Syllabus
M Sc Physics
Assam University,
Silchar

SEMESTER: I

PHY 101: CLASSICAL MECHANICS   Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. Types of constraints on dynamical systems, generalized coordinates ,d Alembert principle, Euler- Lagrange equations of motion, variational calculus and Hamilton's variational principles, Hamilton's canonical equations of motions, cyclic coordinates.

UNIT.II. Lagrangian and Hamiltonian for central forces, electromagnetic forces, coupled oscillators and other simple systems.

UNIT.III. Canonical variables, poission's bracket, Jacobi identity, Canonical transformations, generators of infinitesimal canonical transformations, symmetry principles and conservation laws.

UNIT.IV. Hamilton Jacobi theory, Action and angle variables, centre of mass and laboratory systems, Kepler problem, processing orbits.

UNIT.V. Small oscillations, normal coordinates and its applications to chain molecules and other problems.
Degree of freedom for a rigid body. Euler angles, Rotating frame coriolis force, Foucault's pendulum. Eulerian coordinates and equations of motion for a rigid body, Motion of a symmetrical top.

Text Books:

1. Classical Mechanics, Goldstein, Narosa Publishing, Delhi.
2. Course of theoretical, Landau & Lifshitz, Physics, Vol-I, Oxford University, Press
3. Classical Mechanics, Joag & rana, Mc Graw Hill.

Reference Books:

1. Classical Mechanics: a modern Perspective, Berger, Mc Graw Hill International.
2. Classical Mechanics, Awqhmare, Prentice Hall.
3. Theoretical Lecture, Series. Vol- 1-10, Landau & Lifshitz, Paragon Press, 1976.
4. Lectures on theoretical, Physics. Vol-I, Somerfield, Academic Press, NY 195.
5. New foundations for classical Mechanics, Hestness, Kluwer Academic Publisher.
6. Introductions of Relativity, R. Resnik, Wiley Eastern 1967.
7. Classical Mechanics, Corben & Stehle, Wiley NY 1974.
8. The meaning of relativity 5th Ed., Einstein, Princeton University Press.
9. Theory of space time and   Gravitational 2nd Ed., K. Fock, Peragon 1964.
10. Introduction on to special relativity, Schwartz, Mc Graw Hill, 1968.

PHY 102: MATHEMATICAL PHYSICS –I   Marks:75   Credit:5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT.I. **Linear Vector Space:** Vectors in n-dimensions, Linear independence, Inner product, Schwartz inequality. Representations of vectors and linear operators with respect to a basis, change of basis, Schmidt orthogonalization process. Linear operators and their matrix representation. Determination of eigen values and eigen vectors of operators. Unitary and hermitian operators. Hilbert space. Diagonalization.

UNIT.II. **Complex Variables**: Analytic functions and derivative of multi valued functions, Riemann sheets, Cauchy-Riemann conditions. Cauchy integral theorem and formula. Taylor and Laurent expansions of functions of complex variables. Residue theorem and its applications. Conformal mapping. Analytical continuation.

UNIT.III. **Group Theory**:
Definitions and examples of groups. Abstract groups, subgroups, classes cosets, factor-group, normal subgroup. Homomorphism, isomorphism and automorphism, Permutation groups. Group representations : reducibility, equivalence. Schur's Lemma. Lie groups and Lie algebra.

UNIT.IV. **Differential and Integral equations**:
Partial differential equations. Classification of second order partial differential equations. Laplace and Poisson equations. Simultaneous linear differential equations with constant and variable coefficients. Non-linear differential equations, Euler and Picard-Lineloft existence theorems. Stability variety of critical points. Van-der-Pol equations.

UNIT.V. Curvilinear Coordinates and Tensors:

Introduction to curvilinear co-ordinates, orthogonal curvilinear co-ordinates, differential operators in terms of orthogonal curvilinear co-ordinates. Gauss's theorem, Green's theorem and Stock's theorem.

Definition, notation and summation convention of Tensor, Symmetric and antisymmetric tensor, covariant and contravariant tensor, Tensors of rank greater than two, Scalars or invariants. Tensor fields, Fundamental operations with tensors, Line element and metric tensor, Reciprocal tensor, Christoffel symbols, Covariant differentiation.

Text Books :

1. Vector Analysis, Murry R Speigel, Mc Graw Hill.
2. Complex variables, Murry R Speigel, Mc Graw Hill.
3. Elements of Group Theory for Physicists, A W Joshi, New Age International.
4. Matrices and tensors in physics, A W Joshi, New Age International.
5. Elements of partial differential equations, I Snedden, Mc Graw Hill.
6. Classical Theory of Fields, Landau and Lifshitz, Butterworth Heinemann.

Reference Books:

  1.Mathematical Methods for Physicists, G B Arfken, Academic Press.

PHY 103: QUANTUM MECHANICS I   Marks:75   Credit : 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT.I. Review of elementary ideas:

Inadequacy of classical mechanics—Compton effect.

Double slit experiment/Stern Gerlach experiment to introduce the idea of quantum state. Wave packet description of the state – its time development. Physical interpretation of wave function by Born's probability. Ehrenfest's Theorem.

Postulates of Quantum Mechanics, Physical interpretation of eigen values, eigen functions.

Wave function of Linear Harmonic Oscillator and Hydrogen atom. Uncertainty Principle.

UNIT.II. **General formalism of Quantum Mechanics**:
Adjoint of an operator and self adjointness. Eigen value problem --
degeneracy,Observables—Completeness and normalization of eigen functions, Closure.
Momentum eigen functions – wavefunction in momentum space.
States with minimum uncertainty product. Commuting Observables—removal of
degeneracy. Evolution of a system with time—constants of motion. Ehrenfest's Theorem
. Non-interacting and Interacting systems.

UNIT. III. **Abstract Formulation of Quantum Mechanics**:
Quantum states—state vectors and Wave functions. Hilbert space of state vectors –Dirac
notation. Expansion coefficients; Dynamical variables and linear operators.
Representation of state vectors. Dynamical variables as matrix operators –self adjointness
and hermiticity. Continuous basis—Schrodinger Representation. Change of basis, unitary
transformation .
Time evolution--- Schrodinger, Heisenberg and Dirac pictures. Linear Harmonic
Oscillator using Operator method.

UNIT. IV. **Angular momentum**:
Angular momentum operators, Commutation relations. General angular momentum.
Eigenvalues and eigen functions of J^2 and J_z. Angular momentum matrices, Spin angular
momentum, Spin vectors for spin ½ systems, spin matrices for electron Commutation
relation, Pauli eigen values and eigen function. Electron spin function. Addition of
angular momenta, Clebsch-Gordon coefficients. Symmetric and Antisymmetric wave
functions. Particle exchange operator, Pauli's exclusion principle. Density operator,
Density matrix.

