statistical Mechanics:
Phase space, phase equilibrium, microstates and macrostates, Ensembles, Micro-canonical, Canonical, and grand canonical ensembles and partition functions, Maxwell-Boltzmann statistics, partition function: derivation of thermodynamic properties some examples including (a) classical ideal gas (b) system of classical harmonic oscillator, Gibbs paradox, thermal de Broglie wavelength, equipartition theorem and it applications, Chemical potential, Free energy and connection with thermodynamic variables, First and Second order phase transitions: diamagnetism, paramagnetism, and ferromagnetism, example of superconductivity, Ising model.

UNIT IV

Quantum Statistical Mechanics:
Bose-Einstein, Fermi-Dirac statistics. Bose system: Ideal Bose gas, Debye theory of specific heat, grand partition function for ideal Bose and Fermi gases, properties of black-body radiation, Bose-Einstein condensation, Fermi System: Fermi energy, Ideal Fermi gas, Pauli paramagnetism, electronic specific heat, white dwarf stars.

Learning outcome: On completion, of the course the students will be capable to

- explore the ideas about the statistical systems whose applications are in diverse areas of physics.

References:

1. **F. Reif,** Fundamentals of Statistical and Thermal Physics, McGraw Hill, 1st Edition., 2009
2. **K. Huang,** Statistical Mechanics, John Wiley & Sons, 2nd Edition, 2008.
3. **R. K. Pathria,** Statistical Mechanics, Pergamon Press, 3rd Edition, 2011.
4. **B. B. Laud,** Fundamentals of Statistical Mechanics, New Age, 2nd Edition, 2012.
5. **Mark W. Zemansky and Richard H. Dittman,** Heat and Thermodynamics, McGraw Hill, 8th Edition, 2017.
6. **L. D. Landau and E. M. Lifshitz,** Statistical Physics, Butterworth-Heinemann, 3rd Edition, 2016.
7. **Richard P. Feynman,** Statistical Mechanics, Westview Press. 1st Edition, 1998.
8. **J. P. Sethna,** Statistical Mechanics: Entropy, Order Parameter and Complexity, Oxford University Press, 1st Edition, 2005.

Classical Electrodynamics

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Classical Electrodynamics</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 202 CC 3104</td><td>Prerequisite: Mathematical Methods in Physics I</td><td colspan="4">Total hours = 60</td></tr>
<tr><td colspan="5">Semester II</td></tr>
</table>

Course objective:
This course aims to introduce the student to topics in electrostatic and magnetostatic Theory, Relativity and the Relativistic formulation of electromagnetism. The course also reviews basic knowledge of students on electromagnetic theory and builds on their knowledge on advanced topics like Maxwell equation, Green function solution, waveguide and introduces the basic formulation of relativity in 4-vector notation. In this course, as covariant formulation of electrodynamics and study of motion of charges in fields as well as radiation from moving charges are discussed.

UNIT I

Electrostatics:
Review of electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Differential equation for electric field, Poisson and Laplace equations, formal solution for potential with Green's functions, boundary value problems, examples of image method and Green's function method, solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions

UNIT II

Magnetostatics & Maxwell's Equations:

Review of Magnetostatics: Biot-Savart law, Ampere's theorem, Electromagnetic induction, examples of magnetostatic problems, , Scalar and vector potentials, Gauge symmetry, Coulomb and Lorentz gauges Gauge invariance, Displacement current, Maxwell's equations in free space and linear isotropic media (non conducting) boundary conditions on the fields at interfaces.

UNIT III

Electromagnetic Waves:
Electromagnetic waves in free space.
Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation modes in wave guides.

UNIT IV

Radiation and Relativistic Electrodynamics:

Lorentz Transformation, Lorentz invariance of Maxwell's equation. Dynamics of charged particles in static and uniform electromagnetic fields. Radiation- from moving charges and dipoles and retarded potentials Field of a localized oscillating source, fields and radiation in dipole and quadrupole approximations, Lienard-Wiechert potentials, Total power radiated by an accelerated charge, Lorentz formula.Four-vectors relevant to electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles.

Learning Outcome:

Upon successful completion of this course, students will be able

- to apply the Maxwell's equation and solve the problems involving the propagation of electromagnetic wave in variety of media. Students will have good understanding on application of special relativity in electrodynamics and also get the knowledge about waveguide and cavity.

References:

1. **J.D. Jackson,** Classical Electrodynamics, John Wiley & Sons 2nd Edition, 2003.
2. **David J. Griffiths,** Introduction to Electrodynamics, Benjamin Cummings; 3rd Edition,1999.
3. **L.D. Landau and E.M. Lifshitz,** Classical Theory of Electrodynamics, Butterworth-Heinemann. 4th Edition, 1987.
4. **Wolfgang K. H. Panofsky and Melba Phillips,** Classical Electricity and Magnetism, Dover Publications. 2nd Edition, 2012.
6. **Joseph Edminister,** Schaum's outline of electromagnetics , 2nd Edition, 2017.
7. **Walter Greiner**, Classical Electrodynamics , Springer 1st Edition, 1998.
8. **Melvin Schwartz**, Principles of Electrodynamics, Dover Publications, 1st Edition, 1987.
9. **J. Schwinger, L.L. Deraad Jr, K.A. Milton, W-Y. Tsai and J. Norton**, Classical Electrodynamics ,Westview Press, 1998.
10. **Charles A. Brau**, Modern Problems in Classical Electrodynamics ,Oxford University Press, 1st Edition, 2003.
11. **L. D. Landau and E. M. Lifshitz & L. P. Pitaevskii,** Electrodynamics of Continuous Media Oxford, 1st Edition, 2005.

Mathematical Methods in Physics II

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Mathematical Methods in Physics II</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 203 CC 3104</td><td>Prerequisite: Mathematical Methods in Physics I</td><td colspan="4">Total hours = 60</td></tr>
<tr><td colspan="5">Semester II</td></tr>
</table>

COURSE OBJECTIVE : This course has been developed to introduce students to some topics of mathematical Physics which are directly relevant in different papers of Physics course. It includes Ordinary differential equation, special functions and different transformation methods to solve differential equation .

UNIT I

Second Order Differential Equations
Separation of variables-ordinary differential equations, singular points, series solutions leading to Legendre, Bessel, Hermite, Laguerre functions as solutions. Orthogonal properties and recurrence relations of these functions.

UNIT II

Special functions
Spherical harmonics and associated Legendre polynomials. Sturm -Liouville systems and orthogonal polynomials. Wronskian linear independence and/ linear dependence.

UNIT III

Fourier Transforms
Fourier Transforms: Development of the Fourier integral from the Fourier Series, Fourier and inverse Fourier transform, Convolution theorem. Simple Applications: FTIR, Telecommunication systems, Solution of partial differential equation wave equation

UNIT IV

Laplace Transforms
Laplace transforms and their properties. Convolution theorem. Application of Laplace transform in solving linear, differential equations with constant coefficient, with variable coefficient and linear partial differential equation.

Learning outcome: After completion of the course, students would be able

- to solve second order differential equation.
- to use the special function in Quantum mechanics and electrodynamics
- able to perform Fourier and laplace transform on a given data set.

References:

1. **George Arfken and Hans J Weber**, Mathematical Methods for Physicists, Elsevier Academic Press. 7^{th} Edition 2012.

2. **L. A. Pipe**, Applied Mathematics for Engineers and Physicists, Dover Publication Inc. 2014.
3. **Merle C. Potter and Jack Goldberg**, Mathematical Methods, SCHAND (Prentice Hall of India). 2^{nd} Edition, 1987
4. **Fredrick W. Byron and Robert W. Fuller**, Mathematics of Classical and Quantum Physics, Dover Publications., Vol1 &2, 1970
5. **E.Kreyszig**, Advanced Engineering Mathematics, John Wiley & Sons. 10^{th} Edition, 2015,
6. **K.F.Riley, M.P. Hobson, and S.J.Bence,** Mathematical methods for Physicists and Engineers, SCHAND (Cambridge University Press)., 3^{rd} Edition, 2018.

7. **V Balakrishnan:** Mathematical Physics with Applications, Problems and Solutions; Ane Books, 1^{st} Edition , 2018

Laboratory II

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Laboratory II</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>0</td><td>0</td><td>12</td><td>6</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 204 CC 00126</td><td>Prerequisite: Laboratory I</td><td colspan="4">Total hours = 180</td></tr>
<tr><td colspan="5">Semester II</td></tr>
</table>

Objective of Course: The aim & objective of the course is to impart the practical training on various electronics devices such as; Op-Amp, Vibrators, Amplifiers, Michelson interferometer etc.

1. Study of Balmer series and Rydberg constant
2. Op-Amp as inverting and non-inverting amplifier
3. Op-Amp as differentiator, Integrator and Adder
4. e/m by Thomson method
5. Single stage RC coupled amplifier
6. Frequency response of common emitter amplifier
7. Bistable/Monostable/Astable vibrators
8. Grating spectra
9. Refractive index of water and oil using prism
10. Magneto resistance
11. Temperature dependence of Hall coefficient
12. Digital to Analog converter, Analog to Digital converter
13. Michelson Interferometer
14. Faraday Effect
15. Clipper and clampers
16. Root finding of a polynomial equation using numerical methods
17. Solving first and second order differential equation numerical methods
18. Numerical integration
19. Generating finite and infinite series

Students assigned the general laboratory work will perform at least twelve (12) experiments from the above mentioned. More experiments of similar nature may be added.

