DEPARTMENT OF PHYSICS
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

M.Sc. Physics
Curriculum & Syllabi (2016)

CURRICULUM FOR POST-GRADUATE PROGRAM LEADING TO MASTER OF SCIENCE (M.Sc.) DEGREE IN PHYSICS

I. PROGRAM DETAILS

Name of Degree	Name of Specialization	Intake (Full-time)	Year of Starting Proposed	Duration	Name of Degree &Eligibility for Admission
M.Sc.	PHYSICS	20	2016	2 years	Bachelor's degree with at least 60% marks, with **Physics** as main and **Mathematics** as a subsidiary subject **OR** with **Physics and Mathematics** among the main subjects.

II. PROGRAM STRUCTURE

SEMESTER I

Sl. No.	Course Code	Courses	L	T	P/S	Credits
1	PH6301	Mathematical Physics – I	3	0	0	3
2	PH6302	Classical Mechanics	3	0	0	3
3	PH6303	Electromagnetic Theory – I	3	0	0	3
4	PH6304	Electronics	3	0	0	3
5	PH6381	Electronics Lab	0	0	3	2
6	PH6382	Numerical and Computational Physics Lab	1	0	3	3
		Total	13	0	6	**17**

SEMESTER II

Sl. No.	Course Code	Courses	L	T	P/S	Credits
1	PH6305	Mathematical Physics – II	3	0	0	3
2	PH6306	Quantum Mechanics – I	3	0	0	3
3	PH6307	Statistical Mechanics	3	0	0	3
4	PH6308	Electromagnetic Theory – II	3	0	0	3
5	PH6309	Digital Electronics	3	0	0	3
6	PH6383	Gen. Physics Lab	0	0	3	2
7	PH6384	Electromagnetics Lab	0	0	3	2
		Total	15	0	6	**19**

SEMESTER III

Sl. No.	Course Code	Courses	L	T	P/S	Credits
1	PH7301	Quantum Mechanics – II	3	0	0	3
2	PH7302	Condensed Matter Physics – I	3	0	0	3
3	PH7303	Atomic and Molecular Physics	3	0	0	3
4	PH7304	Nuclear and Particle Physics	3	0	0	3
5		Elective – I	3	0	0	3
6	PH7381	Optics Lab	0	0	3	2
7	PH7382	Solid State Physics Lab	0	0	3	2
		Total	15	0	6	**19**

SEMESTER IV

Sl. No.	Course Code	Courses	L	T	P/S	Credits
1	PH7305	Condensed Matter Physics – II	3	0	0	3
2		Elective – II	3	0	0	3
3		Elective – III	3	0	0	3
4	PH7392	Project	0	0	8	6
		Total	9	0	8	**15**

TOTAL CREDITS = 17+19+19+15 = 70; AVERAGE CREDITS PER SEMESTER = 17.5

ELECTIVES

The department may offer electives based on student's choice, provided at least 6 students opt for a particular elective and also based on faculty availability. Courses at level of M. Tech. or any other M. Sc program in NIT Calicut may be chosen as elective based on student's interest after discussing with the faculty advisor.

LIST OF ELECTIVES

Sl. No.	Course Code	Courses	L	T	P/S	Credits
1	PH7320	General Theory of Relativity	3	0	0	3
2	PH7321	Experimental Techniques	3	0	0	3
3	PH7322	Physics of Climate	3	0	0	3
4	PH7323	Atmospheric Dynamics	3	0	0	3
5	PH7324	Solid State Devices	3	0	0	3
6	PH7325	Phase Transitions & Critical Phenomena	3	0	0	3
7	PH7326	Organic Electronics	3	0	0	3
8	PH7327	Magnetic Resonance	3	0	0	3
9	PH7328	Laser Physics	3	0	0	3
10	PH7329	Photonic Band Gap Structures	3	0	0	3

DETAILED SYLLABI

PH6301 MATHEMATICAL PHYSICS - I

L	T	P	C
3	0	0	3

Prerequisites: NIL
Total hours : 42

Module 1: [8 (L) hours]
Dirac delta function – definition and derivative.
Polar coordinates – cylindrical and spherical coordinates, Scalar and vector fields, vector multiplication, vector analysis – gradient, divergence and curl, Gauss theorem, Stokes theorem, Green's theorem.
Tensor analysis – Rank, covariant and contravariant tensors, Einstein summation convention, contraction, direct product, Levi-Civita symbol, pseudo tensors, dual tensors, covariant differentiation, Christoffel symbols.

Module 2: [10 (L) hours]
Vector spaces, linear independence, bases, operators, matrix representations, eigenvalue problem, basis transformation, applications to quantum mechanics and normal modes of vibration.

Module 3: [10 (L) hours]
Fourier series, integral transforms – Fourier and Laplace transforms, Parseval's theorem, convolution theorem, applications to Physics.

Module 4: [14 (L) hours]
Second order differential equations, Frobenius method, series solution, Special functions – Bessel equation, Bessel functions, Legendre's equation and Legendre polynomials, Hermite functions, Laguerre functions, Spherical harmonics, Green's function method for in-homogeneous equations

References:

1. Thomas and Finney, Calculus and Analytical Geometry, 9^{th} Ed, Addison-Wesley (1996).
2. Arfken, Weber and Harris, Mathematical methods for physicists, 7th ed. Academic Press (2012).
3. Spiegel. M. R, Theory and Problems of Vector Analysis, McGraw Hill (1959).
4. P Halmos, Finite Dimensional Vector spaces, 2nd Ed., Van Nostrand (1958).
5. Erwin Kreyszig, Advanced Engineering Mathematics, 7^{th} ed., John Wiley (1992).
6. G.F.Simmons, Differential equations with applications, Tata-McGraw Hill, (1972).
7. P. Dennery and A. Krzywicki, Mathematics for Physicists, Dover Publications (1996).

PH6302 CLASSICAL MECHANICS

L	T	P	C
3	0	0	3

Prerequisites: NIL
Total hours : 42

Module 1: [10 (L) hours]
Newtonian formulation, Constraints, Generalized coordinates, Introduction to calculus of variations, Principle of least action, Lagrange's equations, Applications of Lagrangian formulation – free particle, charge in electromagnetic field, motion in central field, Kepler's problem.

Module 2: [12 (L) hours]
Free oscillations, system of oscillators, eigenvalue problem and normal modes, damping, forced oscillations and resonance, molecular vibrations, anharmonic oscillations, rotations, Rigid body motion - the inertia tensor, Euler angles and equations of motion, motion in non-inertial reference frames, Coriolis force, Foucault pendulum, collisions and scattering.

Module 3: [12 (L) hours]
Legendre transformations, Hamilton's equations and examples, Cyclic coordinates, Symmetry, Conservation principles and Noether's theorem, Canonical transformations, Poisson bracket formulation,

Module 4: [8 (L) hours]
Hamilton-Jacobi equation, applications to classical optics and wave mechanics, action-angle variables and examples. Dynamical systems - stability analysis, phase space dynamics.

References:

1. Landau and Lifshitz, Mechanics, (III Ed.) Pergamon press (1976).
2. K. R. Symon, Mechanics,3rd edition Addison-Wesley (1971).
3. Spiegl M. R., Theoretical mechanics, (Schaum Series), McGraw Hill (1982).
4. Herbert Goldstein, Classical Mechanics II Edition, Narosa Publishers (2001).
5. R. G. Takwale and P.S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill (1979).
6. N.Rana and P. Joag, Classical Mechanics, McGraw Hill (2001).
7. John R. Taylor, Classical Mechanics University Science Books (2004).