UNIT.V. **Symmetries and Conservation laws**:
Symmetry transformations, Unitary transformations induced by translation and
rotation.Invariance under space and time translations, space rotation and conservation of
momentum, energy and angular momentum, Selection rules and conservation laws.

Text Books:

1.Introductory Quantum Mechanics, R.L. Liboff, Pearson Education, 2006.
2.Quantum Mechanics, L.I. Schiff, Mc Graw Hill, 1998.
3. Quantum Mechanics, A.K. Ghatak and S. Lokanathan, Macmillan, 2000.

References:

1. Modern Quantum Mechanics, J.J. Sakurai, Addison-Wesley, 1990.
2.Quantum Mechanics, E. Merzbacher, John Wiley & Sons, 1999.
3.Advanced Quantum Mechanics, Satya Prakash, Kedar Nath, 1990.
4.Quantum Mechanics,V.K. Thankappan, New Age Intl. Pub., 1996.
5.Quantum Mechanics S. Gasiorowiz, , Wiley, 1995.
6.Quantum Mechanics, P M Mathews and S Venkatesan, Mc Graw Hill, 1986.

PHY104: ELECTRONICS   Marks : 75   Credit : 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT.I. **Network analysis:** Norton, Thevenin, Superposition and maximum power transfer Theorems. Mesh and node, Fourier series, Fourier transform, Laplace transform and their applications.

UNIT. II. **Semiconductor diodes:** P-N junctions and other special diodes with their characteristics and applications. BJT- characteristics, modes of operations, single stage and Multi stage amplifiers. FET: JFET, MOSFET and characteristics. Positive and negative feed back in amplifiers. Oscillator (Hertly, Phase shift, Crystal oscillators), Operational amplifier (OP-Amp): Ideal and practical properties, Virtual ground, CMRR. Op-amp as analog computer (adder, subtractor, integrator, differentiator). Applications of op-amp as: Comparator, Schmitt Trigger, Active filters.

UNIT.III. **Combinational logic circuit:** Boolean operation, simplification of Boolean expression, De Morgans theorem, Adder and subtractor (half and full), Multiplexer and Demultiplexer, encoder and Decoder, RTL, DTL, TTL, ECL, CMOS families. Sequential logic circuit: Flip flops: RS, JK, Master slave, D and T. Comparison between latches and FFs. Counters, registers. RAM and ROM. Basics of Microprocessor and basic architecture of .computer

UNIT. IV. **Modulation**: Amplitude modulation: Modulated wave equation, spectrum, Power, SSB, DSB, DSBSC,VSB, Pilot carrier. Frequency modulation. Pulse modulation: Sampling theorem, PAM, PWM, PCM,: Optical fiber communication: Block diagram and explanation.
Networking- OSI and TCP/IP, LAN, WAN X 400, wireless communication: Wi-Fi, 802.11g. Broad band and Mobile communication.

UNIT.V. **Instrumentation:** Analog and digital Instrumentation, Sensors and actuators, Interfacing using D/A and A/D converters,CRO, Multimeters. Error analysis. DATA acquisition systems: Pulse height analysis- single and multichannel analyzers. Noise: Various types of noises signal to noise ratio. Noise temperature.

Text Books:

1. Millman & Halkias, Integrated Electronics : Abalog & digital circuits and digital circuits and system, Mc Graw Hill, 1972.
2. SM Sze, Physics of semiconductor devices, 2nd Edn. Wiley Inter Science.
3. Millman & Halkias, Electronics Instrumentation, Tata Mc Graw Hill.
4. Prokis J.G. Digital communication 3rd Edn. C Graw Hill International.

Reference Books:

1. Semiconductor Physics and devices-Basic Principles, Neamen D.A, Irasin Homewood, 1992.
2. Principle of communication system, Taub & Schiling, Tata Mc Graw Hill
3. Electronics Communication system, Kennedy, Tata Mc Graw Hill
4. Electronics Communications, Dennis, Roddy, Coolen J, Prentice Hall of India.
5. Electronics instrumentation & Measurement Technique, Helfrick A.D. & Cooper W.D. Prentice Hall of India.
6. Fundamentals of semiconductor theory and Devices physics, Wang S, Prentice Hall of India.
7. Electronics Instruments Hand Book, 2nd Edn., Combs C.F Prentice Hall of India.
8. Optical process in semiconductor, Pankove J.I, Prentice Hall Engle wood. NY.
9. Solid state Electronics devices, Stretman B.G, Prentice Hall 1995.
10. Semiconductor devices, Singh J, Mc Graw Hill, NY 1994.
11. Fibre o;ptics and opto Electronics, Cheo P.K, Mc Grae Hill. NY 1990.
12. Optical Communication, Gowar, Prentice Hall of India, 1993

PHY 105: Electronics Lab (LABORATORY-I)   Marks: 75   Credit: 5

1. Characteristics of FET.
2. Characteristics and applictions of Zener diode.
3. Study of logic gates.
4. Use of oscilloscope.
5. Characteristics and applications of a Solid State diode
6. Study of regulated power supply
7. Transistor Amplifier : gain, phase shift, band width etc.
8. Phase shift oscillator using transistors.
9. To Study a ripple counter.
10. To study encoder and decoder ciecuits.
11. To study half adder and full adder using logic gates.
12. To study half substractor and full substractor using logic gates.
13. Study of OP-AMP as inverting amplifier, non-inverting amplifier, difference amplifier, adder etc.
14. To measure input offset voltage, input offset current, band width and slew rate of an OP-AMP.
15. To study OP-AMP as function generator.
16. Study of monostable multivrator using IC 555.
17. Use of IC 555 (timer) as astable multivibrator.
18. Study of lock – in – Amplifier.
19. Study of modulating and demodulating circuits.
20. To design and implement a 4:1 Multiplexer using Logic gates.
21. To design and implement a 1:4 Demux using Logic gates.
22. To study the operation of the different types of following Flip Flops and verification their truth tables.
23. Use of DA and AD Converters.
24. Use of OPAM as active filters- as 1st order low pass.

25. Use of OPAM as active filters As 1st order high pass.
26. Use of OPAM as active filters As 2nd order low pass.
27. Use of OPAM as active filters As 2nd order high pass.
28. Study of Phase shift oscillator using OP-AMP.
29. Study of Schmitt trigger using OP-AMP.
30. Study of comparator circuit using OP-AMP.
31. Study of RC Integrator and Differentiator circuit using OP-AMP.
32. Study of Photo Diode.
33. Study of LDR.

NB: The list of experiments should be considered as suggestive of the standard. and are subject to availability of equipments. The teachers are authorised to either add or delete experiments whenever necessary.

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SEMESTER: II

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PHY 201: ELECTROMAGNETIC THEORY   Marks: 75   Credit: 5

 (All units carry Equal Marks. Two questions of equal marks are to be set in equal units. Students have to answer one question from each unit.)