Learning outcome: Students will be able to

- understand spectral lines, grating spectra, and interference fringes
- learn the characteristics of Op-Amp, vibrators, clipper, clampers, and DA/ AD
- understand motion of temperature and magnetic field dependence of Hall coefficient.

Latex for Science and Mathematics

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Latex for Science and Mathematics</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>2</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 201 GEC 2044</td><td>Prerequisite: Mathematics</td><td colspan="4">Total hours = 60</td></tr>
<tr><td colspan="5">Semester II</td></tr>
</table>

Course Aim : To impart knowledge to student about different tools used in writing scientific/mathematical literature.

UNIT I

Software installation, Markup Languages

UNIT II

LATEX typesetting basics, LATEX math typesetting

UNIT III

Tables and matrices, Graphics, Packages, User definable

UNIT IV

Document classes, text bibTEX, beamer, flash cards / CV, Creating your own package, Project.

Course Outcome : The student would be able to write CV, documents, books, reports, thesis and seminar presentations using latex.

References:

1. **Helmut Kopka & Patrick W. Daly,**Guide to LATEX.Addison-Wesley Professional; 4th Edition (December 5, 2003)
2. **Stefan Kottwitz** , LaTeX Beginner's Guide, Packt Publishing, UK. 1st Edition, 2011
3 Resources from websites. :
The not so short introduction to LaTeX - Tobi Oetiker

https://tobi.oetiker.ch/lshort/lshort.pdf

Environmental Physics

Scheme Version: 2019	Name of the subject: Environmental Physics	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 202 GEC 3104	Prerequisite: US & PG	Total hours = 60			
	Semester II				

Course Objective: This course aims to introduce students to the application of core physical concepts of the Earth system, with special focus on: atmospheric radiation, greenhouse gases, pollution, and climate change. This course will demonstrate how physics is fundamental to understand natural and human influences on climate and atmospheric composition.

UNIT I

Introduction to Energy:
Importance of energy in science and society. Types of energy (mechanical, heat, chemical, nuclear, electrical). Law of conservation of energy. Energy transformations. Mechanical energy: force, work, kinetic and potential energy, PE diagrams, conservation of mechanical energy, bound systems. Electricity Basics.

UNIT II

Heat Energy and Kinetic Theory:
Heat and Temperature. Internal Energy, Specific Heat. Ideal gas equation. Kinetic theory interpretation of pressure and temperature. Work, heat, and the first law of thermodynamics. Adiabatic lapse rate. Radiant energy. Blackbody radiation. Heat engines and the second law of thermodynamics. The Carnot cycle. Applications of the second law to various energy transformation processes: heat pumps and refrigerators; different engine cycles. Entropy and disorder.

UNIT III

Energy and Climate Change:
Energy balance of the Earth. Greenhouse effect. Climate feedbacks (water, clouds, ice albedo). Global Climate Models. Evidence for climate change. Paleo-climate. Climate change impacts. Climate change mitigation. Target CO_2 levels.

UNIT IV

Energy Source:
Chemical energy. Energy in biology, photosynthesis, respiration. Energy use in the human body, energy content of food. Fossil fuels and their origin (coal, oil, natural gas). Problems with fossil fuels, greenhouse pollution, peak oil. Alternatives to fossil fuels. Alternative energy resource: Wind energy, energy from water on land, ocean energy. Biomass and other sources.

Learning outcome: After completion of this course, students would be able to

- understand the concepts like energy transformations, climate change and its effect on living beings.
- develop an awareness of climate change mitigation, different fossil fuels and their alternatives.

References:

1. R. A. Hinrichs and M. Kleinbach, Energy, Its Use and the Environment, Brooks Cole, 4^{th} Edition, 2005.

2. C. W. Rose, An Introduction to the Environmental Physics of Soil, Water and Watersheds, Cambridge University Press, 1^{st} Edition, 2004.

3. P. Hughes, N. J. Mason, Introduction to Environmental Physics: Planet Earth, Life and Climate, Taylor & Francis, 1^{st} Edition, 2005.

4. J. Monteith, M. Unsworth, Principles of Environmental Physics: Plants, Animals and the Atmosphere, Elsevier, 4^{th} Edition, 2013.

5. Egbert Boeker & Rienk Van Groundelle, Environmental Physics, John Wiley, 2^{nd} Edition, 2000.

6. J.T. Hougtyion, The Physics of Atmosphere, Cambridge University Press, 3^{rd} Edition, 2002.

7. J.T. Widell and J. Weir, Renewable Energy Resources,Elbs, 1^{st} Edition, 1988.

8. Sol Wieder, An Introduction of Solar Energy for scientists and Engineers, John Wiley, 1^{st} Edition, 1982.

9. R.N. Keshavamurthy and M. Shankar Rao, The Physics of Monsoons, Allied Publishers, 1^{st} Edition, 1992.

10. K.L. Kumar, Engineering Fluid Mechanics, S. Chand, 4^{th} Edition, 2016.

11. Landau &Lifshitz, Fluid Mechanics, Pergamon Press, 2^{nd} Edition, 2000.

Computational Physics

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Computational Physics</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 201 DCEC 3024</td><td>Prerequisite: Mathematical Methods in Physics I, Quantum Mechanics and Statistical Mechanics</td><td colspan="4" rowspan="2">Total hours = 75</td></tr>
<tr><td>Semester II</td></tr>
</table>

Course Objective: The objective of the course is to train the students for various computational techniques to solve integration, differentiation and molecular dynamics simulation techniques.

UNIT I

Stochastic Processes:

Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion.

UNIT II

Numerical Integration and Stochastic Differential Equations:

Dynamical equations, Finite Difference Method, Langevin dynamics, TDGL equation, Cahn-Hilliard equation, Burgers' equation, KPZ model, Traffic Flow Dynamics.

UNIT III

Molecular Dynamics (MD) and Monte Carlo (MC) Simulations:

Elementary ideas of molecular dynamics simulation, Physical potentials, Verlet algorithm. Time average and Ensemble average, Monte Carlo methods, Metropolis algorithm. Application of Monte-carlo simulations: (a) Ising model in magnetism (b) Glauber and Kawasaki dynamics.

UNIT IV

Combinatorial Optimization Problems:

Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique.

Computational experiments using computer programming

1. Finite and infinite series
2. Root finding: (bisection, Secant and Newton-Raphson methods),
3. Solving first and second order ordinary differential equations including simultaneous, equations (Euler and Runge-Kutta methods)
4. Numerical integration (trapezoidal, Simpson, Gauss quadrature, methods)
5. Matrices (arrays of variable sizes, addition, multiplication, eigenvalues, eigenvectors, inversion, solutions of simultaneous equations)
6. To determine Wien's constant using bisection method and false position method.
7. To solve Kepler's equation by Newton-Raphson method.
8. To solve van der Waals gas equation for volume of a real gas by the method of successive approximation.
9. To interpolate a real data set from an experiment using the Lagrange's method, and Newton's method of forward differences and cubic splines.
10. To fit the Einstein's photoelectric equation to a realistic data set and hence calculate Planck's constant. To estimate the value of π by rectangular method, Simpson rule and Gauss quadrature by numerically evaluating suitable integral.
11. To find the area of a unit circle by Monte Carlo integration.
12. To simulate Buffen's needle experiment.
13. To simulate the random walk.
14. To study the motion of an artificial satellite by solving Newton's equation for its orbit using Euler method.
15. To study the growth and decay of current in RL circuit containing (a) DC source and (b) AC using Runge Kutta method, and to draw graphs between current and time in each case.
16. To study the motion of two coupled harmonic oscillators.

Learning outcomes: Students will be able to learn

- computations techniques to solve various differential equations
- the computational integration
- the molecular simulations and optimization techniques.

References

1. **D. Frenkel & B. Smit,** Understanding Molecular Simulation, Academic Press,2nd Edition,2001.
2. **Kurt Binder and Heerman,** Monte Carlo Simulation in Statistical Physics,Springer,6th Edition,2019.
3. **M. Plischke & B. Bergersen,** Equilibrium Statistical Physics, World Scientific, 3rd Edition, 2006.
4. **W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling,** Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007.
5. **M. P. Allen,** Computer Simulation of Liquids, Oxford University Press,2nd Edition , 2017**.**
6. **V. Rajaraman,** Computer Oriented Numerical Methods, Prentice Hall of India, 3rd Edition, 1993.

7. V. Rajaraman, Computer Programming in FORTRAN 90/95, Prentice Hall of India, 1st Edition,1997.

Advanced Quantum Mechanics

Scheme Version: 2019	Name of the subject: Advanced Qauntum Mechanics	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 202 DCEC 3024	Prerequisite: Mathematical Methods in Physics I, Quantum Mechanics I	Total hours = 60			
	Semester II				

Course Objective: Aim of the course is to discuss the fundamental notions of ensemble of identical particles in quantum mechanics (fermions and bosons) and elements of second quantization. Knowledge of the Klein Gordon and Dirac equations and their solutions for simple potentials, together with an understanding the need of going beyond relativistic quantum mechanics, and elements of relativistic quantum field theory.

UNIT I

Classical Field Theory:

Interaction Picture; Constant and harmonic perturbations; Fermi Golden rule; Sudden and adiabatic approximations. Beta decay as an example. Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem.