PH6303 ELECTROMAGNETIC THEORY – I

Prerequisites: Nil
Total hours: 42

L	T	P	C
3	0	0	3

Module 1: [11 (L) hours]
Electrostatics: Electric field and electric potential, Electric dipole and multipole expansion, Differential equation for electric field, Poisson and Laplace equations, Solutions of Laplace equation in rectangular, cylindrical and spherical coordinates, Electric fields in dielectric media, Polarization, Boundary conditions, Electrostatic energy- potential energy of a group of point charges-energy density of an electrostatic field, Force and torques.

Module 2: [10 (L) hours]
Magnetostatics: Current density, Equation of continuity, Force on a current carrying conductor, Biot-Savart law, Ampere's circuital theorem, Differential equation for static magnetic field, Vector potential, Boundary conditions Faraday's law of induction, self-inductance and mutual inductance magnetic energy of steady current distributions.

Module 3: [10 (L) hours]
Maxwell's Equations: Displacement current, Maxwell's equations, Electromagnetic energy –Poynting vector, wave equation, Boundary conditions, vector and scalar potentials, Coulomb and Lorentz gauges, electromagnetic energy and momentum, conservation laws, inhomogeneous wave equation and Green's function solution.

Module 4: [11 (L) hours]
Electromagnetic Waves: Plane waves in a dielectric medium, Plane waves in conducting media, Reflection and refraction at dielectric interfaces, Complex Fresnel coefficients – reflection from a conducting plane, Reflection and transmission by a thin layer- interference, Optical dispersion in materials-dielectric constant and anomalous dispersion.

References:

1. John R. Reitz, Frederic J. Milford and Robert W. Christy, Foundations of Electromagnetic Theory, 3rd Edition, Narosa Publishing House, New Delhi. (2012).
2. D.J. Griffiths, Introduction to Electrodynamics. 4th Edition, PHI Learning, New Delhi.(2012).
3. J.D. Jackson, Classical Electrodynamics. 3rdEdition,Wiley India.(1998).
4. Jordan E.C. and Balmain K. G., Electromagnetic Waves and Radiating Systems, 2nd Edition, Prentice Hall (2001).

PH6304 ELECTRONICS

L	T	P	C
3	0	0	3

Prerequisites: NIL
Total Hours: 42

Module 1: [10 (L) hours]
Op-Amp internals; datasheet and interpretation; basic Op-amp application: comparators, amplifier circuits and mathematical operations; four types of feedback amplifiers: VCVS, VCCS, CCVS and CCCS.

Module 2: [10 (L) hours]
Introduction; instrumentation amplifier and characteristics; programmable op-amps; op-amps for current, voltage and power applications; high speed op-amps; operational transconductance amplifier (OTA) and Norton amplifier. Introduction; log and antilog amplifiers; the linear multiplier; IC comparator; Schmidt trigger circuit; active limiters and clampers; precision rectifiers and peak detectors.

Module 3: [10 (L) hours]
Introduction; filter types; the use and advantages of active filters, filter order and poles; filter class or alignment; Butterworth, Bessel, Elliptic and Chebyshev types; First and higher-orders low-pass and high-pass filters, band-pass, band-rejection, all pass and state variable switched capacitor filters; filter characteristics and applications.

Module 4: [12 (L) hours]
(i) IC 566 -voltage controlled oscillator (VCO) operating principles and applications; (ii) IC 565- phase locked loop (PLL) operating principles and applications; (iii) IC 555 timer as an astablemultivibrator and Monostablemultivibrator and (iv) IC 8038 waveform generator (function generator) operating principles and applications. Introduction; linear regulators; series and shunt regulators; current boosting and current limiting circuits; IC three terminal voltage regulator principles and applications; adjustable voltage Regulators; switching regulators: types and their applications.

References:

1. T. L Floyd and Buchla, Basic operational Amplifiers and Linear Integrated Circuits**,** III Edition;Pearson Education Asia (2003).
2. R. A Gayakwad, Op- Amps and Linear Integrated Circuits**,** VI Ed., Prentice Hall of India, (2003).
3. R. F.Coughlin and Driscoll, Op- Amps and Linear Integrated Circuits**,** IV Ed., Prentice Hall of India (2003).
4. A. P Malvino**,** Electronic Principles**,** Tata- Mc-Graw Hill, VI Ed, (2002).
5. W. D Stanley, Operational amplifiers with linear integrated circuits**,** IV Edition,Pearson education, (2003).

PH6381: ELECTRONICS LAB

L	T	P	C
1	0	3	3

Prerequisites: NIL
Total hours : 42

1. Summing and Difference amplifiers
2. Inverting and non-inverting amplifers
3 Integrator
4. Differentiator
5. Voltage Follower
6. First order low-pass and high pass filter
7. Triangular Wave Generator
8. Astable Multivibrator
9. Experiments involving Digital Logic Circuits.
10. Experiments using 8085 microprocessor trainer kits.
11. Experiments using trainer kit for study of transient response, fourier analysis, rectification, and other practically important circuits

PH6382 NUMERICAL AND COMPUTATIONAL PHYSICS LAB

L	T	P	C
0	0	3	2

Prerequisites: NIL
Total Hours: 56

Programming in FORTRAN/MATLAB/PYTHON may be introduced, and elements of each of these programming languages may be taught in the lecture hours.

1. Interpolation and curve fitting, Zeros of functions –bisection, secant method, Newton-Raphson method.

2. Linear Algebra and matrix methods– Solving linear equations (Gaussian elimination, Gauss Jordan method etc.) and matrix eigenvalue problems (also problems related to Quantum Mechanics and small oscillations).

3. Integration and methods for solving ODE - Trapezoidal rule, Simpsons' rule, Euler's method, mid-point method, Runge-Kutta method.

4. Interpolation – Newton and Lagrange, least squares curve fitting

References:

1. Anthony Ralston, Philip Rabinowitz , First course in numerical analysis - II Edition, Dover Publications (2001).
2. Teucholsky, Vetterling, Flannery, Numerical Recipes in C / FORTRAN (III Edition), Cambridge University Press (2007).
3. Hamming, Numerical Methods for Scientists and Engineers, Dover, (1987).
4. Garcia,Numerical Methods for Physics, 2nd Edition, A.L. Prentice Hall (2000).
5. Springer, An Introduction to Programming and Numerical Methods in MATLAB, Verlag, (2005).

Web resources: The Third Branch of Physics, Essays on Scientific Computing by Norbert Schörghofer. An insightful manuscript on some aspects of computational physics:
http://www2.hawaii.edu/~norbert/compphysics.html

PH6305 MATHEMATICAL PHYSICS - II

L	T	P	C
3	0	0	3

Prerequisites: NIL
Total hours : 42

Module 1: [10 (L) hours]
Complex plane, Complex functions, analytic functions, Cauchy-Riemann condition, power series – Taylor series and Laurent series, zeros and singularities, line integrals, Cauchy's integral theorem, Indefinite integrals, Cauchy's integral formula, Residue theorem and application to evaluation of integrals.

Module 2: [8 (L) hours]
Partial differential equations, separation of variables, wave equation, use of Fourier series, D'Alembert solution to wave equation, heat equation, two dimensional wave equation, Laplace equation.