UNIT. I. Review of special theory of Relativity, concept of invariant interval, Four vector, Lorentz transformation in four dimensional Space, Electromagnetic field tensor in four dimensional space Maxwell equation, Lagrangian of a charged particle, Lorentz force.

UNIT. II. Motion of a charged particle in electromagnetic field: uniform E and B fields. Non uniform fields, Diffusion across magnetic fields, Time varying E and B Fields, Adiabatic Invariants of electron moment.

UNIT. III. Saha's equation of ionization, Plasma oscillations, Plasma Parameters, Debye Length, Hydrodynamical description of Plasma, Fundamental equations, Hydro-magnetic waves : Magneto Sonic and Alfven waves, waves, propagation, phase and group velocity.

UNIT. IV. Radiation from an accelerated point charge, Lienard-wieohirt potentials, power radiated by a point charge. Spectral Resolution of retarded potential, Dipole, Quadrupole and magnetic dipole radiation, angular distribution of power radiation by linearly and circularly accelerated charge.

UNIT.V. Scattering: Scattering due to harmonically bound charge, Rayleigh and Thompson scattering, coulomb collision due to a harmonically bound charge, scattering due to large particle, scattering phase function formulation of Mie - T-matrix formulation (only expression).

Text Books:

1. Classical Electrodynamics, J.D. Jackson, Wiley Eastern, 1989.
2. Introduction of Electrodynamics, Grifiths, Prentice Hall.
3. The classical theory of fields, L.D. Landau & E,M Lifshitz, Butterworth Heinemann Ltd. Oxford.

Reference Books:

1. Quantum Electrodynamics, Berestetkii, Lifshit, Pitaevski, , Pergaman Press.
2. Fundamentals of Electromagnetic, Miah M.A.W, Tata Mc Graw Hill.
3. Theory of Electromagnetic Fluids, Cook D.M , Prentice.
4. Electromagnetic field and waves, Lorrain & CorsonFreeman & company San, Fransiscs.
5. Electrodynamics Vol- III, Somber field, Academic Press.

PHY 202: MATHEMATICAL PHYSICS II   Marks: 75   Credit: 5

UNIT. I. **Numerical Techniques:**
Finite difference calculus, interpolation and extrapolation (forward backward and central), Trapezoidal rule and Simpsons 1/3rd rule of integration , roots of polynomial, Newton-Rapshon, Picard's method, Runge- Kutta method. matrix eigenvalue problems, simple programming with FORTRAN

UNIT. II. **Dynamical System and Nonlinear Dynamics:**
One dimesional flow: Fixed points and stability, linear stability analysis, existence and uniqueness, impossibility of oscillations, potentials
Bifurcations: different types of bifurcations(Saddle-node, Transcritical, Pitchfork etc), Imperfect bifurcation and catastrophes, Volterra's Prey Predators Method

UNIT. III. **Chaos and Fractals:**
Lorenz Equations: Its properties, Strange Attractor, Lorenz Map, Exploring Parameter Space
One Dimensional Maps: Logestic Map, Liapunov Exponent, universality
Fractals: Cantor Set, Self similar fractals, Box dimension, Pointwise and correlation dimension

UNIT. IV. **Special functions:**
Green's functions ; Hypergeometric functions ; Functions related to Hypergometric function-Jacobi , Legendre ; Confluent Hypergeometric functions ; Functions related to Confluent Hypergeometric function-Hermite , Laguerre , Bessel, Elliptical integral of first and second kind

UNIT. V. **Topology:**
Basis for topology, Order topology, Continuous functions, Product topology, Metric topology, Quotient topology.

Connected spaces, Components and local connectedness, Compact spaces, Limit point compactness, Local compactness, One point compactification.

The Countability Axioms, Separation Axioms, Normal spaces, The Urysohn Lemma, The Urysohn metrization theorem (statement only), The Tietze extension theorem.

Text Books:

1. Numerical Methods for Scientific and Engineering Computation, M.K.Jain, S.R.K. Iyengar, R.K.Jain , New Age International (P) Ltd.
2. Introductory Methods of Numerical Analysis, S. S. Sastry, PHI.
3. An Introduction to Numerical Analysis, Kendall E. Atkinson, Wiley Eastern.
4. Nonlinear Dynamics and Chaos: With application to Physics, Biology Chemistry and Engineering, Steven H Strogatz, Westview.
5. Functional Analysis, Balmohan. V. Limaye, New Age International (P) Ltd.
6. Functional Analysis, Rudin Walter Tata McGraw-Hill.
7. Introductory Functional Analysis with Applications, Erwin Kreyszig, WILEY.
8. Special Functions, Z X Wang and D R Guo, World Scientific Publishing Co.

Reference books:

1. Elementary Numerical analysis – An Algorithmic approach, 3rd Edition., Corte S.D. and de Boor, McGraw Hill International Book Company, 1980.
2. Numerical Mathematical Analysis, James B. Scarboraugh, Oxford & IBH Publishing Company, New Delhi.
3. Introduction to Numerical Analysis, F.B. Hildebrand, McGraw Hill, New York, 1956.
4. Chaos in classical and quantum Mechanics, N Gutzweiler Springer, 1990.
5. Mathematical Methods for Physicists, G. Arfken, Academic Press.
6. Special Functions of Mathematical Physics and Chemistry, I.N. Sneddon, Longman.
7. Applied Mathematics for Physicists and Engineers, L.A. Pipes and L.R. Harwill, McGraw-Hill.
8. Mathematical Physics, P.K. Chattopadhyay, Wiley Eastern.
9. Advanced Engineering Mathematics, C.R. Wylie and L.C. Barrett, McGraw-Hill.
10. Advanced Engineering Mathematics, E. Kreyszig, Wiley Eastern.
11. Mathematics for Scientists and Engineers, H.Cohen, Prentice Hall,1992.
12. Introduction to Topology and Modern Analysis, G.F. Simmons, Mc-Graw Hill.
13. Topology A first Course, J.R. Munkers, Prentice Hall of India.
14. Topology, J. Dugundji, Allyn and Bacon, Boston, 1966.
15. Introduction to General Topology, K. D. Joshi, Wiley Eastern Limited.

PHY 203(A) (Optional): RELATIVITY FOR ALL   Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. Concept of Space and Time:
Galilean and Newtonian concept of space and time -inertial frames - Michelson Morley experiment- Einstein's postulates and consequences on space time- principle of relativity- non-absolute nature of space and time- space and time are only observer dependent

UNIT. II. Special theory of Relativity (STR):
Lorentz transformation equation- Time dilation and Twin paradox- space time continuum- mass energy equivalence ($E = MC^2$).

UNIT. III. Space, Time and Gravity in Newtonian Physics:
Newtonian Gravity, Gravitational and Inertial mass, variational principle in Newtonian Mechanics- Inertial frames- Olber's paradox- Mach's principle.