UNIT II

Symmetry in Quantum mechanics:
Symmetry Operations and Unitary Transformations, conservation principles, space and time translation, rotation, space inversion and time reversal, symmetry and degeneracy, identical particles, Pauli-exclusion principle, spin statistics connection.

UNIT III

Second Quantization:
First Quantization: Many Body Quantum Mechanics; Slater Determinant. Second Quantization: Creation & Annihilation Operators, Number Operator; Non-Interacting Bose & Fermi Gas; Hamiltonian for the interacting system; Adding Spin.

UNIT IV

Relativistic Quantum Mechanics:

Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Feynman interpretation of antiparticles, Gamma matrices and their properties, Covariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariants, Plane wave solution, Two component theory of neutrino, Spin & Helicity, Relativistic Hydrogen atom problem.

Learning outcome: The students will be able to gain

- knowledge about fundamental quantum mechanical processes in nature.
- experience using mathematical tools to construct approximate quantum mechanical models

References:

1. **C. Cohen-Tannoudji, Bernard Diu and FrankLaloe,** Quantum Mechanics, Wiley, 1st Edition, 1991.
2. **Albert Messiah,** Quantum Mechanics, Dover Publications, 1st Edition, 2014.
3. **R.Shankar,** Principles of Quantum Mechanics, Springer, 2nd Edition, 2011.
4. **L.I. Schiff,** Quantum Mechanics, McGraw Hill, 4th Edition, 2017.
5. **J.J. Sakurai,** Modern Quantum Mechanics, Pearson Education , 2nd Edition, 2013.
6. **E. Merzbecher,** Quantum Mechanics, John Wiley, 3rd Edition, 1998.
7. **J. D. Bjorken and S.D. Drell,**Relativistic Quantum Mechanics, McGraw Hill 1st Edition, 1964.
8. **Amitabha Lahiri and P.B. Pal,**A First Book on Quantum Field Theory, Alpha Science, 2nd Edition, 2005.

Analog Electronics

Scheme Version: 2019	Name of the subject: Analog Electronics	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 203 DCEC 3104	Prerequisite: Semiconductor Devices, Quantum Mechanics	Total hours = 60			
	Semester II				

Course Objective: Course Objective: To introduce students to entire circuit designs, and to provide in-depth theoretical base of Digital Electronics.

UNIT I

Linear Wave Shaping: High Pass RC circuits: Its response to step, Pulse, Square wave, Ramp, exponential waveforms, Low pass RC Circuit: Its response to step, pulse, Square wave, Ramp, Exponential wave forms, Its application as an integrator. Attenuators, Time base Signal in a CRO. Operation of Clamping Circuits, Clamping Circuit theorem, Practical Clamping Circuit theorem, Operation of Transistor as a switch.

Clipping and Switching Circuits: Diode Clippers, Combinational and Biased clippers Transistor Clippers, Comparators, Applications of Voltage Comparators.

UNIT II

Multivibrators: A bistable multivibrator-basic concepts of its operation. Symmetrical and Unsymmetrical triggering, Application (brief). Monostable Multivibrator, Basic concepts of its operation, quantitative discussion of Quasi stable state, Application, Astable multivibrator - basic concepts of operation. Quantitative discussion of the period of oscillation, Application.

UNIT III

Analog Systems: Operational Amplifier, Differential Amplifier, Transfer Characteristics, Frequency Characteristics, IC Operational Amplifier, Compensation in Operational Amplifiers, Application of OP-AMP as adder, Multiplier, Differentiator, Integrator, Log and Antilog Amplifier, Application of Operational Amplifier to analogue computation.

UNIT IV

Logic Systems: Basic Concepts of dc positive and negative logic systems, Dynamic logic systems, OR gate and AND gate, NOT gate, NAND gate, EX-OR gate, NOR gate & their applications, Response to input pulse operation. TTL (transistor transistor logic) and DTL (diode transistor logic) logics Binary Adders, Half adders and full adders, Multiplexing and demultiplexing.

Learning outcomes: The students will be able to learn

- the techniques to shape of signals
- working of CRO
- fundamental designing concepts of different types of Logic Gates, Minimization techniques etc.
- working of various amplifiers

References:

1. P. Horowitz and W. Hill, The Art of Electronics, Cambridge University Press, 2^{nd} Edition, 1989.

1. **J.J. Cathey,** Schaum's Outline of Electronic Devices and Circuits, McGraw Hill Education, 2^{nd} Edition, 2002.
2. **Millman and Halkias** ,Integrated Electronics, Tata McGraw Hill, 2^{nd} Edition, 2017.
3. **A.P. Malvino**, Electronic Principles, Tata McGraw, New Delhi, 7^{th} Edition, 2009.
4. **W. Kleitz**, Digital Electronics, A Practical Approach, Pearson, 9^{th} Edition 2011.
5. **J.H. Moore, C.C. Davis and M.A. Coplan**, Building Scientific Apparatus, Cambridge University Press, 4^{th} Edition 2009.
6. **R.L. Boylestad and L. Nashelsky**, Electronics Devices and Circuit Theory, Prentice Hall of India, 8^{th} Edition 2003.
7. **R. J. Tocci**, Digital Systems-Principles and Applications, Prentice Hall of India, 10^{th} Edition 2013.

Nonlinear Optics

Scheme Version: 2019	Name of the subject: Nonlinear Optics	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 204 DCEC 3104	Prerequisite: Quantum Mechanics	Total hours = 60			
	Semester II				

Course Objective: Course Objective: To introduce aware students about the nonlear optics and related study of nonlinear crystals.

UNIT I

Interaction of Light with bulk Matter : Scattering, absorption, dispersion, different types of polarization such as oriental polarization, electronic polarization, ionic polarization etc. Dispersion equations, Sellmeir equatuions . birefringence, Ordinary and extraordinary waves, electro-optic effect, magneto –optic effect, Acousto-Optic effect.

UNIT II

Nonlinear optics : Lorentz oscillator model , Wave equations, Index ellipsoid, Uniaxial , Biaxial Crystals , optical activity and induced anisotropy, Generation of Second harmonics, Sum Frequency, difference Frequency generation and Optical rectifications, Miller's Rule, Relation between IInd order susceptibility d and χ

UNIT III

Phase Matching: Kleinmman's symmetry conditions,Piezoelectric effect , definition of d_{eff}. Manley –Rowe relationship, Gain in DFG process, SHG output power, Introduction and Importance of Phase matching to nonlinear medium and its characterization. Power flow in nonlinear medium and coupling of power between input and harmonics, Brief history of development of nonlinear materials, their characterization Measurement of second order nonlinearty using Maker fringe technique, Kurtz powder technique .

UNIT IV

Study of some nonlinear crystals :KDP, KD*P, ADP, BBO, LiNbO3 etc .and Parametric Up-Conversion, Sum Freq. generation, Limitation to up-conversion, effect of Phase matching, Acceptance angle etc, Optical parametric oscillator (OPO), Effect of Phase matching , Parametric Mismatching, Mode Hopping, Cluster effect , Power gain solution. Damage and optical characterization of nonlinear materials: Types of damage mechanisms and effect of laser pulse , wavelength and inclusions., Introduction to Third order nonlinearity and measurement techniques

Course Outcomes: The students will learn about

- The interaction of light with matter through different optical phenomena
- Phas matching and its characterization
- Properties of some nonlinear crystals.

References:

1. Max Born and Emril Wolf, Principle of Optics, Cambridge University Press, 1st Edition, 1999.
2. R.W. Boyd, Nonlinear Optics, Elsevier, 3rd Edition, 2008.
3. Zernike and Midwinter, Applied Nonlinear Optics, Elsevier, 4th Edition, 2006.
4. Y. R. Shen, The Principle of Nonlinear Optics, Springer, 1st Edition, 2002.
5. Walter Koechner , Solid State Laser Engineering, Springer, 1st Edition, 2009.

Seminar Presentation

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Seminar Presentation</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>0</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 204 CC 0202</td><td>Prerequisite: None</td><td colspan="4" rowspan="2">Total hours = 30</td></tr>
<tr><td>Semester II</td></tr>
</table>

This may include subject/research oriented topics.

Atomic, Molecular Physics and Lasers

Scheme Version: 2019	Name of the subject: Atomic, Molecular and Lasers	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 301 CC 3104	Prerequisite: Mathematical Methods in Physics I, Quantum Mechanics I, Statistical Mechanics	Total hours = 60			
	Semester III				

Course Objective: Aim of the course is to aware students about various atomic and molecular spectra and to understand the working of LASERs

UNIT I

Atomic Spectra I:
Review of Atomic Models: Rutherford's Model, Bohr's model, Sommerfeld's model, Stern-Gerlach experiment for electron spin. Revision of quantum numbers, exclusion principle, electronic configuration. Relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect.

UNIT II

Atomic Spectra II:
Spin-orbit interaction and fine structure, LS and JJ coupling, Relativistic correction to spectra of hydrogen atom, Lamb shift, effect of magnetic field on the hydrogen atom spectra, Zeeman and Paschen-Back effect. Hyperfine structure and isotope shift, Auger Effect and Frank Condon Principle. Born-Oppenheimer approximation.

UNIT III

Molecular spectra:
Rotational levels in diatomic and polyatomic molecules, vibrational levels in diatomic and polyatomic molecules, diatomic vibrating rotator, Born-Oppenheimer approximation, symmetry of the molecules and vibrational levels, experimental aspects of vibrational and rotational spectroscopy of molecules, polarization of light and Raman effect, Raman Spectroscopy (Brief Introduction).