Module 3: [12 (L) hours]
Elements of group theory. Discrete groups with examples, finite groups, Abelian and non-Abelian groups, examples of continuous groups, group properties of rotations in 3D. Representations, Equivalent representations, reducible and irreducible representations, characters. Applications to spectroscopy, crystal structure etc.

Module 4: [12 (L) hours]
Probability distributions and probability densities, Standard discrete and continuous probability distributions, examples of discrete and continuous distributions – Binomial, Geometric, Poisson, normal, central limit theorem.

References:

1. Complex Variables and Applications, J. W. Brown and R. V. Churchill, 8th Edition, McGraw Hill (2009).
2. George B Arfken, Mathematical methods for physicists, 4th ed. Academic Press (1995).
3. Erwin Kreyszig, Advanced Engineering Mathematics, 7th ed., John Wiley (1992).
4. P. Dennery and A. Krzywicki, Mathematics for Physicists, Dover Publications (1996).
5. Elements of Group Theory for Physicists, A. W. Joshi, New Age international publishers (4th Ed reprint 2005).
6. Group theory in Physics – an introduction, J. F. Cornwell, Academic Press(1997).

PH6306 QUANTUM MECHANICS – I

Prerequisites: NIL
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]
Origins of quantum theory, wave function, probability interpretation, quantum state, Dirac formalism – kets, bra, operators, Hermitian and unitary matrices, eigenvales and eigenvectors, basis transformations, commutation relations, Born interpretation, measurement theory, expectation values, uncertainty principle, position and momentum representation, time evolution, Hamiltonian operator, Schrödinger, Heisenberg and Interaction pictures, Schrödinger equation

Module 2: [14 (L) hours]
One dimensional potential problem, charged particle in external magnetic field, simple harmonic oscillator- operator formalism, raising and lowering operators, eigenvalues and eigenvectors, Schrödinger equation for the oscillator

Module 3: [8 (L) hours]
Angular momentum: Infinitesimal rotations, rotation operator, angular momentum operators, commutation relations, eigenvalues, matrix representation, orbital and spin angular momentum, central field problems, hydrogen atom, orbitals

Module 4: [8 (L) hours]
Symmetry, conservation laws, degeneracy, density matrix, pure and mixed states, connection to partition function, introduction to path integral formalism

References:

1. J. J. Sakurai and J. J. Napolitano, Modern Quantum Mechanics, Pearson (2013).
2. N. Zettili, Quantum Mechanics: Concepts and Applications (2nd Ed), Wiley (2009).
3. R. Shankar, Principles of Quantum Mechanics (II Ed.), Springer (1994).
4. David. J. Griffiths, Introduction to Quantum Mechanics, (2nd Ed.) Pearson Education (2005).
5. L. I. Schiff, Quantum Mechanics, (III Ed.) McGraw Hill (1968).
6. Constantinescu and Magyari, Problems in Quantum Mechanics, Pergamon (1974).

PH6307 STATISTICAL MECHANICS

Prerequisites: Nil
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]
Need for statistical physics, models of macroscopic systems, macrostates and microstates, phase space, Liouville's theorem, energy quantization, review of basic probability theory and thermodynamics, fundamental postulate of equilibrium statistical mechanics, microcanonical ensemble, Gibbs paradox and enumeration of microstates, canonical ensemble, partition function, free energy, calculation of thermodynamic quantities, entropy, fluctuations, grand canonical ensemble

Module 2: [10 (L) hours]
Classical ideal gas, Maxwell-Boltzmann distribution, equipartition theorem, virial theorem, specific heat of gases, real gases, paramagnetism, Langevin and Brillouin functions, Curie's law, nuclear spins, ortho and para hydrogen, negative temperature concept, system of harmonic oscillators

Module 3: [12 (L) hours]
Systems of identical, indistinguishable particles, spin, symmetry of wavefunctions, bosons, fermions, Pauli's exclusion principle, Bose-Einstein and Fermi-Dirac distributions, degeneracy, ideal Fermi gas and ideal Bose gas, applications – free electron gas, liquid helium, radiation, specific heat of crystalline materials – Einstein and Debye theories

Module 4: [8 (L) hours]
Introductory ideas on phase transitions, first order phase transition, theory of Lang and Lee, dynamical model of phase transitions, Weiss theory of ferromagnetism, second order phase transition, Landau theory, critical point exponents

References:

1. F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw-Hill (1985).ss
2. Kerson Huang, Statistical Mechanics, II Ed, John Wiley (1987).
3. Herbert B. Callen, Thermodynamics (II Ed.) Wiley (1985).
4. R. K. Pathria, Statistical Mechanics (II Ed.), Butterworth-Heinemann (1996).
5. E. Atlee Jackson, Equilibrium Statistical Mechanics, Prentice-Hall (1968).

PH6308 ELECTROMAGNETIC THEORY – II

Prerequisites: PH 6303 Electromagnetic Theory – I
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [10 (L) hours]
Wave propagation between parallel conducting ting plates, metallic wave guides –rectangular and cylindrical, boundary conditions at metallic surfaces, propagation modes in wave guides, resonant modes in cavities.

Module 2: [14 (L) hours]
Potentials and fields- Scalar and vector potential, Coulomb gauge and Lorentz gauge. Retarded potentials, Jefimenlo's equations. Lienard-Wiechert potentials, field of a moving point charge. Radiation- Electric dipole radiation, magnetic dipole radiation, radiation from an arbitrary source, power radiated from a point charge, radiation reaction, physical basis of radiation reaction.

Module 3: [8 (L) hours]
Plasma, Electrical neutrality in plasma, particle orbits and drift motion in a plasma, hydromagnetic equations, the pinch effect, plasma oscillations and wave motion, the use of probes for plasma measurements.

Module 4: [10 (L) hours]
Special theory of relativity, Lorentz transformation, relativistic mechanics and dynamics,four-vectors in electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles.

References:

1.D.J. Griffiths, Introduction to Electrodynamics, 4th Edition, PHI Learning, New Delhi.(2012).
2. J.D. Jackson, Classical Electrodynamics, 3rdEdition,Wiley India.(1998).
3. L.D. Landau and E. M. Lifshitz, Classical Theory of Fields (4th Ed. revised), Elsevier (2011).
4. John R. Reitz, Frederic J. Milford and Robert W. Christy, Foundations of Electromagnetic Theory , 3rd Edition Narosa Publishing House, New Delhi.(2012).
5. W.K.H. Panofsky and M. Phillips, Classical Electricity and Magnetism, (2nd edition), Addison-Wesley (1962).

PH6309 DIGITAL ELECTRONICS

Pre-requisites: Nil
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]
Number systems: Decimal, binary, octal, hexadecimal number system and conversion, Complements of numbers, signed binary numbers. Codes: BCD code, Excess-3 code, Gray code, ASCII character code. Digital Logic gates, Boolean algebra: Basic theorems and properties, Boolean functions. Canonical and standard forms: minterms and maxterms. Standard form: the sum of products and products of sums. Gate level minimization: the map method, two, three and four variable Karnaugh map, simplification of Boolean functions, product of sums simplification, don’t-care conditions, NAND and NOR implementation. Logic families and their characteristics: TTL, ECL and CMOS integrated circuits and their performance comparison. Tri-state logic.