UNIT. IV. Geometry in Physics and General Theory of Relativity:
Different geometries- specifying geometry- Co-ordinates and line elements- the invariants in GTR- Gravity is geometry- curvature of space time as a measure of gravity - Equivalence principle of gravitational and inertial mass – clocks in a gravitational field- Global Positing System.

UNIT. V. Observed Universe:
Composition of the Universe- Hubble's law- expanding Universe- evolution of universe- Big Bang- the dimension of universe- finiteness of universe- cosmic microwave background radiation (CMBR) - accelerated expansion- dark energy- dark matter- alternate cosmology

Text Books:

1. Relativity: the Special and the General Theory- Albert Einstein (English Translation: R W Lawson) Routledge, London, 2000.
2. The Classical Theory of Fields volume 2, J. L. D.Landau and E. M. Lifshitz (1st edition Pergamon Press, 1951; 4th edition Butterworth-Heinemann 1980.
3. C W Misner, K S Thorne and J A Wheeler, Gravitation, W. H. Freeman and Company, New York 1972.
4. S. Weinberg, Principles and Applications of the General Theory of Relativity, John Wiley & Sons Inc. 1972.
5. Gravity, Hartley, Pearson education.
6. Space-Time and space time , Lawrence Sklar, Univ of California Press.
7. Relativity for Million, Gardner

PHY 203 (B) (Optional): ELECTRONICS AND INSTRUMENTATION
                                                        Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. **Basic Characteristics of Instruments:**
 Basic block diagram of an instrument. Static and Dynamic Characteristics, their related parameters (Calibration, accuracy, sensitivity, resolution, repeatability, speed of response, measuring lag, fidelity etc.). Different types of Instrumental errors.

UNIT. II**. Transducer and digital signal processing:**

Transducer: classifications, ideal characteristics and importance. Different types of transducers: Optoelectronic transducer, Temperature sensor, Pressure sensor, Flow meter, Displacement transducer and Humidity sensor**.**

 Digital Signal processing: Types of Signals, convolution, correlation, Fourier series and transforms (Discrete Time), Z-transform, DFT and FFT, digital filter design, data acquisition system.

UNIT. III. **Analytical instrumentation:**
Spectroscopy and spectral methods of analysis. Spectrophotometers- basic principle and uses: UV/VIS, Photoluminescence, FT-IR, Raman spectroscopy, X-Ray diffraction, NMR. Impedance analyser, AAS. Chromatography.

UNIT. IV. **Advanced Optical and electronic instrumentation:**

Polarization, polarizers, dichroism, birefringence, optical activity, induced optical effects - Kerr effect, Pockel effect.   Telescope-working principles, different types and applications. Polari meter and CCD: basic principle of operation. Electron Microscope: Basic principle, different types of Electron Microscopes (eg.SEM, TEM, AFM, STM etc), their advantages and uses.

UNIT. V. **Biomedical instrumentation:**

Cardiography: Working of Electrocardiograph (ECG), Echocardiograph (ECHO) and Vectro cardiograph (VCO), their advantages and disadvantages. Computerized axial tomography scans (CT scan): working and applications. Medical sonography (ultrasonography) – basic principle and importance. Blood pressure measurement.

Text Books:

1.Principle of Industrial Instrumentation, D. Patranabis, Tata McGraw-Hill, Publishing Company, New Delhi.
2.Transducers and   Instrumentation, D.V.S Murthy, Prentice – Hall of India.

3. Modern Electronic Instrumentation & Measurement Techniques, Albert D.
   Helfrick & William D. Cooper, Prentice – Hall of India.
4. Sensors and Transducers, D. Patranabis, Prentice – Hall of India.
5. Instrument Transducers an Introduction to their Performance and design: Hermann
   and Neubert, Oxford University Press.
6. Electronic Instrumentation, H.S. Kalsi, Tata McGraw-Hill, Company, New Delhi.
7. Instrumentation, Devices and System, C.S. Rangan, G.R. Sarma, V.S.V. Mani,
   Tata McGraw-Hill, Company, New Delhi.

PHY 204: SOLID STATE PHYSICS   Total Marks: 75   Credits: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit.
Students require to answer at least one question from each unit.)

UNIT. I. **Crystal Structure:**
Crystal lattice, Unit cell, Bravais lattices, X-ray diffraction, Bragg's law, Reciprocal
lattice, Laue diffraction, Crystal structures, Atomic scattering factor, Neutron diffraction,
Electron diffraction, Crystal structure determination by Laue, Powder and Rotating
crystal methods.

UNIT. II. **Crystal Binding and Crystal Vibration:**
Type of crystal binding, Crystals of inert gases, van der Waals-london Interaction, Ionic
bonding and Madelung constant.
 Quantization of lattice vibrations, Dispersion relations, Anharmonic vibrations, Thermal
expansions and Thermal conductivity.

UNIT. III. **Motion of electron in a periodic lattice:**
Bloch theorem, Kronig-Penney model and origin of bands in solids, Brillouin zones for
simple lattices, Crystal momentum, Effective mass of electrons and holes, Free electron
approximation, Tight binding approximation, Application to simple cubic lattices.
Fermi Surface: Ideas of Fermi surfaces and its study by the De Hass-van Alphen effect,
Cyclotron resonance.

UNIT. IV. **Physics of Semiconductor:**
Intrinsic and Extrinsic Semiconductor, Carrier concentration in intrinsic and extrinsic
semiconductor, Fermi levels, Recombination process, Rectifier equation, Continuity
equation, I-V Characteristics of p-n junction, Hall effect, Application of Hall Effect.

UNIT.V. **Superconductivity:**
Type I and Type II superconductors, Meissner effect, London-Equations,
Thermodynamics of Superconductors, BCS Theory, Quantum tunneling, Josephson
effect, High temperature superconductivity.

Text Books:

1. Elementary Solid State Physics, M. A. Omar, Pearson, 4th ed.(2004).
2. Solid State Physics, N.W. Ashcroft & N.D. Mermin (Harcourt Asia, 2001).
3. Introduction to Solid State Physics, Charles Kittel. (7th ed. Wiley)
4. Principles of the Solid State, H.V. Keer (Wiley Eastern Limited, 1994).
5. Elements of Solid State Physics, J. P. Srivastava (Prentice Hall of India, 2006).

PHY 205 : GENERAL PHYSICS LAB   Marks: 75   Credit: 5

1. Experiments with Michelson Interferometer: Determination of wavelength, small difference in wavelength, etc.

2. Experiments with Fabry-Perrot Interferometer: Determination of wavelength, small difference in wavelength, etc.

3. Study of Zeeman Effect and determination of e/m of electron.

4. Determination of wavelengths of spectral lines using Constant Deviation Spectrometer.

5. Analysis of elliptically polarized light using Babinet Compensator.

6. Determination of refractive index or thickness of a thin film using Jamin's Inetrferometer.

7. Study of Hall Effect.

8. Study the variation of resistivity of a semiconductor with temperature and hence to determine the Band Gap.using Four Probe set up.