UNIT IV

Lasers:
Spontaneous and stimulated emission, Spatial and temporal Coherence, Einstein A and B coefficients, Optical Pumping, Population Inversion, Modes of resonator, Q-switching and Mode Locking, Ultra short pulse generation, He-Ne Laser and Ruby Laser- Principle, Construction and working, Application of lasers in the field of medicine and Industry.

Learning outcomes: The students will be able to

- Understand different models of an Atom and derive the energy distribution corresponding to different levels of an atom
- Understand Raman effect and Raman spectroscopy of molecules.
- understand the working of He-Ne Laser and Ruby Laser

References:
1. **B. H.Bransden and C. J Joachain,** Physics of Atoms and Molecules, Pearson , 2^{nd} Edition, 2003.
2. **K. Thyagarajan and A.K. Ghatak,** Lasers - Theory and Applications, Plenum Press, 1^{st} Edition, 1981.
3. **H. E. White,** Introduction to Atomic Spectra, McGraw Hill, 1^{st} Edition, 1934.
4. **H. G. Kuhn,** Introduction to Atomic Spectra, Green and Co., 2^{nd} Edition, 1969.
5. **R. Eisberg and R. Resnick,** Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, 2^{nd} Edition, 2006.
6. **Arthur Beiser,** Perspectives of Modern Physics, McGraw Hill, 6^{th} Edition, 2006.
7. **Gerhard Herzberg,** Molecular Spectra and Molecular Structure, Krieger Pub Co, 2^{nd} Edition, 1989.
8. **C. N. Banwell,** Fundamentals of Molecular Spectroscopy, Tata McGraw Hill, 4^{th} Edition, 2017.

Nuclear & Particle Physics

Scheme Version: 2019	Name of the subject: Nuclear and Particle Physics	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 302 CC 3104	Prerequisite: Mathematical Methods in Physics I, Quantum Mechanics I, Statistical Mechanics	Total hours = 60			
	Semester III				

Course Objective: The aim and objective of this course is to enable the M.Sc. students to understand the basic concepts of static properties of nuclei, radioactive decays, nuclear forces, nuclear reactions. They will also learn about the elementary particle physics

UNIT I

Introductory Concept of Nuclei:

Scattering and electromagnetic methods for determining the nuclear radius, Nuclear angular momentum, Nuclear magnetic dipole moment and Electric quadruple moment, Parity quantum number, Statistics of nuclear particles, Nuclear Disintegration: Simple theories of decay, Properties of neutrino, Non conservation of parity and Wu's experiment in beta decay, Electron capture, Internal conversion.

UNIT II

Inter Nucleon Forces:

Properties and simple theory of the deuteron ground state, Spin dependence and tensor component of nuclear forces, Nucleon-nucleon scattering at low energy, Charge-independence of nuclear forces, Many–nucleon systems and saturation of nuclear forces, Exchange forces, Elements of meson theory.

UNIT III

Nuclear Structure and Models:

Fermi gas model, Experimental evidence for shell structure in nuclei, Basic assumption for shell model, Single- particle energy levels in central potential, Spin-orbit potential and prediction of magic numbers, Extreme single- particle model, Prediction of angular moment, Parities and magnetic moment of nuclear ground states, Liquid drop model, Semi-empirical mass formula, Nuclear fission, The unified model.

UNIT IV

Particle Physics:

Properties and origin, Elementary particles, Properties, classification, type of interactions and conservation laws, Properties of mesons, Resonance particles, Strange particles and Strangeness quantum number, Simple ideas of group theory, Symmetry and conservation laws, CP and CPT invariance, Special symmetry groups SU (2) and SU (3) classification of hadrons, Quarks, Gell-Mann-Okubu mass formula.

Learning outcomes: Students will be able to learn

- nuclear forces existing in two-nucleon systems
- about single particle shell model, magic numbers, and collective nuclear model.
- about the Radioactive decays like α-particle emission, Beta decays and gamma decay
- about nuclear deformations. Exotic nuclei and their production
- elementary particle physics

References:

1. **Roy & Nigam,**Nuclear Physics, John Wiley & Sons, 1st Edition, 1967.
2. **H. Enge,**Introduction to nuclear Physics, Addison Wesley, 1st Edition 1969.
3. **J.M. Blatt and V.F. Weisskopf,**Theoretical Nuclear Physics, Springer, 1st Edition, 1969.
4. **J.D. Walecka,**Theoretical Nuclear and Subnuclear Physics, World Scientific, 2nd Edition, 2004.
5. **M.Leon,**Particle Physics:An introduction, Elsevier, 1st Edition, 1973.
6. **F.I. Stancu,** Group Theory in Subnuclear Physics, Clarendon Press,1st Edition, 1997.
7. **B. R. Martin and G. Shaw,**Particle Physics, John Wiley & Sons, 3rd Edition, 2008.

Solid State Physics

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Solid State Physics</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 303 CC 3104</td><td>Prerequisite: Mathematical Methods in Physics I, Quantum Mechanics I, Statistical Machanics, Classical Mechanics</td><td colspan="4" rowspan="2">Total hours = 60</td></tr>
<tr><td>Semester III</td></tr>
</table>

Course Objective: This course is designed for the students to explore various experimental and theoretical concepts like, crystal lattice, binding, lattice dynamics, properties of solids and superconductors.

UNIT I

Crystal structure:
Crystal structures and lattices with basis, Common crystal structures, Reciprocal lattice, Brillouin zones, X-ray diffraction by a crystal and their equivalence, Laue equations, Ewald construction, Brillouin interpretation, Crystal and atomic structure factors, Structure factor; Experimental methods of structure analysis: Types of probe beam, the Laue, rotating crystal and powder methods. Ordered phase of matter: translational and orientational order, kinds of liquid crystalline order, quasi crystal.

UNIT II

Lattice dynamics, Crystal Binding and Thermal properties:
Classical theory of lattice dynamics: Vibrations of crystals with monatomic basis and Two atomic basis, Dispersion relation, Group velocity, Acoustical and optical modes; Bonding in solids, Elastic constants and properties, Phonons: Quantization of lattice vibration, Phonon momentum, Inelastic scattering of neutrons by phonons; Thermal properties: heat capacity, Density of states, Normal modes, Debye and Einstein models

UNIT III

Electronic properties of solids:
Free electron gas model: Electrical conductivity, Ohm's law and electronic specific heat, Response and relaxation phenomena, Drude Model of electrical and thermal conductivity, Density of states, Heat capacity, Hall effect and thermoelectric power, Fermi energy, Effect of temperature, effective mass, Limitations of the free electron gas model, Band theory of solids: metals, insulators and semiconductors, Kronig-Penney model.

UNIT IV

Superconductivity:
Introduction to Superconductivity, effect of magnetic field, Meissner effect, Type I and type II superconductors, Entropy, Free energy, Heat capacity, Energy gap, Isotope effect; Thermodynamics of the superconducting transition, London equation and penetration depth, Coherence length, Ginzburg Landau parameter, BCS theory of superconductivity, Cooper Pair, Flux quantization, DC and AC Josephson effects; SQUIDs, High Tc superconductors, Applications of superconductors.

Learning outcomes: On accomplishing this, the students will be able to

- deal with the ideas of crystal structures, electronic properties and superconductivity which have many industrial applications.

References:

1. **Charles Kittel,**Introduction to Solid State Physics, Wiley, 8th Edition, 2012
2. **Neil W. Ashcroft and N. David Mermin,** Solid State Physics, Holt, Rinehart and Winston, Revised Edition, 2016.
3. **Rajnikant,** Applied Solid State Physics, Wiley, 1st Edition, 2011.
4. **H. Ibach and H. Luth,** Solid State Physics: An Introduction to Theory and Experiment, Springer, 4th Edition, 2009
5. **J. M. Ziman,**Principles of the Theory of Solids, Cambridge University Press, 2nd Edition, 1979
6. **M. A. Wahab**, Solid State Physics: Structure and Properties of Materials, Narosa Publications, 2nd Edition, 2009
7. **J. P. Srivastava**, Elements of Solid State Physics, Prentice-Hall of India, 2nd Edition, 2006
8. **J. F. Annett**, Superconductivity Super fluids and Condensates, Oxford University Press, 1st Edition, 2004.
9. **S. O. Pillai**, Solid State Physics, New Age International Publishers, 8th Edition, 2018.

Laboratory III

Scheme Version: 2019	Name of the subject: Laboratory III	L	T	P	C
	Applicable to Programs: M.Sc. Physics	0	0	12	6
Subject Code: SPMS PHY 01 304 CC 00126	Prerequisite: Laboratory I & II	Total hours = 180			
	Semester III				

Course Objective: Aim of Lab III is to train students for advanced practicals related to solid state physics, nuclear physics, electronics, numerical techniques and material science.

Each student is required to perform at least five experiments from Section A and at least three experiments from any one of the optional subtopics of Section B: (i) Electronics (ii) Thin Film and Nano-Material (iii) Numerical Techniques; depending upon the courses opted under discipline centric elective course.