Module 2: [8 (L) hours]
Combinational circuits: Binary adder-subtractor, BCD adder. Binary multiplier. Decoders: BCD to seven segment decoder. Encoders: priority encoder. Multiplexers. Boolean function implementation.

Module 3: [12 (L) hours]
Sequential circuits: Latches: SR and D latch. Flip-flops: Edge triggered D, JK and T flip-flops. Analysis of clocked sequential circuits: state equations, state table and state diagram. Registers: register with parallel load, Shift registers: serial transfer, universal shift register. Ripple counters: binary ripple counter, BCD ripple counter. Synchronous counters: binary counter, BCD counter, binary counter with parallel load. Ring counter. Digital-to-analog converters: weighted-resistor and R-2R ladder D/A converters. Analog-to-digital converters: quantization and encoding, parallel-comparator and successive-approximation A/D converters.

Module 4: [10 (L) hours]
Memory: Random-access memory, write and read operation, timing waveforms, types of RAMs. Memory decoding: internal construction, address multiplexing. Read-only memory: combinational circuit implementation, types of ROMs. Programmable logic arrays, sequential programmable devices.

References:

1. M. Morris Mano and Michael D Ciletti, Digital Design, Prentice- Hall of India.(2006).
2. Digital Principles and Applications, Malvino, Leach, Tata McGraw -Hill.(2009).
3. Modern digital electronics, R P Jain, Tata McGraw- Hill.(2010).
4. Fundamentals of Digital Circuits A. Anand Kumar, Prentice- Hall of India.(2003).
5. Digital electronics, an introduction to theory and practice, William H. Gothmann, Prentice -Hall of India.(1982).

PH6383 GENERAL PHYSICS LAB

L	T	P	C
0	0	3	2

Prerequisites: NIL
Total hours : 42

Experiments Involving properties of matter, semiconductors, optics, acoustics…etc.

1. Energy band gap and diffusion potential of a semiconductor
2. Photoelectric effect & Determination of Planck's constant expt – using LED
3. Hall effect experiments including temperature dependence of resistance.
4. Solar cell characteristics
5. Speed of Rotary Pump & Pirani gauge
6. Measurement of Magnetoresistance of semiconductors
7. Ultrasonic Interferometer - Acousto-optic effect- Determination of ultrasonic velocity in liquid
8. Determination of Elastic constants by Cornu's method
9. Fourier transforms processor
10. Faraday effect and determination of Verdet's constant
11. Four probe – Resistivity measurements
12. Michelson Interferometer

References:

1. B.L. Worsnop and H.T. Flint, Advanced Practical Physics for students, Asia Publishing House, (1971).
2. S.L.Gupta and V. Kumar, Practical Physics, Pragathi Prakash (2005).

PH6384 ELECTROMAGNETICS LAB

L	T	P	C
0	0	3	2

Prerequisites: NIL
Total hours : 42

Experiments based on microwave radiation. Eight experiments to be done.

1. Study of characteristics of a Klystron Tube and to determine its electronic tuning range.
2. Frequency and wavelength in a rectangular waveguide working in TE_{10} mode.
3. To determine the Standing Wave Ratio and Reflection Coefficient.
4. To measure an unknown impedance using the Smith Chart.
5. To measure the polar pattern and gain of a wave guide horn antenna.
6. Study of a multi-hole directional coupler.
7. Study of the magic –T.
8. Study of circulator/Isolator.
9. Study of fixed and variable type Attenuators.
10. Measurement of dielectric constant of solids and liquids.
11. Phase shift measurements

Reference :

1. C. G. Montgomery, Technique of microwave measurements, 1947
2. R. G. Carter, Electromagnetic waves: Microwave Components and Devices, Chapmann & Hall, 1990.

PH7301 QUANTUM MECHANICS – II

L	T	P	C
3	0	0	3

Prerequisites: PH 6306 Quantum Mechanics – I
Total hours: 42

Module 1: [10 (L) hours]
Addition of angular momenta, Clebsch-Gordon coefficients, tensor operators, Wigner-Eckart theorem, identical particles, distinguishable and indistinguishable particles, symmetric and antisymmetric wave functions, exchange degeneracy, projection operator, bosons and fermions, Slater determinant, Pauli's exclusion principle

Module 2: [12 (L) hours]
Stationary perturbation theory, first and second order approximation to wave function and energy eigenvalue, degenerate perturbation theory, applications to- harmonic oscillator, Zeeman effect, Stark effect. Time dependent perturbation – method of variation of constants, transition rate, sudden and adiabatic approximations, Fermi golden rule, scattering theory, scattering cross section, Born approximation, partial wave analysis, variational method –application to ground state of He-atom, WKB approximation.

Module 3: [10 (L) hours]
Maxwell's equations, plane waves and perturbation theory, transition probability, absorption and emission, dipole transitions and selection rules, forbidden transitions, spontaneous emission, simulated emission, quantized radiation field.

Module 4: [10 (L) hours]
Relativistic effects, Klein-Gordon equation, Dirac equation, Dirac matrices, spinors, positive and negative energy solutions, physical interpretation, non relativistic limit of the Dirac equation.

References:

1. David .J. Griffiths, Introduction to quantum mechanics (2ndedn), Pearson education (2005).
2. N. Zettili, Quantum Mechanics: Concepts and Applications (2nd Ed), Wiley (2009).
3. J. J. Sakurai and J. J. Napolitano, Modern Quantum Mechanics, Pearson (2013).
4. R. Shankar, Principles of Quantum Mechanics, (II Ed.), Springer (1994).
5. L. I. Schiff, Quantum Mechanics, (III Ed.) Mc Graw Hill, (1968).
6. Constantinescu and Magyari, Problems in Quantum Mechanics, Pergamon (1974).

PH7302 CONDENSED MATTER PHYSICS – I

Prerequisites: Nil
Total hours: 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]
Crystal Physics: Classification of condensed matter-crystalline and noncrystalline solids, Bonding and internal structure of solids - Ionic, covalent and metallic solids, the van der Waals interaction, hydrogen bonding, crystal symmetry, point groups, space groups, lattices and basis, typical crystal structures, reciprocal lattice, Bragg's law of diffraction, X-ray, neutron, and electron diffraction, Brillouin zone, structure factor.

Module 2: [8 (L) hours]
Lattice Vibrations and Thermal Properties: Monoatomic and diatomic lattices, normal modes of lattice vibration, phonons and density of states, dispersion curves, specific heat – classical, Einstein and Debye models. Thermal expansion, thermal conductivity, normal and Umklapp processes.

Module 3: [10 (L) hours]
Free Electron theory: Dependence of electron energy on the wave vector, E-K diagram. Free electron theory of metals. Thermal and Electrical transport properties, Electronic specific heat. Fermi surface. Motion in a magnetic field: cyclotron resonance and Hall effect. Thermionic emission. Failures of free electron theory.

Module 4: [12 (L) hours]
Energy Band Theory: Energy spectra of atoms, molecules and solids- formation of energy bands. Bloch theorem, Kronig-Penny Model, construction of Brillouin zones, extended, reduced and periodic zone schemes, effective mass of an electron, nearly free electron model, tight binding approximation, orthogonalized plane wave method, pseudo-potential method, insulators, conductors and semiconductors.