9. Determination of velocity of ultrasonic wave liquid using Ultrasonic Interferometer.

10. Determination of velocity of ultrasonic wave in liquid by study of diffraction of light by the wave.

11. Determinatioon of Stefan's Constant.

12. Determination of Plank Constant using photo cell.

13. Charecteristics of a PN junction, determination of reverse saturation current, material constant, temperature co-efficient of junction voltage etc.

14. Study of Characteristics of LED.

15. Determination of Dielectric Constant.

16. Study of plateau of a Geiger –Muller counter and carry out statistical analysis of the data.

NB: The list of experiments should be considered as suggestive of the standard. and are subject to availability of equipments. The teachers are authorised to either add or delete experiments whenever necessary.

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PHY 301: STATISTICAL PHYSICS   Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. Thermodynamic laws and functions, Entropy, Free energy, Internal Energy, Enthalpy, Chemical Potential, Fugacity (definitions and significance). Micro and macro states, Phase space of a classical system, Density of states, Liouville's Theorem.

UNIT. II. Micro canonical, Canonical and Grand canonical ensembles. Concept of ensemble average, Equation of state, specific heat and entropy of a classical ideal gas using microcanonical ensemble. Entropy of mixing, Gibb's paradox, Sakura Tetrode Equation. Energy and Density fluctuations; Equivalence of various ensembles, Virial and equipartition theorems.
Partition function: Definition and significance. Application to an ideal diatomic gas. Classical harmonic oscillator, magnetic dipoles in a magnetic field.

UNIT.III. Inadequacy of classical theory, Quantum mechanical ensemble theory, density matrix, Ensembles in quantum statistical mechanics.
 Partition functions with examples including: (i) an electron in a magnetic field (ii) Free particle in a box (iii) Linear Harmonic oscillator.
Ensembles of ideal Boltzmann, Bose-Einstein and Fermi gas. Identical particles and symmetry requirement, difficulty with Maxwell-Boltzmann statistics, quantum distribution functions, Bose-Einstein and Fermi-Dirac statistics. Grand partition function for ideal Bose and Fermi gas.

UNIT.IV. Ideal Bose System: Thermodynamic behavior of ideal Bose gas, Bose-Einstein condensation (Experimental evidences), Liquid Helium: two fluid hydrodynamics, Second sound, Theories of Landau and Feynman (qualitative only).
Thermodynamics of Black body radiation – Stephan Boltzmann law, Wein's Displacement Law.
Ideal Fermi System: Thermodynamic behavior of an ideal Fermi Gas, Degenerate Fermi Gas, Pauli Paramagnetism.

UNIT.V. Fluctuations, Gaussian distribution, Brownian motion (Langevin's Theorem). Approach to equilibrium: Fokker -Planck Equation. Fluctuation- dissipation theorem.

Phase Transitions: Phenomenology —First and Second order phase transitions, elementary idea of critical phenomena, Universality of critical exponents, scaling of thermodynamic functions. Elementary ideas of Mean field theories, Exact solutions -- Ising model in 1- dimension.
Text Books:

1. RK Patharia, Statistical Mechanics (2nd Ed) Butterworth Heinman,(Elsevier) 2005

2. K Huang, Statistical Mechanics (2nd ed) John Wiley & Sons, 2002
3. F Reif, Statistical and Thermal Physics, McGraw Hill, 1985
4. B B Laud, Fundamentals of Statistical mechanics, New Age International Publishers, 1998
5. L D Landau & E M Lifshitz, Statistical Physics, Part I & II, Butterworth and Heinman, 1980.

PHY 302: QUANTUM MECHANICS II   Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT.I. **Perturbation Theory**:
Time independent perturbation theory - non-degenerate and degenerate cases, Fine structure and Zeeman effect (without spin), Stark effect, Time dependent perturbation theory - Fermi Golden rule, Harmonic perturbation--Adiabatic and sudden approximations, (Absorption and emission of Radiation – Einstein's A,B coefficients – selection rules).

UNIT.II. **Approximation methods:**
WKB approximation, connection with classical limits, connection formula, validity of WKB approximation, Alpha emission, Variational technique – ground state of hydrogen ion.

UNIT. III. **Scattering Theory:**
Amplitude and cross-section, CM and Laboratory frame, Solution of scattering problem by the method of partial wave analysis, Expansion of a plane wave into a spherical wave and scattering amplitude, Green's function for scattering problem, Green's function with different boundary conditions, the optical theorem. Scattering by an attractive square well potential, Breit-Wigner formula. Born approximation and its validity for scattering problem, Coulomb scattering problem under first order Born approximation in elastic scattering.

UNIT.IV. **Relativistic Quantum Mechanics:**
Attempt for relativistic formulation of Quantum Mechanics, The Klein-Gordon equation, Probability density and probability current density, solution of free particle Klein-Gordon equation in momentum representation, interpretation of negative probability density and negative energy solutions, Dirac equation for a free particle, properties of Dirac matrices and algebra for gamma matrices, Solution of the free particle, orthogonality and completeness relation for Dirac spinors, fine structure of hydrogen atom, Lamb shift, interpretation of negative energy solution and hole theory.

UNIT.V. **Scalar field Theory:**
Concept of systems with infinite degrees of freedom, Classical fields, Equations of motion, Hamiltonian. Symmetries and invariance principles – Noether's Theorem.

Canonical quantization of scalar field—creation, annihilation operators, Commutation relations. Interpretation of the quantized field --- number operator, connection with harmonic oscillator.

Text Books:

1. Quantum Mechanics, Ghatak and Loknathan
2. Quantum Mechanics, Mathews and Venkatesh
3. Quantum Mechanics, Greiner
4. Field Quantization, Greiner
5. Classical Theory of Fileds, Landau Lifshitz

Reference Books:

1. Quantum Mechanics, Sakurai
2. Quantum Mechanics, Schiff
4. Field Theory, Ryder.

PHY 303 (A) (Optional Paper): Basic Astronomy   Marks: 75   Credit:5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. **Time and co-ordinate system:**
Spherical Trigonometry, the celestial sphere; the cardinal points and circles on the celestial sphere. Equatorial. ecliptic and galactic system of co-ordinates.
Constellations and nomenclature of stars. Aspects of sky from different places on the earth. Twilight, Seasons, Sidereal, Apparent and Mean solar time and their relations. Equation of time. Ephemeris and Atomic Times. Calendar. Julian date and heliocentric correction. precession, nutation and proper motion on the coordinates of stars.