Section A

1. Kerr Effect
2. Curie Temperature
3. B-H curve
4. Dielectric constant
5. Solid State Nuclear Track Detector (SSNTD)
6. G.M. Counters: characteristics, dead time and counting statistics
7. Scintillation detector-energy calibration, resolution and determination of gamma ray energy
8. Quinks tube method to find susceptibility of a material
9. Nuclear Magnetic Resonance
10. Zeeman Effect
11. To study Lattice Dynamics

Section B

(i) Electronics

1. PCM/delta modulation and demodulation
2. Fiber optic communication
3. Modulation/Demodulation
4. 4-bit ripple counter

(ii) Thin Film and Nano-Material

1. Data Analysis of XRD, SEM and TEM
2. Chemical Deposition (for CNT growth)
3. ZnO wire by thermal oxidation
4. Band gap estimation by Tauc-plot method
5. Thin film deposition technique
6. DTA/TGA analysis

(iii) Numerical Techniques

1. Solution of Linear algebraic equation: Gauss Jordon elimination, Singular Value Decomposition, Sparse linear system.
2. Evaluation of Functions: special functions, evaluation of functions by path integration, incomplete gamma, beta function.
3. Random Numbers: Uniform random numbers generators, statistical distributions and their properties, Rejection Methods, transformation method, simple Monte Carlo integration, Adaptive and recursive Monte Carlo methods, Test of randomness.
4. Signal Processing: FFT, IFFT, Filtering with FFT, convolution and correlation functions, application to real time series data.
5. Eigen systems: Solving eigenvalues and finding eigen functions of Schrodinger equation for analytically unsolvable potentials using variational principle.

Learning outcomes:

- Apart from some experiments based on nuclear physics, electronics, computation and solid state physics, students will also perform the advance experiments like DTA, TGA, UV-VIS, Microwave furnace and thin film coating techniques.
- To understand the basic synthesis and characterization techniques for different materials such as thin films and nanoparticles.

References:

1. W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007.

2. J. P. Sethna, Statistical Mechanics: Entropy, Order Parameters, and Complexity, Oxford University Press, 2nd Edition, 2007.

3. A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press, 2nd Edition, 2003.

4. E. Balagurusamy, Numerical Methods, Tata McGraw Hill, 1st Edition, 2017.

5. Albert Malvino, Digital Principles and Applications, McGraw Hill, 4th Edition, 1986.

Physics of Electronic Material and Devices

Scheme Version: 2019	Name of the subject: Physics of Electronic Materials and Devices	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 301 DCEC 3104	Prerequisite: Quantum Mechanics	Total hours = 60			
	Semester III				

Course Objective: This course intends to provide knowledge about band structure and electronic properties of semiconducting materials. In addition, this course aims to provide a detailed theory and design of electronic, microwave and photonics devices.

UNIT I

Physical Mechanisms-I:
Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Band consideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Hole concentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation, effective mass of hole and electron, Heavy hole

UNIT II

Physical Mechanisms-II
Carrier mobility in semiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors (Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, Shockley read theory of recombination, Switching in electronic devices.

UNIT III

Electronic Devices:
Metal/Semiconductor Junction or (Abrupt P-N Junction), Current-voltage characteristics, C-V measurements, Estimation of Barrier Height and carrier concentration from C-V characteristics, Surface/Interface States, Role of interface States in Junction Diodes. Field Effect devices, C-V characteristics of MIS diodes (Frequency dependence), Estimation of Interface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices).

UNIT IV

Microwave and Photonics Devices:
Tunnel diode, MIS Tunnel diode, Degenerate and Non-degenerate semiconductor, MIS switch diode, MIM Tunnel diode. IMPATT diode. Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred electron devices.
Photonic devices: LED and LASER, Photo detectors, Solar-cells.

Learning outcome:
- The students should be able to elucidate the important features of semiconducting materials.
- They will be able to learn about electronic and microwave devices.

.**References:**

1. S.M. Sze,Physics of Semiconductor Devices, John Wiley & Sons , 2nd Edition, 2003.
2. Jasprit Singh,Semiconductor Devices Basic Principles, John Wiley & Sons, 1st Edition, 2000
3. A.S. Grove, Physics and Technology of Semiconductor Devices, WILEY; 1st Edition , 1967
4. B.L. Sharma,Metal/Semiconductor Schottky Barrier Junction and their Applications, Springer (US) 1st Edition, 1984.
5. E. H.Rhoderick, Metal/Semiconductor Contacts, Clarendon Press, 1st Edition , 1988.

Electronic Communication

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Electronic Communication</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 302 DCEC 3104</td><td>Prerequisite: Physics of Semiconductor Devices, Analog Electronics</td><td colspan="4" rowspan="2">Total hours = 60</td></tr>
<tr><td>Semester III</td></tr>
</table>

Course Objective: The aim of this course is to aware students about digital communication and related noise along with a knowledge of data transmission and computer communication system.

UNIT I

Digital communication:
Need for communication: AM, FM, modulation index. Pulse – Modulation systems, sampling theorem – Low – Pass and Band – Pass signals, PAM, Channel BW for a PAM signal. Natural sampling. Flat – top sampling. Signal recovery through Holding, Quantization of signals, Quantization error, Differential PCM, Delta Modulation, Adaptive Delta Modulation, CVSD.Digital Modulation Techniques: BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK.

UNIT II

Mathematical representation of Noise:
Sources of noise. Frequency domain representation of noise, effect of filtering on the probability density of Gaussian noise, spectral component of noise, effect of a filter on the power spectral density of noise. Superposition of noises. Mixing involving noise. Linear filtering. Noise Bandwidth, Quadrature components of noise, Power spectral density of nc(t), ns(t) and their time derivatives.

UNIT III

Data Transmission:
Baseband signal receiver, probability of error. Optimum filter. White noise.
Noise in pulse–code and Delta–modulation system: PCM Transmission, Calculation of Quantization noise, Output – signal power, Effect of thermal noise in D M, Output signal–to–noise ratio in PCM, DM, Quantization noise in DM, Effect of thermal noise in Delta modulation, Output signal to noise ratio in DM.

UNIT IV

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

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, Cellular communications, Mobile communication via Satellites, Bandwidth consideration in INTERNET.

Learning outcome: Students will be able to understand

- the need for communication.
- various sources of noise in digital communication.
- modulation and demodulation of digital signals
- communication via satellite and mobile

References:

1. **Taub and Schilling,** Principles of Communication Systems, McGraw Hill, 3rd Edition, 2007,.
2. **Simon Haykin,** Communication Systems, Wiley, 2nd Edition, 2007.
3. **Jack, W. Hudson and Jerry Lucke,** Basic Communications Electronics, Master Publications,1st Edition, 1999.
4. **Robert L. Shrader,** Electronic Communication, Glencoe K Macmillan, 5th Edition, 1985.
5. **B.P. Lathi,** Modern Digital and Analogue Electronic Communication, Oxford University Press, 4th Edition, 2011.

Spectroscopy

Scheme Version: 2019	Name of the subject: Spectroscopy	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 303 DCEC 3104	Prerequisite: Quantum Mechanics, Atomic Molecular and Lasers	Total hours = 60			
	Semester III				

Course Objective: The aim of this course is to aware students about molecular structures, Raman spectroscopy, nuclear magnetic resonance and Electron spin resonance.

UNIT I

Molecular structure and Vibration spectroscopy:
Molecular structure determination, Stark effect, inversion spectrum of ammonia, Applications to chemical analysis. Vibrational spectroscopy of diatomic and simple polyatomic molecules, Harmonic Oscillator, Anharmonic Oscillator - Rotational vibrators - Normal modes of vibration of Polyatomic molecules, Experimental techniques, Applications of infrared spectroscopy, H_2O and N_2O molecules, Reflectance spectroscopy.

UNIT II

Raman Spectroscopy:
Classical theory of Raman Scattering - Raman effect and molecular structure, Raman effect and crystal structure, Raman effect in relation to inorganic, organic and physical chemistry, Experimental techniques, Coherent anti-Stokes Raman Spectroscopy, Applications of infrared and Raman spectroscopy in molecular structural confirmation of water and CO_2 molecules, Laser Raman Spectroscopy.

UNIT III

NMR
Theory of NMR, Bloch equations, Steady state solution of Bloch equations, Theory of chemical shifts, Experimental methods, Single Coil and double coil methods, Pulse Method, High resolution method, Applications of NMR to quantitative measurements. Quadruple Hamiltonian of NQR, Nuclear quadruple energy levels for axial and non-axial symmetry – Experimental techniques and applications.

UNIT IV

ESR and Mossbauer spectroscopy:
Quantum mechanical treatment of ESR:Nuclear interaction and hyperfine structure, Relaxation effects, Basic principles of spectrographs, Applications of ESR method, Mossbauer Effect,Recoilless emission and absorption - Mossbauer spectrum - Experimental methods - Mossbauer spectrometer, Hyperfine interactions, Chemical Isomer shift, Magnetic hyperfine interactions, Electric quadruple interactions, Simple biological applications

Learning Outcome: Students will be able to understand

- stark effect and normal modes of vibration of polyatomic molecules.
- stokes and anti stokes part of Raman Spectra
- steady state solution of Bloch equation.
- steady state solution of Bloch equation.
- nuclear interactions and hyperfine structures

References:

1. **C.N. Banwell and E.M. Mc Cash,** Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill, 4th Edition, 1994.
2. **G. Aruldas,** Molecular Structure and Spectroscopy, Prentice Hall of India , 2nd Edition, 2007.
3. **D.N. Satyanarayana,** Vibrational Spectroscopy and Applications, New Age Publications, 1st Edition, 2000.
4. **Raymond Chang,** Basic Principles of Spectroscopy, McGraw Hill, 1st Edition, 1970.
5. **Martin Karplus and Richard N. Porter,** Atoms and Molecules: An Introduction For Students of Physical Chemistry, W.A. Benjamin, Inc, 1st Edition, 1970,

Physics of Nanomaterials

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Physics of Nanomaterals</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 304 DCEC 3104</td><td>Prerequisite: Quantum Mechanics, Solid State Physics</td><td colspan="4" rowspan="2">Total hours = 60</td></tr>
<tr><td>Semester III</td></tr>
</table>

Course Objective:
This course aims to introduce the students to physics of nanosystems as well as emerging area of nanotechnology. In addition, this course provide knowledge about the synthesis, characterization and applications of nanomaterials.