References:
1. Kittel, C.: Introduction to Solid State Physics, Wiley (2007).
2. Ashcroft and Mermin: Solid state Physics, Thomson (2007).
3. Ali Omar: Elementary Solid State Physics, Addison-Wesley (2005).
4. M A Wahab: Solid State Physics-Structure and Properties of Materials, Narosa (2005).

PH7303 ATOMIC AND MOLECULAR PHYSICS

L	T	P	C
3	0	0	3

Prerequisites: Nil
Total hours: 42

Module 1: [8 (L) hours]
Schrodinger equation for one-electron atoms, eigen functions of bound states, virial theorem, one electron atoms in parabolic coordinates, extension to two-electron atoms, spin wave functions, level scheme, independent particle model, many electron atoms, central field approximation, spin orbitals, slater determinants, Thomas Fermi model of an atom,

Module 2: [12 (L) hours]
Charge particles in EM field, transition rates: absorption, stimulated emission, spontaneous emission, Dipole approximation, velocity and acceleration forms, schrodinger equation in length and velocity gauges, spontaneous emission from 2p level, Einstein coefficients, selection rules, spin of photon, line intensities and lifetimes of excited states, line shapes and width.

Module 3: [14 (L) hours]
Fine structure of hydrogenic atoms, fine structure splitting, Lamb shift, hyperfine structure and isotope shifts, interaction of one-electron atoms with external electric and magnetic fields: linear and quadratic stark effect, Zeeman effect, Paschen-Back effect, anamolous Zeeman effect

Module 4: [8 (L) hours]
Molecular symmetry, rotational spectroscopy, vibrational spectroscopy, Raman spectroscopy, electronic spectroscopy of molecules, Frank-Condon principle, spin resonance spectroscopy

References:

1. B.H.Bransden and C.J. Joachain, Physics of Atoms and Molecules, (II Ed.), Pearson Education (2004).
2. P.W.Atkins and R.S.Friedman, Molecular Quantum Mechanics, (3^{rd} Ed.) Oxford Univ. Press (1997).
3. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill (1994).
4. R. Eisberg and R. Resnick, , Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles,John Wiley, New York (1974).
5. H. E. White, Introduction to Atomic Spectra, Mc Graw Hill, Kogakusha, Tokyo (1934).
6. J. Michael Hollas, Basic Atomic and Molecular Spectroscopy, Royal Society of chemistry (2002).
7. C.J. Foot, Atomic Physics, Oxford University Press (2005).

PH7304 NUCLEAR AND PARTICLE PHYSICS

Prerequisites: NIL
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]
General properties of nuclei, nuclear decay, nuclear binding energies and forces, nuclear forces- charge independence, isospin symmetry. Nuclear models - shell model: Evidence for shell structure; Magic numbers, the shell model potential, spin-orbit potential, filling of the shells, ground state spins and parities of nuclei, excited states, liquid drop model.

Module 2: [14 (L) hours]
Nuclear decay- alpha, beta and gamma emission, basic beta decay process, energy release in beta decay, Fermi's theory of beta decay, non-conservation of parity in beta decay, energetic of gamma decay, angular momentum and parity selection rules, life times for gamma emission, Theory of alpha particle emission, Nuclear reactions – classification and kinematics, Fission process, chain reactions, criticality and multiplication, nuclear reactors, breeder reactors, fast breeders, nuclear fusion process, thermonuclear reactions in plasma.

Module 3: [10 (L) hours]
Particle interactions and families, symmetries and conservation laws: angular momentum; parity; baryon number lepton number, isospin, strangeness and charm, the quark model; coloured quarks and gluons, charm, beauty and truth quarks dynamics; The neutrino, CP violation, K0-K0* oscillations. Grand unified theories

Module 4: [6 (L) hours]
Radiation interaction with matter, radiation detection, detectors and counters particle accelerators, ion beams and applications, experimental techniques in nuclear and particle physics.

References:

1. Kenneth S. Krane : Introductory Nuclear Physics, John Wiely& Sons (1988).
2. Griffiths, D.:Introduction to Elementary particles,John Wiley & Sons, (1987).
3. Enge, H.A.:Introduction to Nuclear Physics, Addison-Wesley (1971).
4. Segre, E.:Nuclei and Particles, (II Edition) Benjamin (1977).
5. Reid,J.M: Atomic Nucleus, ManchesterUniv.Press, (1986).
6. D.H. Perkins, Introduction to High Energy Physics,Addison Wesley (1987).
7. J.J. Sakurai, Invariance Principles and Elementary Particles, Princeton University Press (1964).

PH7305 CONDENSED MATTER PHYSICS – II

Pre-requisites: Nil
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]

Semiconductors: Semiconductor materials, crystal structure, valence bonds, energy bands, density of states, intrinsic carrier concentration, donors and acceptors, effective mass, carrier drift, mobility effects, Hall effect in semiconductors.

Dielectric properties: Local electric field at an atom, Clausius-Mossotti equation, dielectric constant and polarizability- classical theory of electronic polarizability, dipolar polarizability, piezo-, pyro- and ferroelectric crystals, ferroelectricity, ferroelectric domains, antiferroelectricity and ferrielectricity.

Module 2: [10 (L) hours]

Magnetism: Classification of magnetic materials, origin of permanent magnetic moments, Langevin's classical theory of diamagnetism, quantum theory of paramagnetism, ferromagnetism, Weiss molecular field, ferromagnetic domains, antiferromagnetism, ferrimagnetism and ferrites, magnons, neutron scattering.

Module 3: [10 (L) hours]

Superconductivity: Meissner effect, London equation, Type I and II superconductors, thermodynamics, superconducting band gap, Cooper pairs, flux quantization. BCS theory (qualitative). Josephson Effect, SQUIDS, high temperature superconductors.

Physics of nanomaterials: Mesoscopic Physics, quantum wire, well and dot, size and interference effects, quantum confinement and Coulomb blockade, imaging techniques for nanostructures - electron microscopy, scanning tunnelling microscopy and atomic force microscopy.

Module 4: [10 (L) hours]

Defects in Crystals: Point defects - Frenkel and Schottky defects, colour centres, excitons. Dislocations - models of screw and edge dislocations, Burgers vector. Surface imperfections – grain boundaries, tilt boundaries, twin boundaries and stacking faults; Volume defects.

References:

1. Kittle, C.: Introduction to Solid State Physics, Wiley (2007).
2. Ashcroft and Mermin: Solid state Physics, Thomson (2007).
3. Ali Omar: Elementary Solid State Physics, Addison-Wesley (2005).
4. M A Wahab: Solid State Physics: Structure and Properties of Materials, Narosa (2005).
5. Sze S. M., Semiconductor Devices: Physics and Technology; John Wiley and Sons (2002).

PH7381 OPTICS LAB

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Prerequisites: NIL
Total hours : 42

L	T	P	C
0	0	3	2

1. Principles of Physical Optics.
   Experiments based on polarization, Reflection, Refraction, Diffraction, Interference and Coherence.

References:

1. M. Born and E. Wolf, Principles of Optics, (VI Edition),Pergamon, (1989).
2. A. Ghatak and K.Tyagarajan**,** Introduction to Optics, Cambridge University Press, (1999).
3. A. Yariv**,** Optical Electronics (1985).
4. A. Ghatak and K.Tyagarajan, Optical Electronics, Cambridge University Press, (1999).
5. J.W. Goodman, Introduction to Fourier Optics, McGraw Hill, (1968).
6. D.L. Clark and J.F.Grainger, Polarised light and Optical measurement, Pergamon Press, (1971).