UNIT. II. **Astronomical Measurements and Telscopes :**
Magnitude systems: apparent and absolute magnitudes, distance modulus, color index; Atmospheric extinction, *seeing* and scintillation.
Distances of stars from the trigonometric and moving cluster, parallaxes. Stellar motions. Black-body approximation to the continuous radiation and temperatures of stars. Variable stars as distance indicators.
Basic optics and optical telescopes, Detectors and instruments, Radio telescopes, Infrared, ultraviolet and X-ray telescopes, Detectors: photographic plate, PMT, CCD; Analysers: Polarimeter, Photometer and Spectrometer.

UNIT. III. **Solar system:**

Origin and evolution of the Solar System - Physical characteristics, Rotation, Sunspots. Inner planets, Jovian planets, Dwarf planets. Asteroids: classification, origin. Comets: Discovery and designation, physical nature, classification, origin. Meteors and Meteorites.

UNIT. IV. **Stars and Our Galaxy:**
Colour –magnitude relation, H R diagrams, Different spectral types of stars, Star formation in Molecular clouds, Stellar Evolution, End state of stars : Supernova, Neutron star and Black hole:
Our Galaxy: Milky way, structure and morphology of our galaxy, Galactic rotation, Missing Mass problem.

UNIT.V. **External Galaxies and Cosmology:**
Normal Galaxies, AGNs, Classification scheme for external galaxies, Hubble's law, Distances, Big Bang and steady state theory of the origin of universe, The present epoch and evolution of universe, Alternate cosmology

Text Books:

1. Physical Universe, Frank Shu
2. Text book of Spherical Astronomy, W.M.Smart.
3. Astronomy: From the Earth to the Universe(Sixth Edition), Jay M. Pasachoff.
4. Orbital Motion, A.E.Roy.
5. Introduction to Celestial Mechanics, McCusky.
6. Astrophysics:Stars and Galaxies, K.D.Abhyankar, Tata McGraw Hill Publication (Chap.2)
7. Exploration of the Universe, G.Abell.
8. A.Unsold: New Cosmos.
9. Introduction to Astrophysics, B Basu, T chatterjee, S N Biswas.

PHY303 (B) (Optional Paper) : NANOPHYSICS

                         Marks : 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. Fundamentals of nanomaterial and nanotechnology. Importance and Challenges of nanotechnology. Concept of strong and weak quantum confinement. Semiconductor, metal nanomaterials, and their size dependent properties.

UNIT.II. Concept of Top down and bottom up approaches, their advantages and disadvantages. Different synthesis techniques: Lithography, vapour deposition, laser deposition, RF sputtering, Molecular beam epitaxy, sole gel. Chemical and quenching methods of preparation.

UNIT. III. Importance of nano characterizations. Different characterization techniques. UV/VIS/NIR/IR spectroscopy, X-Ray diffraction, Electron microscopy (TEM, SEM, AFM, STM etc), Photoluminescence, Electroluminescence. Particle size analysis and Impedance analysis.

UNIT.IV. Laser (UV/VIS), Swift ion irradiation and their related parameter.s Experimental set up. Effect of irradiations on nano materials. Creations of crystal defects and Improvement in optical, electronic properties of nano materials.

UNIT. V. Applications of nano materials: Light emitting and detecting device. electronic and photonic switch, Tuning device, filter, single electron transistor (SET), photo voltaic cell, second harmonic generator, gas sensor, antibacterial element, drug delivery system.

Text books:

1. S S Nath, Synthesis of semiconductor quantum dots and their applications, LAP LAMBERT Academic Publishing AG & Co. KG, Germany, ISBN: 978-3-8383-6106-2, 2010.
2.V.Rajendran, B.hillebrands,K Saminathan,K.E.Geckeler, Ed., Synthesis and characterization of Nanostructured Materials, MacMillan Publishers, 2010.
3. G. Cao, Nanostructures and Nanomaterials, Imperial College Press, 2004.
4. G. A. Mansori: Principles of Nanotechnology, World Scientific, Chicago, 2005.
5. C. P. Poole,and F. J. Owens, Introduction to Nanotechnology, Wiley Interscience: New Jersey, 2003.

Reference books:

1. Gautam Gope, D Chakder, S S Nath, Preparation of quantum dots and their uses in electronics and optics, VDM Verlag Dr. Muller GmbH & Co. KG, Germany. ,ISBN: 978-3-639-20197-0, 2010.
2. K. Klabunde, Nanoscale Materials in Chemistry, Wiley Interscience: New York, 2001.
3.V. Rotello (Ed.): Nanoparticles: Building Blocks for Nanotechnology, Nanostructure Science and Technology, Kluwer Academic/Plenum Publishers, New York, 2004.
4. P.M.Ajayan, L.S.Schadler,P.V.Braun, Nanocomposite science and technology, Wlley-VCH, 2003.

304 (A): ASTROPHYSICS I   Marks : 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. **Celestial co-ordinate system and observational techniques**:
Celestial sphere-Sidereal and solar time, Equation of time-different co-ordinate system, determination of luminosity-Black body radiations-luminosity and magnitude of star-relations with mass, radius,-colour index-distance determination by parallax and other methods.

UNIT. II. **Telescopes and Instrumentations**:
Different optical configuration for astronomical telescope plate scale and diffraction limits-telescopes for Y-ray, X-ray UV, IR mm and radio astronomy- photometry with photometers and CCD- spectrometry and polarimetry with various instruments.

UNIT. III. **Stellar structure and Evolution Part-I**:
Spectral classification of stars- Saha's equation-CNO- cycles –HR Diagram-description of radiation fields opacities-radiative transfer- structure of spectral line-hydrostatic equilibrium equation of state-main sequence.
Formation of stars in Molecular clouds: Jeans mass and Instability conditions, Role of rotation and Magnetic field

UNIT. IV. **Stallar structure of Evolution Part-II**:
Evolution of main sequence-late stages-supernovae degenerate remnants: white dwarf Chandrasekhar limit-Neutron star- pulsars Black Holes.
Binary stars- different types of binaries- WD binaries- neutron star and black hole binaries.

UNIT. V. **Sun and Solar system**:
Physical characteristics of sun-rotation, magnetic field, granulation, sunspots, other chromospheric activities.
Primordial Solar Nebula-Origin and evolution of solar system- planets, comets, asteroids and other minor bodies-formation of comets-Oort cloud planetary dust and gas.

Text Books:

1.Astrophysics, K.S Krishnaswamy , CUP.
2.Astrophysics, Baidyanath Basu, Prentical Hall.
3.Astrophysics, KD Abhankar, Orient Longman.
4.Electronic Imaging in Astronomy, Mclean, Willey.
5.Text Book on Astronomy and Astrophysics with elements of cosmology, V.B.Bhatia, Narosa.
6.

Reference Books:

1. Observational, Astrophysics-Smith, CUP.
2. Physical Universe, F Shu, CUP.
3. Astrophysical Quantities, Allen, Willey.
4. Astrophysical Quantities, KR Lang, Springer Verlag.