UNIT I

Introduction to Nanostructure Materials:
Nanoscience & nanotechnology, Size dependence of properties, Moor's law, Surface energy and Melting point (quasi melting) of nanoparticles, Excitons, Density of states for O, 1, 2 and 3D, Variation of density of states with energy and Size of crystal. Population of conduction and valance band for 0D, 1D, 2D & 3D material.

UNIT II

Quantum Size Effect:
Quantum confinement: carrier and photon, Nanomaterials structures, Two dimensional quantum system, Quantum well, Quantum wire and Quantum dot, Fabrication techniques.

UNIT III

Synthesis of Nanomaterials:
Key issue in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches, Thermal and e-beam evaporation, Cluster beam evaporation, Ball Milling, Chemical bath deposition with capping agent, synthesis of graphene and carbon nanotubes (CNT).

UNIT IV

Characterization techniques:
Determination of particle size, XRD (Scherrer's formula), Increase in width of XRD peaks of nanoparticles, Shift in absorption spectra peak of nanoparticles, Shift in photoluminescence peaks, Electron Microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy(TEM), Scanning Probe Microscopy (SPM), Scanning Tunnelling Electron Microscopy(STEM), and Atomic Force Microscopy (AFM). Estimation of band gap using UV-Vis-NIR spectroscopy, Thermogravimetric analysis.

Learning Outcome:
The students will be able to elucidate the properties of nanomaterials and compare them with their bulk counterparts. Topics cover in this paper will enhance the knowledge of students in emerging area of nanotechnology.

References:

1. **Guozhong Cao,** Nanostructures & Nanomaterials, Synthesis, Properties & Applications, World Scientific Publisher,. Volume 2, 2nd Edition, 2011.
2. **Guozhong Cao,** Nanostructures & Nanomaterials, Synthesis, Properties & Applications, Imperial College Press, 1st Edition, 2004
3. **Charles P. Poole, Jr. Frank J. Owens,** Introduction to Nanotechnology, John Wiley & Sons 1st Edition, 2003.
4. **Paul Harrison, Alex Valavanis**, Quantum Wells, Wires and Dots: Theoretical and Computational Physics of Semiconductor Nanostructures, John Wiley & Sons, 4th Edition (2016)
5. **D. Bimberg, M. Grundmann, N.N. Ledenstov,** Quantum Dot Hetrostructures, John Wiley & Sons, 1st Edition, 1999.
6. **Hornyak G.L., Tibbals H.F., Dutta J.,Moore J.J.,** Introduction to Nanoscience and Nanotechnology, CRC Press, 1st Edition, 2008.
7. **Liming Dai,** Carbon Nanotechnology, Elsevier, 1st Edition , 2006.
8. **Michael J. O'Connell,** Carbon Nanotubes: Properties and Applications, CRC Press, 1st Edition, 2006.
9. **T. Pradeep**, Nano: The Essentials, McGraw Hill Companies, 1st Edition, 2007.

Advanced Statistical Mechanics

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Advanced Statistical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 305 DCEC 3104</td><td>Prerequisite: Quantum Mechanics, Statistical Mechanics</td><td colspan="4" rowspan="2">Total hours = 60</td></tr>
<tr><td>Semester III</td></tr>
</table>

Course objective: The aim of this course is to aware students about the concept of phase transition, non-equilibrium systems and coarse grained models.

UNIT I

Phase Transitions and Critical Phenomena

Thermodynamics of phase transitions, metastable states, Van der Waals' equation of state, coexistence of phases, Landau theory, critical phenomena at second-order phase transitions, spatial and temporal fluctuations, scaling hypothesis, critical exponents, universality classes. Ising model, mean-field theory, exact solution in one dimension.

UNIT II

Nonequilibrium Systems I

Systems out of equilibrium, kinetic theory of a gas, approach to equilibrium and the H theorem, Boltzmann equation and its application to transport problems, master equation and irreversibility, simple examples, ergodic theorem.

UNIT III

Nonequilibrium Systems II

Brownian motion, Langevin equation, fluctuation-dissipation theorem, Einstein relation, Fokker-Planck equation. Time correlation functions, linear response theory, Kubo formula, Onsager relations.

UNIT IV

Coarse-grained Models

Hydrodynamics, Navier-Stokes equation for fluids, simple solutions for fluid flow, conservation laws and diffusion.

Learning Outcome: The students will be able to learn

- the concepts of phase transition
- various model like Landau and Ising model

- coarse grained models.

References:

1. **K. Huang,** Statistical Mechanics, Wiley, 2nd Edition, 2008.
2. **R.K. Pathria,** Statistical Mechanics, Elsevier, 3rd Edition, 2011.
3. **E.M. Lifshitz and L.P. Pitaevskii,** Physical Kinetics, Butterworth-Heinmann, 1st Edition, 1981.
4. **D.A. McQuarrie,** Statistical Mechanics, Viva Books, 1st Edition, 2011.
5. **L.P. Kadanoff,** Statistical Physics: Statistics, Dynamics and Renormalization, World Scientific Publishing Company, 2000.
6. **P.M. Chaikin and T.C. Lubensky,** Principles of Condensed Matter Physics, Cambridge University Press, 1st Edition, 2000.
7. **Robert Zwanzig,** Nonequilibrium Statistical Mechanics, Oxford University Press, 1st Edition, 2001.

General Theory of Relativity

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: General Theory of Relativity</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 306 DCEC 3104</td><td>Prerequisite: Quantum Mechanics, Mathematical Methods in Physics I & II</td><td colspan="4" rowspan="2">Total hours = 60</td></tr>
<tr><td>Semester III</td></tr>
</table>

Course objective : To aware students about the different principles of general theory of relativity.

UNIT I

Equivalence principle and Tensors in GTR:
Equality of Gravitational and inertial Masses, Equivalence Principle, Principle of general Covariance; Tensor Analysis: Covariant and Contravariant tensor. Metric Tensor, Parallel Displacement and covariant differentiation, Affine conncetion and relation to metric tensor,
Curvature tensor and its symmetries

UNIT II

Geodesics
Equation of motion of a particle, Weak fields and newtonian approximation, Time and distance in gravitational theory, gravitational red and blue shift, experimental verification, Einstein Field Equation, Schwarzschild Solution, Mach's Principle, Radial motion towards centre, Nature of singularities, Black holes, event horizons, Kruskal coordinates.

UNIT III

Applications of GTR:
General orbits, constants of motion, deflection of light, precession of perihelion and radar echo, Standard, isotropic and harmonic coordinates, Post Newtonian formalism and status of observational verifications

UNIT IV

Energy content and equation of Motion:
Energy momentum for a perfect fluid, equation of motion from field equation for equation of dust, Action principle for field equations, conservation laws in curved space and pseudo energy tensor for energy fields.

Learning outcome : After completing this course the students shall be able to understand the mathematical rigour that goes behind the theory of relativity and also be able to understand few applications of general theory of relativity.

References:
1. **S. Weinberg**, Cosmolgy, Oxford University, 1st Edition, 2008.
2. **Ray D'Inverno**, Introducing Einstein's General Relativity, Oxford University, 1st Edition, 1992.
3. **M. Berry**, Principle of Cosmology and Gravitation, Taylor & Francis; 1st Edition, 1989.
4. **Tai L. Chow**, Introduction to General theory of Relativity and Cosmology, Springer, 1st Edition, 2008.
5. **P.A.M. Dirac,** General theory of Relativity, Wiley-Blackwell, 1st Edition, 1975**.**
6. **L.D. Landau and E.M. Lifshitz**, The Classical Theory of Fields, Publishere, Shroff, 2nd Edition, 2010

Digital Electronics and Microprocessor

Scheme Version: 2019	Name of the subject: Digital Electronics and Microprocessor	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	0	2	4
Subject Code: SPMS PHY 01 307 DCEC 3104	Prerequisite: Physics of Semiconductor Devices, Analog Electronics	Total hours = 75			
	Semester III				

Course objective: The aim of the course is to train the students for digital systems, their implementation and application of microprocessor.

UNIT I

Digital Systems : Digital signals, binary number system, conversions, boolean algebra, logic gates, standard gate assemblies, Bipolar and MOS digital systems and their comparison, implementing circuits from boolean expressions, SOP, POS, Simplifying logic circuits: algebraic method, K-mapping, Flip flops: SR, T, D and J-K. Error detection: Parity method, checksum method.