Course Outcome:

- Acquire practical knowledge of optical concepts/phenomena like interference, diffraction, polarization etc.
- Acquire practical knowledge of lab protocols and work in a team.
- Acquire practical knowledge of optical components/devices like Laser,Photodiode, Phototransistor etc. and get hands on experience.
- To perform experimental measurements, analyze the experimental dataandprovide meaningful conclusions.

PH7382 SOLID STATE PHYSICS LAB

Prerequisites: NIL

L	T	P	C
0	0	3	2

Total hours : 42

Syllabus: Experiments based on measurement of resistivity, Hall coefficient, Magnetic susceptibility, Energy band gap, Specific heat capacity, Curie temperature, Magnetoresistance etc.

PH7320 GENERAL THEORY OF RELATIVITY

Pre-requisites: Nil
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]
Review of Special Relativity (SR); global inertial frames; four-vectors and tensors in SR; covariant vectors and tensors. Covariance of equations under Lorentz transformations. Classical field theory of a real scalar field: action, Lagrangian density, Euler-Lagrange field equation. The mass less vector field: Lagrangian, field equations, Lorentz condition. The field tensor, Maxwell's equations. Energy density, Poynting vector. Invariance of the electromagnetic field. Lorentz transformation properties of electric and magnetic fields.

Module 2: [14 (L) hours]
General coordinate invariance, Principle of Equivalence. Tensors in curved space-time, connection, parallel transport, covariant derivative, Bianchi identities. Metric, energy-momentum and curvature tensors. Geodesics. Einstein's field equations, simple solutions.

Module 3: [10 (L) hours]
Precession of the planetary orbits, the gravitational red shift, gravitational waves and their signatures, bending of light. Black hole singularities, general properties of black holes and black hole thermodynamics.

Module 4: [6 (L) hours]
Homogeneity and isotropy. Friedmann-Robertson-Walker metric. Standard model of cosmology. Elementary ideas on big bang nucleosynthesis, phase transitions, structure formation. Cosmic microwave background radiation (CMBR) anisotropy.

References:

1. B. Schutz, A first course in General Relativity, Cambridge university press (1985).
2. S. Weinberg, Gravitation and Cosmology, John Wiley & Sons (1972).
3. L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields, 4th Edition, Pergamon (1975).
4. M. Carmeli, Classical Fields, Wiley (1982).
5. C. W. Misner, K. S. Thorne, and J. A. Wheeler, Gravitation, Freeman, NewYork, (2000).
6. P. A. M. Dirac, General Theory of Relativity, Prentice Hall of India, 2001.
7. W. Rindler, Relativity - Special, General, and Cosmological, Oxford University Press,New York, 2001.
8. J. V. Narlikar, Introduction to Cosmology, Cambridge University Press, New Delhi(1993).

PH7321 EXPERIMENTAL TECHNIQUES

L	T	P	C
3	0	0	3

Prerequisites: Nil
Total hours : 42

Module 1: [9 (L) hours]
Probability distributions: binomial, Poisson, Gaussian, and Lorentzian distributions, error analysis, applications of error equations, method of least squares, statistical fluctuations, probability tests, χ^2-test of a distribution, least-squares fit to: a straight line, polynomial, arbitrary function

Module 2: [12 (L) hours]
Electron techniques, principles of scanning electron microscopy (SEM), signal generation, image formation, resolution, practical aspects of the method, principles of transmission electron microscopy (TEM), practical aspects of the method, deviation parameter, z-contrast imaging, principles of scanning tunneling microscopy (STM), practical aspects of the method

Module 3: [11 (L) hours])
Optical imaging and microscopy, basic optical microscope, finite tube length microscopes, infinity corrected microscopes, Kohler illumination, critical illumination, bright field microscopy, dark field microscopy, phase contrast microscopy, confocal microscopy, photoluminescence spectroscopy,

Module 4: [10 (L) hours]
Temperature sensors, pressure sensors, optical sensors, sensors of position and movement, photoelectric switches, optical chemical sensors, flow sensors, accelerometers and inclinometers

References:

1. P. R. Bevington, D.K. Robinson, Data Reduction and Error Analysis for the Physical Sciences, 3rd Edition, Mc Graw Hill.(2002).
2. Elton N. Kauffmann (Ed.), Characterization of Materials, Wiley-Interscience (2003).
3. Tomasz S. Tkazyk, Field Guide to Microscopy, SPIE Press Bellingam, Washington USA (2009).
4. Pavel Ripka and Alois Tipek (Eds), Modern Sensors Handbook, ISTE Ltd. (2007).

PH7322 PHYSICS OF CLIMATE

Pre requisite: Nil
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [11 (L) hours]
Components of climate system – Structure and composition of the atmosphere; the hydrosphere: properties of water, the hydrologic cycle, measuring the water content of the atmosphere; cryosphere; biosphere. Radiation: Sun as primary source of energy for the earth, black body radiation and solar radiation spectrum, albedo, radiation balance at the earth's surface and determination of surface temperature, UV radiation, ozone layers and depletion, greenhouse effect, the carbon cycle, atmospheric aerosols and their effect on radiation balance.

Module 2[11 (L) hours]
Laws of thermodynamics, energy transfers – conduction, convection, radiation, evaporation, ideal gas model, exponential variation of pressure with height, temperature structure and lapse rate. Stability. Atmospheric dynamics – Navier Stokes theorem, continuity equation, general idea about synoptic and meso-scale disturbances. Entropy in the climate system.

Module 3: [11 (L) hours]
Winds in the atmosphere – measuring wind, origin of winds – the atmosphere as a heat engine, the principal forces acting on an air parcel, cyclones and anticyclones, thermal gradients and winds, global convection and global circulation; Angular momentum cycle; Energetics – energy equations, observed energy balance, polar energetic; divergence, vorticity and momentum balance; The Ocean structure and the thermohaline circulation.

Module 4: [9 (L) hours]
Modeling of climate – global climate circulation models and predictions, nature of climate system, climate state and climate variability – inter annual and inter decadal variability, climate cycles – El Nino, North Atlantic Oscillation, climate observation – instrumentations and techniques for measuring climate variables, discussions on climate change.

References:

1. J. P. Peixoto and A. H. Oort, Physics of Climate, AIP & Springer Verlag (1992).
2. N. Mason and P. Hughes, Introduction to Environmental Physics: Planet Earth, Life and Climate, Taylor and Francis (2001).
3. J. R. Holton, An Introduction to Dynamic Meteorology, Academic Press (1992.
4. Boeker and van Grondelle, Environmental Science: Physical Principles and Applications, Wile (2001).

PH7323: ATMOSPHERIC DYNAMICS

L	T	P	C
3	0	0	3

Prerequisites: NIL
Total hours : 42

Module 1: [11 (L) hours]
Introduction – The scope of dynamical meteorology, scales and types of motion in the atmosphere. Continuum Hypothesis, Lagrangian and Eulerian frames of references, velocity potential, stream function, two dimensional potential flows, Bernoulli's equation. Forces in geophysical fluids, scale analysis, structure of the atmosphere, coordinate systems. Conservation laws – Momentum equation in rotating coordinates, hydrostatic balance, continuity equation, thermodynamic energy equation. Viscous forces and diabatic processes.