PHY 304 (B): CONDENSED MATTER PHYSICS I　　　　Marks: 75　　　　Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. **Elastic Constants and Elastic Waves:**
Analysis of elastic Stress, Analysis of elastic strain, Elastic compliance and Stiffness constants, stiffness constants for cubic crystals, Elastic energy density, Elastic waves in cubic crystals, waves in (100), (110), (111) directions, Experimental determination of elastic constants.

UNIT.II**. Thermal properties of Solids:**
Lattice heat capacity, Classical theory, Einstein's theory, Debye's theory, Born's modification, Heat capacity of diatomic lattices, Lattice thermal conductivity, Phonon mean free path, phonon-phonon scattering-Umklapp processes, Anharmonic crystal interactions, Gruneisen relation, Thermal expansion.

UNIT. III. **Free Electron Theory of Metals:**
Drude-Lorentz free electron theory, Electrical conductivity, Thermal conductivity, Wiedmann –Franz ratio, Sommerfield quantum theory, Free electron gas in three dimensions, Density of electron states, Fermi dirac statistics and distribution function, Effect of temperature on FD function, Electronic specific heat, Failure of free electron model.

UNIT.IV. **Crystal Imperfections:**
Imperfections in Crystals, Equilibrium concentration of point defects, Colour centres and coloration of crystals, Dislocations, Edge and Screw dislocations, Burger's vector, Dislocation energy, Dislocation densities, Dislocation and Crystal Growth, Diffusion in solids, diffusion constant, self-diffusion, Fick's law.

UNIT.V. **Liquid Crystals and Nano Science:**
Elementary concepts of liquid crystals, thermotropic and lyotropic, nematics and semantics, applications, Nano materials, elementary properties of nano materials and applications, bottom up approaches, top-down approaches, tools for measuring nanostrcutures, tools to make nanostructures.

Text Books:

1. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Harcourt Asia, 2001.
2Quantum theory of solids, C. Kittel, Academic.
1. Introduction to Solid State Physics, Charles Kittel, 7th ed. Wiley.
2. Solid State Physics, M. S. Rogalski and Stuart B. Palmer, Gordon and Breach, 2001.
3. Solid State Physics, M. A. Wahab, Narosa, 2006.
4. Solid State Physics, H.Ibachs & H. Luths, Springer, 1996.
5. Elementary electronic structure, W.A.Harrison, World Scientific, 2004.

PHY 304 (C): ADVANCED QUANTUM FIELD THEORY I

Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. Review of relativistic quantum mechanics – Klein Gordon equation, Dirac equation, antiparticles, Dirac spinors, algebra of γ-matrices, bilinear covariants, Maxwell's equations, gauge transformations.

Lagrangian formulation – action functional, Euler-Lagrange's equation, variational principle and Noether's theorem, Hamilton's formalism, Poisson's bracket.

UNIT.II. Canonical quantization of real and complex scalar fields, Fourier decomposition, creation and annihilation operators, normal ordering, Green's function.

Quantisation of the Dirac field, Dirac propagator. Quantisation of the electromagnetic field, Coulomb and Lorentz gauges, photon propagator.

UNIT.III. S-matrix expansion, Wick's theorem, matrix element, fermion scattering, Feynman diagrams and Feynman rules.

Decay rate, decay of a scalar into a fermion – antifermion pair, μ-decay into e^-, $\bar{\nu}_e$, ν_μ.

Scattering cross-section and kinematics, laboratory and centre of mass frames, Mandelstam variables.

UNIT.IV. Parity, charge conjugation and time reversal for free scalar, Dirac & electromagnetic fields and for interacting fields. CP transformation and CPT theorem. Invariance principles and weak interactions.

UNIT.V. Symmetry groups, examples of continuous symmetry groups – U(1), SU(2), SU(3), etc, generators of continuous groups and representations.

Spontaneous symmetry breaking – discrete symmetry, U(1) and non-abelian symmetries, Goldstone theorem and Goldstone boson, Higgs mechanism.

Text Books:

1. Quantum Mechanics, L I Schiff, McGraw Hill
2. Advanced Quantum Mechanics, J J Sakurai, Pearson Education, 2001
3. Quantum Field Theory, L H Ryder, Academic Publisher
4. A First Book on Quantum Field Theory, A Lahiri and P B Pal, Narosa, 2007
5. Field Quantisation, W Greiner and Reinhardt, Springer
6. Relativistic Quantum Mechanics, J D Bjorken and S D Drell, McGraw Hill
7. Relativistic Quantum Fields, J D Bjorken and S D Drell, McGraw Hill
8. Quarks and Leptons, F Halzen and A D Martin, John Wiley and Sons
9. Introduction to Quantum Electrodynamics and Particle Physics, D C Joshi, I K International Publishing House Pvt Ltd, 2007
10. Introduction to High Energy Physics, D H Perkins, Addison-Wesley
11. Gauge Theory of Elementary Particle Physics, T P Cheng and L F Li, Oxford University Press, 1988
12. The Quantum Theory of Fields, Vol I, II, Steven Weinberg, Cambridge University Press, 1995

PHY 304 (D): NON-LINEAR OPTICS AND LASER SPECTROSCOPY I

Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. Introduction to Non-linear optics: non-linear response, graphical representation, experimental observation of optical non-linear phenomenon - Frenken's expt. Non-linear susceptibility and properties. Maxwell equations for non–linear optics, an-harmonic oscillator and free electron gas model (illustration of non-linearity). General description of wave propagation in non-linear medium, Coupled wave equations, Manley-Rowe relations.

UNIT.II. Quantum theory of non-linear susceptibility : Schrödinger wave equations; perturbation theory. Calculation of probability amplitude. Derivation of first, second and third order susceptibilities.
Two level approximation - density matrix equations, optical Bloch equations, Rabi solution of Schrödinger equations - atom initially in ground state.

UNIT.III. Second order non-linear processes: second harmonic generation; generation by focused Gaussian beams. Sum and difference frequency generation, phase matching consideration; Sum frequency generation, difference frequency generation, optical rectification and field induced magnetisation.

Parametric Amplification & Oscillations - single & doubly resonant, frequency tuning.

UNIT.IV. Third order non-linear processes: Self-Phase modulation, temporal solition, Cross phase modulation, Self-focussing, Four wave mixing, Optical phase conjugation, optical bistability and switching.

UNIT.V. Electro-optic and magneto-optic effect: Electro-optic effects, idea of electro-optic modulators, magneto-optic effect and modulator. Introduction to Photorefractive effect, Kukhtarev et al equations. Acousto-optic effect, Raman-Nath diffraction and acoustic-optic modulator.