UNIT II

Digital Circuits: Combinational Circuits: Half Adder, Full Adder, Decoder, Encoder, Multiplexer, Demultiplexer and their applications, Sequential Circuits: Shift Register, Parallel and Serial data transfer, Timming Waveforms. Counters: Synchronous and Asynchronous Up, Down, and Bidirectional Counters, Timming Wave forms. Digital to Analog Converters and their properties, Weighted resistor and R-2R Ladder type, Analog to digital Converters: Flash, Successive approximation, Sigma- Delta ADC.

UNIT III

Applications: Memory: Read Only Memory (ROM): PROM, EPROM, EEPROM, Applications, Programming a ROM, Random Access Memory(RAM): SRAM, DRAM, Applications, Memory Storage cell, Read and Write operations, Programmable Logic Devices (PLD) Digital Display, Seven segment display,

UNIT IV

8085 Microprocessor: Basics of Microprocessor-8085, PIN description, Microprocessor initiated operations. Internal data operations. Introduction to 8085 assembly language programming. 8085 instruction., General purpose programmable Peripheral devices. Microprocessor Applications, Recent trends in Microprocessor Technology

Laboratory Assignments:

1. To construct logic gates OR, AND, NOT, NOR, NAND gates using discrete components and verify their truth tables
2. To construct logic gates AND, NOT, EX-NOR and EX-OR using NANAD gates and verify their truth tables.
3. To perform 4 bit DAC and ADC operations
4. To arrange a data set in ascending order using 8080 microprocessor.
5. Use the IC555 chip as astable, bistable and monostable multivibrator.

6. To study various operations of Arithmetic logic Unit (ALU).
7. To perform the addition and subtraction of n 8 bit numbers using 8085 microprocessor
8. To perform the multiplication and division of two 8 bit number using 8085 microprocessor
9. To write a program to arrange an array of data in ascending order using 8085 microprocessor
10. To design and construct multiplexer and demultiplexer and verify their truth tables.
11. To study the encoders and decoders
12. To perform BCD to Binary operation using 8085 microprocessor.

Learning outcome: The students will be able to learn

- the basics of digital systems
- digital arithmetic operations
- application as memory devices
- microprocessor and its various operations

References:

1. **Tocci R. J**., Digital Systems-Principles and Applications, Prentice Hall of India, 8th Edition, 2015.
2. **Gaonkar R. S**., Microprocessor Architecture, Programming and Applications, Prentice-Hall, 2nd Edition, 2014.
3. **Malvino A.P**. and **Brown A**., Digital Computer Electronics, Prentice-Hall, 3rd Edition, 1999.

Project

Scheme Version: 2019	Name of the subject: Project	L	T	P	C
	Applicable to Programs: M.Sc. Physics	0	0	0	12
Subject Code: SPMS PHY 01 401 PROJ 00012	Prerequisite: None	Total hours = 60			
	Semester IV				

Course Code: SPMS PHY 01 401 PROJ 00012

The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics according to the skill and merit of the students.

Nuclear Physics: Interaction and Detection

Scheme Version: 2019	Name of the subject: Nuclear Physics: Interaction and Detection	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 401 DCEC 3104	Prerequisite: Quantum Mechanics, Nuclear and Particle Physics	Total hours = 60			
	Semester IV				

Course Objective: To aware students about the nucleon-nucleon interactions and deformations of nuclei. To aware the students about the interaction of radiations with matter and their detector.

UNIT I

N-N interaction:
Phenomenological N-N Potentials (Soft core & hard core) and meson theoretical potentials, Polarization in N-N scattering, .Probing charge distribution with electrons, Form factors, Proton form factors, Qualitative ideas on deep inelastic electron-proton scattering, Bjorken scaling and the patron model, Quark structure of the nucleon.

UNIT II

Nuclear Models
Single particle model of the nucleus, Qualitative discussion and estimates of transition rates, Configuration mixing, Magnetic moments and Schmidt lines. Simple description of Two particle shell model spectroscopy. Deformable liquid drop and nuclear fission, Collective vibrations and excited states, Permanent deformation and collective rotations, Nilsson model and equilibrium deformation, Behavior of Nuclei at high spin.

UNIT III

Radiation Detection: Interaction of radiation with matter**,** Detection of nuclear radiation and their measurement: Methods for detection of free charge carriers, ionization chamber, Proportional counter, Geiger-Muller counter, Semi-conductor detectors for X-rays, gamma rays, and charged particles detection, Cherenkov detector.

UNIT IV

Nuclear Accelerators: Accelerators of charged particles: Classification and performance characteristics of accelerators, ion sources, Electrostatic accelerators, Cockroft – Walton generator, Cyclotron, Electron and Proton synchrotron. Particle Physics Experiments, Higgs Boson, Large Hadron Collider.

Learning Outcome: Students will be able to understand
- Two body and three body interactions among the nucleons.
- Various aspects of nuclear models that includes the high spin states as well as deformations of nuclei
- Interactions of radiation with matter and their detection using different type of detectors.

References:

1. **S. N. Ghoshal,** Nuclear Physics, S. Chand Limited, 2nd Edition, 1994.
2. **M. A.Preston and R. K. Bhaduri,** Nuclear Structure, Perseus Books Group, 1st Edition, 1993.
3. **Brown and Jackson,** Nucleon-nucleon Interaction, North-Holland Pub. Co., 1st Edition 1970.
4. **S.S.M. Wong,** Introductory Nuclear Physics, Prentice Hall, 1st Edition, 2013.
5. **M.K.Pal,** Nuclear Structure, 1st Edition, Pearson Publication, 1st Edition, 2008.
6. **Knoll G. F.,** Radiation Detection and Measurement, John Wiley and Sons, 3rd Edition, (2008).

Microprocessor and Microcontroller

Scheme Version: 2019	Name of the subject: Microprocessor and Microcontroller	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 402 DCEC 3104	Prerequisite: Physics of Semiconductor Devices, Analog Electronics	Total hours = 60			
	Semester IV				

Course Objective: The aim of this course is to make the students aware about architecture and interfacing of microprocessor and microcontrollers

UNIT I

Architecture :
8085 Architecture - Programmer's model - ALU - Registers and Flags - Stacks - Complete instruction set of Intel 8085 - State transition and timing diagrams - T States - Machine cycles - Instruction cycles - Addressing modes - Assembly language programs – Timing diagram for memory read and memory write cycles - time delay subroutines and delay calculations – maskable and Non-maskable Interrupts.

UNIT II

Interfacing memory and devices– I/O and Memory mapped I/O – Simple polled I/O and Handshaking operations - Programmable keyboard/display interface 8279 - Programmable peripheral device 8255A - 8253 Timer Interface - Wave form generation (Square, triangular and ramp wave) - Programmable communication interface 8251 (USART).

UNIT III

Microcontroller
Introduction – 8 and 16 bit Microcontroller families –Flash series – Embedded RISC Processor – 8051 Microcontroller Hardware – Internal registers – Addressing modes – Assembly Language Programming – Arithmetic, Logic and Sorting operations.

UNIT IV

Interfacing
Interfacing I/O Ports, External memory, counters and Timers - Serial data input/output, Interrupts – Interfacing 8051 with ADC, DAC, LED display, Keyboard, Sensors and Stepper motor.
Embedded microcontroller system – types of embedded operating system – Micro chip PIC 16C6X /7X family – features – Architecture – Memory Organization – Register file map – I/O ports – Data and flash program memory – asynchronous serial port – Applications in communication and industrial controls.

Learning outcome: Students will be able to understand

- complete instruction set of Intel 8085
- programmable peripheral device 8255A - 8253 Timer Interface

- arithmetic, Logic and Sorting operations
- applications of microcontrollers in communication and industrial controls

References:

1. **R.S.Gaonkar,** Microprocessor Architecture, programming and Application with the 8085, Cengage Publication, 5^{th} Edition, 2008.
2. **V.Vijayendran,** Fundamentals of Microprocessor 8085 - Architecture, programming and interfacing. Pearson, 1^{st} Edition, 2009.
3. **Kenneth J. Ayala,** The 8051 Micro Controller Architecture, Programming and Applications., Tata-McGraw Hills, 2^{nd} Edition, 1996.
4. **John B. Peatman,** Design with PIC Microcontrollers, Tata-McGraw Hills, 1^{st} Edition, 1997.

Nonlinear Dynamics

Scheme Version: 2019	Name of the subject: Nonlinear Dynamics	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 403 DCEC 3104	Prerequisite: Mathematical Methods in Physics I and Quantum Mechanics	Total hours = 60			
	Semester IV				

Course Objective: The aim of this course is to aware students aware about Dynamical and dissipative systems within the framework of Hamiltonian mechanics.

UNIT I

Introduction to Dynamical Systems

Physics of nonlinear systems, dynamical equations and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classification, Poincaré 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, Hénon map, Lorenz equations, fractal geometry, generalized dimensions, examples of fractals.

UNIT III

Hamiltonian Systems

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

UNIT IV

Advanced Topics

Selections from quantum chaos, cellular automata and coupled map lattices, pattern formation, solitons and completely integrable systems, turbulence.

Learning outcome: Students will be able to understand

- physics of nonlinear systems
- lorentz equations, fractal geometry, generalized dimensions
- liouville's theorem and representation in action-angle variables
- concept of turbulence.

References:

1. **E. Ott,** Chaos in Dynamical Systems, Cambridge University Press, 2nd Edition, 2002.
2. **E.A. Jackson,** Perspectives of Nonlinear Dynamics (Volumes 1 and 2), Cambridge University Press, Reprint edition, 1992.