Module 2: [11 (L) hours]
Basic applications – Geostrophic wind and thermal wind balance. Ageostrophic flow and secondary circulation, Elements of weather analysis (maps). Dry / moist thermodynamics and vertical stability. Mesoscale thermal circulations. Vorticity – Circulation and vorticity, barotropic vorticity, potential vorticity, Ertel-Rossby potential vorticity. Perturbation theory and atmospheric oscillations. Phase velocity, Group Velocity, Dispersion, Sound waves, Gravity waves, Inertial Waves Rossby waves, Haurwitz Rossby waves, Mountain waves, Lee waves, Stationary planetary waves.

Module 3: [10 (L) hours]
Momentum and energy transports by waves in the horizontal and the vertical. Log-Pressure Coordinate System, Equatorial Beta plane Approximation. Atmospheric Kelvin and Mixed Rossby Gravity Waves. Quasi-geostrophic theory – QG scale analysis and approximations. Towards a prognostic set of equations: QG tendency and potential vorticity equations. Diagnosing vertical motion: the omega equation (Q-vectors vs traditional form).

Module 4: [10 (L) hours]
Baroclinic instability – Introducing turbulence on a planetary scale: polar front and storm tracks. Features of extratropical cyclones. Cyclogenesis theory. Introduction to general circulation – the planetary atmospheric circulation: observed features and example theoretical models (e.g. the Rossby model for stationary eddies). Variability at different time scales.

References:

1. J. R. Holton, Introduction to Dynamical Meteorology, 4th ed., Academic Press (2004).
2. J. Marshall and R. A. Plumb, Atmosphere, Ocean, And Climate Dynamics: an Introductory Text, Elsevier Academic Press (2008).
3. M. L. Salby, Physics of the Atmosphere and Climate, Cambridge University Press (2012).
4. M. Mak, Atmospheric Dynamics, Cambridge University Press (2011).

PH7324 SOLID STATE DEVICES

L	T	P	C
3	0	0	3

Prerequisites: Nil
Total hours : 42

Module 1: [10 (L) hours]
Semiconductor materials; Crystal structure; Valence bonds; Energy bands; E-k diagram, Electron effective mass,energy band gap, Direct and indirect band gap semiconductors, Density of states; Intrinsic carrier concentration; Donors and acceptors; Carrier drift; mobility effects; Conductivity; Carrier diffusion; diffusion current density; Injection of excess carriers, Generation and recombination processes; Poisson's and continuity equations; High field effects.

Module 2: [12 (L) hours]
Basic structure of the pn junction- thermal equilibrium condition, built in potential barrier, depletion region, the space charge width and electric field, forward and reverse bias operation, depletion capacitance and storage capacitance, Current –voltage characteristics; Junction breakdown mechanisms. Open circuited, step, graded junctions. Metal Semiconductor contacts- Ohmic contacts, Schottky barriers, Rectifying contacts. Comparison of the Schottky barrier diode with p-n junction diode, Small signal and large signal diode models, junction capacitance.

Module 3: [8 (L) hours]
Fundamentals of BJT operation; charge carrier distribution in each region; different modes of operation; current-voltage characteristics of common-base and common emitter configurations; frequency response and switching of bipolar transistors.

Module 4: [12 (L) hours]
Basic p-n JFET operation; Basic MESFET operation.
Fundamentals of MOSFETS**:** Introduction; the two terminal MOS structure – energy band diagram, MOS capacitor, concept of accumulation, depletion and inversion, four terminal structure, MOSFET - I-V characteristics, drain current equation in terms of W/L, second order effects, brief introduction to MOS scaling; types of MOSFETS – depletion and enhancement type; NMOS and CMOS, Power MOSFET construction, Comparison with power BJT.

References:

1. Sze S. M., Semiconductor Devices: Physics and Technology**;** John Wiley and Sons (2002)
2. Sedra A. S. and Smith K. C.; Microelectronic Circuits, 2e, Holt, Rinehart and Winston (1987)
3. Ben G. Streetman and Sanjay Benerjee, Solid State Electronic Devices**,** Pearson Education (2002)
4. Donald A Neaman, Semiconductor Physics and Devices, McGraw Hill (2003)

PH7325 PHASE TRANSITIONS AND CRITICAL PHENOMENA

Prerequisite : Statistical Mechanics (PH6207 or equivalent)

Total hours :42

L	T	P	C
3	0	0	3

Module 1: [5 (L) hours]
Intrinsic stability of thermodynamic systems, stability conditions for thermodynamic potentials, physical consequences, Le Chatelier and Le Chatelier-Braun principles, First order phase transitions, general attributes of first order phase transitions, Gibbs phase rule, rule, second order phase transitions, Thermodynamics and statistical mechanics of phase transition, order parameter, Critical point exponents and exponent inequalities.

Module 2: [12 (L) hours]
Ising model, equivalence of Ising model to lattice gas model and binary alloys, magnetization, Bragg-Williams approximation, Bethe-Peierls approximation, one-dimensional Ising model

Module 3: [12 (L) hours]
Correlation function and fluctuation dissipation theorem, critical exponents, scaling hypothesis, dimensional analysis, scaling forms, Widom's scaling form, scale invariance Goldstone excitations, importance of dimensionality, dimensional reduction

Module 4: [13 (L) hours]
Landau approach, model Hamiltonian, Ising Model, XY-Model, mean-field theory, Van der Waals equation of state, tricritical point, Gaussian model, Ginzburg criterion, renormalization group theory: block spins, 1D-Ising model, Renormalization group transformation, fixed points and scaling fields, momentum space formulation, Gaussian model, renormalization of partition function, Landau-Wilson model, Fixed points and trajectories.

References:

1. H.E.Stanley, Introduction to Phase transitions and Critical Phenomena, Oxford (1971). .
2. J. M. Yeomans, Statistical Mechanics of Phase transitions, Oxford (1992).
3. K. Huang, Statistical Mechanics, John Wiley (2000).

PH7326 ORGANIC ELECTRONICS

Prerequisites: NIL
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]
Conducting polymer, Organic semiconductor, conduction mechanism, Pi and Sigma electron band theory. Polymers fundamentals-conducting polymers. Organic semiconductors, charge transport in conjugated polymers. Conduction mechanism in doped polymeric semiconductors. Physics of organic semiconductors (Luminescence, injection and transports properties) Methods of developing organic semiconductors.

Module 2: [10 (L) hours]
Basic device architecture in organic devices. Historical review. Organic light emitting diodes (OLED) and Polymer light emitting diodes (PLED). Multilayer architecture. Single layer architecture. Bulk hetero-junctions. Operating characteristics and electrical characterization. Flexible electronics : new display media. Flexible displays device architecture. Fabrication and characterization. Organic transistors. FETs: Principle and device architecture.

Module 3: [10 (L) hours]
Plastic solar cells. Basic principles. Multilayer and heterojunction structures, cell architecture. Charge transport and exciton formation – effects of exciton diffusion, dissociation and luminescence. Photogeneration process in organic heterojunction photovoltaic cells. Processing of organic solar cells. Dye sensitization – dye sensitized solar cell.

Module 4: [10 (L) hours]
Essential characteristics of electrode materials for organic electronic devices – work function. Conductivity and transparency factors. Indium Tin Oxide (ITO) as anode material. Effect of ITO oxidative properties on efficiency and shelf life of organic electronic devices, novel inorganic anode materials and their limitations. Buffer organic layer protection to the active layer. Doping the device and annealing the device for increased efficiency and shelf life – architecture.
Organic electronic materials. Thin film coating techniques for devices fabrication. Spin coating, dip coating, doctor blading screen printing, inkjet printing, vapor deposition. R.F and microwave plasma assisted film coating.

References:

1. Gil. Semiconductors and Organic Materials for Optoelectronic Application. Elsevier (1997)
2. Nalwa. Supra molecular photo sensitive and electro – active materials Elsevier (2001)
3. Equer. Thin film materials for large area electronics . Elsevier (1999)
4. Bernier. Advancn synthetic metals. Elsevier (1999)
5. R. Farchioni (Editor) G. Grosso (Editor) Organic Electronic Materials. Conjugated polymers and low molecular weight organic solids. Springer series in materials science (2007)
6. Gregory Crawford. Flexible flat panel display, Wiley series in display technology (2005)
7. Klauk Hagen (ED). Wiley VCH. Organic electronics (2006)

PH7327 MAGNETIC RESONANCE

Pre-requisites: Nil
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [12 (L) hours]
Principles of magnetic resonance: Nuclear Magnetic Resonance (NMR) theory, relaxation, Bloch equations. NMR spectra of the hydrogen and helium atoms. NMR of solids and liquids. Analysis of NMR spectra in liquids. Chemical shift, spin – spin coupling. Wide-line and high resolution NMR.

Module 2: [10 (L) hours]
Electron Spin Resonance (ESR). Spin Hamiltonian –Zeeman interaction, hyperfine interaction, super hyperfine interaction. The theory of g – factor and calculation and electronic structure. ESR of free radicals and transitions metals.

Module 3: [10 (L) hours]
Double resonances: Electron Nuclear Double Resonance (ENDOR), Electron Electron Double Resonance (ELDOR), Nuclear Magnetic Double Resonance (NMDR), Optical Detection of Magnetic Resonance (ODMR).

Module 4: [10 (L) hours]
Zero Field Nuclear Magnetic Resonance, Ferromagnetic Resonance, Spin Wave Resonance. Practical aspects of resonance spectrometers: NMR, ESR and ENDOR. Pulsed spectrometers, Measurement of relaxation times.

References:

1. Carrigton and McLachlan , Introduction to Magnetic Resonance Harper and Row, New York(1967).
2. John A Weil, James R Bolton and John E Wertz, Electron Paramagnetic Resonance, John Wiley (1994).
3. P.C. Poole and H.A. Farach. Theory of Magnetic Resonance, John Wiley (1987).
4. A. Abragam and B. Bleaney, Electron Paramagnetic Resonance of Transition Ions Clarendon Press, Oxford, (1970).

PH7328 LASER PHYSICS

Pre-requisites:PH6208 Electromagnetic Theory II
Total hours : 42

L	T	P	C
3	0	0	3

Module 1: [11 (L) hours]
Light-matter interaction – Einstein's coefficients, optical gain, electron oscillator model, Line broadening mechanisms and lineshapes– homogeneous and inhomogeneous broadening. Pumping mechanisms, Laser rate equations – two level, three-level and four-level systems.

Module 2: [11 (L) hours]
Passive optical resonators – modes of a rectangular cavity, open and closed resonators.Quality factor.Optical cavity containing amplifying media – threshold population inversion, variation of laser power around threshold, optimum output coupling, single mode and multi-mode laser operation, ultimate linewidth of a laser.CW and transient laser operations – Q-switching, techniques for Q-switching and mode-locking mechanism – active and passive mode locking.

Module 3: [10 (L) hours]
Solid state lasers – Ruby laser, Nd-YAG, Nd-glass lasers. Atomic gas lasers – He-Ne laser, Argon ion lasers. Molecular gas lasers – CO_2 laser, hydrogen and nitrogen lasers.Liquid lasers, Semiconductor lasers, Fiber lasers. Ultrafast lasers and pump-probe measurements.

Module 4: [10 (L) hours]
Laser in material processing and electronics industry, Laser in medicine and surgery, Laser in defense, Measurement of distance, Optical communication systems, Laser in nuclear energy.

References:

1. K.Thyagarajan and A. K. Ghatak, Lasers: Theory and Applications, IInd Ed., Springer Science (2010)
2. C. Christopher Davis, Lasers and Electro-optics: Fundamentals and Engineering,IVth Ed., Cambridge University Press (2006)
3. S. Hooker and C. Webb, Laser Physics, Ist Ed., Oxford University Press (2010)
4. A. Yariv, Quantum Electronics, John Wiley (1998)

PH7329 PHOTONIC BAND GAP STRUCTURES

L	T	P	C
3	0	0	3

Pre requisite: Nil
Total hours : 42

Module 1: [10 (L) hours]
Physics of linear photonic crystals: Review of Electrodynamics – Maxwell's equations, wave propagation in periodic systems, Photonic crystals: 1D, 2D and 3D, Bloch's theorem, the electromagnetic Eigenvalue problem, band diagrams, the variational theorem, origin of the photonic band gap. Computation of band gaps: semi-analytical methods using perturbation theory, scaling properties of the Maxwell equation,discrete andcontinuous frequency ranges.

Module 2: [12 (L) hours]
Photonic-crystal slabs: index-guiding in periodic systems, projected band diagrams, Point defects (cavities) and line defects (waveguides), waveguides, cavities, and losses, omnidirectional mirrors with 1d crystals. Coupled-mode theory and projected band structures.Hybrid structures lacking a complete band gap, waveguide bends, channel-drop filters, waveguide crossings, Mechanisms for high-Q with Incomplete gaps.

Module 3: [10 (L) hours]
Resonant cavities, Photonic-crystal and micro-structured fibers: Bragg (& OmniGuide) fibers, 2d-crystal fibers, holey (index-guided) fibers, perturbation theory in electromagnetism, band gaps of bragg fibers, guidedmodes of Bragg fibers, losses in hollow-core fibers, cladding losses, inter-modal coupling.

Module 4: [10 (L) hours]
Technology, materials and fabrication of photonic crystals: Choice of materials-semiconductors, polymers, fabrication of Photonic band gap structures: 1D, 2D and 3D, Photonic integrated circuits, channel waveguides, coupled cavity waveguides, add/drop multiplexers, polarization filters.

References:

1. John D. Joannapoulos, Steven G. Johnson, Joshua N. Winn and Robert D. Meade: Photonic crystals-Molding the flow of light, Princeton University Press (2008)
2. Mool Chand Gupta, John Ballato: The handbook of Photonics, 2nd edition, CRC press (2007)
3. K. Sakoda, Optical Properties of Photonic Crystals, Springer (2000)
4. Chai Yeh, Applied Photonics, Academic Press (1994)
5. R. Kashyap, Fiber Bragg Gratings, Academic Press, San Diego (1999)
6. K. Yasumoto, Electromagnetic Theory and Applications for Photonic Crystals (Optical Science and Engineering), Taylor & Francis Group (2006)
7. A. Bjarklev, J. Broeng, Photonic Crystal Fibers, Springer (2003)

PH7392 PROJECT

Prerequisites: Nil
Total Hours: 112

L	T	P	C
0	0	8	6

The student will be assigned a suitable project at the institute, to be taken up and completed in the 4th semester of the course. The student is expected to present a detailed thesis report relating to his/her project work and imbibe the rudiments of research during this training. He/she is also expected to give a final presentation on the project work.

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