3. **A.J. Lichtenberg and M.A. Lieberman,** Regular and Stochastic Motion, Springer-Verlag, 1st Edition,1982.
4. **A.M. Ozorio de Almeida,** Hamiltonian Systems: Chaos and Quantization, Cambridge University Press, Reprint Edition, 1990.
5. **M. Tabor,** Chaos and Integrability in Nonlinear Dynamics, Wiley, 1st Edition, 1989.
6. **M. Lakshmanan and S. Rajasekar,** Nonlinear Dynamics: Integrability, Chaos and Patterns, Springer, 1st Edition, 2003.

Introduction to Astrophysics and Cosmology

Scheme Version: 2019	Name of the subject: Introduction to Astrophysics and Cosmology	L	T	P	C
	Applicable to Programs: M.Sc. Physics	3	1	0	4
Subject Code: SPMS PHY 01 404 DCEC 3104	Prerequisite: Mathematical Methods in Physics I and Nuclear and Particle Physics	Total hours = 60			
	Semester IV				

Course Objective:To make the students aware about different theoretical and observational technique adopted in understanding astrophysics and cosmology

UNIT I

Observational Data: Astronomical Coordinates- Celestial Sphere, Horizon, Equatorial, Ecliptic and galactic system of coordinates, Conversion from one coordinate system to another. Magnitude Scale – Apparent and absolute magnitude, distance modulus, Determination of Mass, luminosity, radius, temperature and distance of a star, H-R Diagram, Empirical mass-luminosity relation.

UNIT II

Sun : Physical Characteristic of Sun – Basic data, solar rotation, solar magnetic fields, Photosphere- granulation, sun-spots, Babcock model of sunspot formation, solar atmosphere-chromospheres and corona, Solar activity – flares, prominences, Solar wind, activity cycle, Helioseismology

UNIT III

Cosmology : Cosmological Principle, Maximally symmetric spaces, Killing vectors, Robertson Walker Metric, Redshift via Hubble's Law, Magnitude red shift relation, Hubble's Constant and deaccleration parameter,

UNIT IV

Models of Universe:
Einstein equation and standard model, Closed flat and open Universes, Age of the Universe, critical density and problem of missing mass or missing light. History of early Universe, helium formation, decoupling of matter and radiation, microwave background radiation.

Learning Outcome : The student will be able to differentiate between various coordinate systems, should know about the characteristics of Sun, The student should also be able to grasp concepts like redshift, age of the universe and dark matter & dark energy present in observable universe

References:

1. **M. Zeilik,** Astronomy, The evolving Universe CUP , 1st Edition, 2002
2. **I. Morrison,** Introduction to astronomy and cosmology, Wiley, 1st Edition, 2008)
3. **P.V. Foukal,** Solar Astrophysics , Wiley-VCH, 1st Edition, 2004.
4. **J. V. Narlikar,** Introduction to Cosmology, CUP, 1st Edition, 2000.

Thin Film and Integrated Devices

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Thin Film and Integrated Devices</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 405 DCEC 3104</td><td>Prerequisite: Physics of Nanomaterial</td><td colspan="4" rowspan="2">Total hours = 60</td></tr>
<tr><td>Semester IV</td></tr>
</table>

Course Objective: The aim of this course is to make the students aware about material for integrated circuits, metallic and non metallic thin films and various techniques related to lithography.

UNIT I

Materials for Integrated Circuits:

Classification of IC, CMOS Process Overview, Electronic grade silicon, Crystal growth, Czeehralski and float zone crystal growing methods, Silicon shaping lapping, Polishing and wafer preparation, Hot Processes-I: Oxidation and Diffusion, Oxidation of silicon, oxide deposition by thermal dry oxidation and wet oxidation method Diffusion Process, Diffusion Coefficient, Fick's 1st and 2nd Laws of Diffusion, Vacancy –Impurity interactions, Dopants and Dopant Sources, Doping by Diffusion, ion implantation, Diffusion Process Control, Diffusion Systems, Implantation Technology, Selective Implantation, Junction depth, Channeling, Lattice Damage, Annealing, Dopant Diffusion and Related Operations: Equipment for Diffusion and Related Operations.

UNIT II

Thin Films: Metals and Nonmetals

Vacuum Science and Technology, Evaporation theory and electron beam evaporation, evaporation system, idea of DC and R.F. sputtering system, Physical vapour deposition methods, Design construction of vacuum coating units, Chemicals Vapour Deposition, Reactors for Chemical Vapour Deposition, CVD Applications, Epitaxy methods for thin film deposition, Vapour-Phase Epitaxy, Photolithography, Photoresist Processing and Etching.

UNIT III

Lithography:

Wafer Cleaning methods, Wafer Preparation method: photoresist coating methods, soft backing of photo resist, post exposure backing of photo resist, Negative photoresist, Positive photoresist, Contrast and sensitivity of photoresist, Chemical Modulus Transfer Function (CMTF) of Photoresist, Resist Exposure (single, bi-layer and multi-level photoresist exposure) and Resist

Development, Hard Baking and Resist curing, Photolithographic Process Control. Photolithography: An Overview, Photo lithography source, Photolithographic methods: Contact, proximity and projection and their resolution limit, Idea of electron beam lithography, Idea of an X-ray lithography.

UNIT IV

Interconnections and Contacts and Packaging and Yield

Ohmic Contact Formation, Contact Resistance, Electro-migration, Diffused Interconnections, Poly-silicon Interconnections, Buried Contacts, Butted Contacts, Silicides, Multilayer Contacts, Liftoff Process, Multilevel Metallization. Testing, Die Separation, Die Attachment, Wire Bonding, Packages, Flip-Chip Process, Tape-Automated-Bonding Process, Yield, Uniform and Nonuniform Defect Densities.

Learning outcomes: The students will be able to learn

- to understand the basic steps in the formation of Electronic Grade silicon.
- to understand different terminology related to diffusion.
- to understand basic thin film fabrication techniques such as PVD, Vacuum coating units, D.C and R.F. sputtering and their applications.

References:

1. **Millman and Taub,**Integrated Electronics, McGraw Hill , 1st Edition, 2017.
2. **Millman and Gros,**Microelectronics, McGraw Hill ,1st Edition, 1987.
3. **K.L. Chopra,**Thin Film Phenomena, McGraw Hill 1st Edition, 1969.
4. **S.M. Sze,**VLSI Technology, McGraw Hill 2nd Edition, 2017.

Superconductivity: Conventional and High temperature Superconductors

<table>
<tr><td rowspan="2">Scheme Version: 2019</td><td>Name of the subject: Conventional and High Temperature Superconductors</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Applicable to Programs: M.Sc. Physics</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Subject Code: SPMS PHY 01 405 DCEC 3104</td><td>Prerequisite: Quantum Mechanics, Solid State Physics</td><td colspan="4" rowspan="2">Total hours = 60</td></tr>
<tr><td>Semester IV</td></tr>
</table>

Course Objective: The aim of this course is to understand the intricate mechanism of superconductivity. Various theoretical and experimental concepts have been discussed like, Meissner effect, BCS theory, SQUID and High Temperature Superconductors

UNIT I

Conventional Superconductors:
Brief Introduction of Superconducting materials, critical temperature, zero resistivity, critical field, persistent current, Meissner-Ochsenfeld effect, perfect diamagnetism, type I and type II superconductors: properties of mixed state, vortex state.

UNIT II

London Theory and Ginzburg-Landau Theory:
London's phenomenological theory, London vortex, Penetration depth, Ginzburg-Landau theory: Ginzburg-Landau parameter, Order parameter, Condensation energy, Ginzburg-Landau theory of the Bulk phase transition, Ginzburg-Landau theory in a magnetic field, Flux quantization in a superconducting ring, Isotope effect, thermodynamics of superconductors, thermal specific heat below, density of states and Debye temperature, specific heat in a magnetic field, superconductor in zero field, superconductor in magnetic field.

UNIT III

Microscopic Theory:
BCS Theory of superconductors: electron-phonon interaction, mechanism of Cooper pairing, BCS wave function, Hamiltonian, BCS Energy gap and quasiparticle states, Josephson effects: Josephson junction, DC and AC Josephson effects, Applications of superconducting Magnets, Superconducting Quantum Interference device: SQUIDs schematic diagram and working.

UNIT IV

High temperature Superconductors:
Origin of High temperature superconductivity, Characteristics of High Temperature Superconductors, Crystal Structure and phase diagram, Perovskites, Cubic Form, Orthorhombic Form, Tetragonal Form, YBCO superconductor: Copper Oxide planes, Stacking rules, Hg-Ba-Ca-Cu-O and Tl-Ba-Ca-Cu-O superconductors, crystal structures, layering schemes, applications of superconductors.

Learning Outcome: Students will achieve a platform to comprehend the many application of Superconductors like Maglev Trains, MRI and fast digital circuits etc.

References

1. **J F Annett**, Superconductivity Superfluids and Condensates, Oxford University Press, 1st Edition, 2004.
2. **G Deutscher**, New Superconductors from Ganular to High , World Scientific Publishing, 1st Edition, 2006.
3. **C P Poole, H A Farach, R J Creswic, R Prozorov,** Superconductivity, Elsevier, 3rd Edition, 2014.
4. **P J Ford, G A Saunders**, The Rise of the Superconductors, CRC Press, 3rd Edition, 2004.