Text Books:

1. Principles of Non-linear optics, Y.R. Shen
2. Non-linear optics, N. Bloembergen, World scientific publishing co.
3. Non-linear optical spectroscopy, S. Mukamel, OUP
4. Non-linear optics, R. W. Boyd, Elsevier.
5. Laser Spectroscopy, W. Demtrider, Springer.
6. Essentials of laser and Non-linear Optics, G.D Baruah, Pragati Prakashan.
7. Non-Linear Optics and Laser, B B Laud

PHY 305 (A): Laboratory on Astrophysics I   Marks: 75   Credit: 5

1. Calibration of plate scale of a given astronomical telescope
2. Determination of diameter of moon by transit
3. Determination of diameter of sun by transit
4. Calibration of a photometer for astronomical measurement
5. Determination of the width of lunar craters and Maria
6. Recording of the number of sunspots and study of its variation
7. Determination of the time period and angular velocity of spin motion of sun (from Sun spot studies)
8. Determination of photospheric temperature of sun from Planck's law
9. Determination of solar constants
10. Determination of intensity of solar Fraunhoffer lines
11. Determination of orbital periods of satellite of Jupiter
12. Determination of angular diameter of Saturn Ring
13. Application of Image Processing Software(IRAF/Epoch 2002) to determine magnitudes of different stars in a star field.
14. Application of image processing software(IRAF/Epoch 2002) to determine angular separations of different stars in a star field.

NB: This list is tentative, subject to the availability of equipments and other relevant considerations.

Phy 305 (B): LABORATORY ON CONDENSED MATTER PHYSICS I

Marks: 75   Credit: 5

1. Study of temperature dependence of Hall Effect.

2. Study of Magnetic Hysteresis Loop.

3. Study of Magnetoresistance of a semiconductor.

4. Determination Lande g factor by Electron Spin Resonance Spectrometer.

5. Study of variation of resistivity of a large sample and a thin slice using high precision low current source, microvoltmeter, four probe arrangement and PID controlled oven.

6. Determination of ionic susceptibility of a given solution and magnetic moment of the ion in terms of Bohr Magnetron.

7. Study of dispersion curve for mono-atomic lattice and di-atomic lattice by Lattice Dynamic Kit.

8. Determination of Dielectric Constant using LCR meter.

9. Determination of Currie Temperature of a ferroelectric material.

10. Determination of Curie Temperature of a ferromagnetic material.

NB: This list is tentative, subject to the availability of equipments and other relevant considerations.

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SEMESTER -IV

PHY 401: ATOMIC AND LASER PHYSICS   Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. Review of atomic models and concepts, Hydrogen spectrum from the Bohr and Bohr-Sommerfeld theories, Variation of the Rydberg constant, Unquantized states and

continuous spectra, Larmor's precession, Space quantization, Electron spin, Stern-Gerlach experiment, Vector atom model.

UNIT.II. Hydrogen fine structure, Relativistic correction, Spin-Orbit interaction, Lamb shift, Hyperfine structure, Zeeman and Back-Goudsmit effects in hyperfine structure, Breadth of spectral lines.

UNIT. III. LS and JJ coupling schemes, Derivation of spectral terms under these schemes, Lande Interval rule, Normal and inverted multiplets, Spectra of alkali and alkaline earth elements, Selection and intensity rules, Oscillator strength.

UNIT.IV. Hartree's SCF method, X-ray spectra, Zeeman effect (normal and anomalous), Lande g-formula, Paschen-Back effect, Stark effect.

UNIT.V. **Lasers:** Einstein's coefficients, Requisites for producing laser light, Laser rate equations, Optical resonators, He-Ne laser, Solid state laser, Gas lasers, Free electron laser, Semi conductor lasers, Laser applications.

Text Books:

1. Introduction to Atomic Spectra, H. E. White, McGraw-Hill Book Company.
2. Physics of atoms and Molecules, B H Bransden and C J Joachain, Pearson Education
3. Concept of Modern Physics, A. Beiser, McGraw-Hill Science
4. Spectroscopy Volume I, B.P. Straughan and S. Walker, John Wiley & Sons, Inc., New York.
5. Lasers: Theory and Application, K. Thyagarajan and A. K. Ghatak, Plenum Press, New York and London.

Reference Books:

1. Atomic Spectra by H. G. Kuhn,
2. Atomic Spectra and Atomic Structure by G. Herzberg.
3. Principles of Lasers by O. Svelto,

PHY 402: NUCLEAR AND PARTICLE PHYSICS

Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT.I. Evidence for saturation property, exchange character spin dependence, charge dependence and charge symmetry of Nuclear force. Isospin formalism, Central and tensor forces. General form of nucleon-nucleon force.
Dipole and quadrupole moment of the deuteron. S and D states.

UNIT.II. Shell Model: Single particle model with square well, harmonic oscillator and spin-orbit potentials, Collective model, Nilsson model.

Nuclear reaction & decay : Direct and compound reactions. Reaction cross-section and resonance. electromagnetic decays, selection rule. Fermi's theory of β-decay, Kurie plot, parity violation, Wu's experiment, 2-component theory of neutrinos, neutrino helicity, concepts of neutrino mass and oscillation (solar and atmospheric neutrino problems), Majorana neutrino.

UNIT.III. Scattering cross-section and kinematics (relativistic quantum mechanical treatment to be introduced), Rutherford and Mott cross-sections, nuclear form factors, electron-proton scattering, electromagnetic form factors, deep inelastic scattering, structure functions, Bjorken scaling.

UNIT.IV. Dynamical quark structure of hadrons, valence and sea quarks, quark momentum distribution, gluon distribution, strong coupling constant, asymptotic freedom, scaling violation of structure functions.

Charged leptons and neutrinos, violation of quantum numbers in weak interactions (hadronic decays, semi-leptonic and leptonic processes) and electromagnetic interactions, $W^{\pm}$ and Z^0 bosons, charged current (e.g. muon decay) and neutral current processes. Overview of the Standard Model.

UNIT.V. Synchrotron. Modern colliders : LHC and RHIC. Germanium and silicon solid state detectors. Scintillation and Cerencov counters. Hybrid detectors.

Data acquisition technique. Single channel and multi channel analysers.

Text Books:

1. Nuclear Physics, R R Roy and B P Nigam, New Age International.
2. Nuclear Physics, Experimental and Theoretical, H S Hans.
3. Concepts of Nuclear Physics, B L Cohen, Tata McGraw Hill.
4. Introduction to High Energy Physics, P H Perkins, Addison-Wesley.
5. Quarks and Leptons, F Halzen and A D Martin, John Wiley and Sons.
6. Nuclear Physics, S N Ghosal, S Chand and Company.
7. Nuclear Physics, D C Tayal.
8. Particles and Nuclei, B Povh, K Rith, C Scholz and F Zetsche, Springer.
9. Introduction to Nuclear and Particle Physics, A Das and T Ferbel, World Scientific.
10. Nuclear Physics, Principles and Application, John Lilley.

PHY 403: MOLECULAR SPECTROSCOPY

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. **Molecular Formation and Structure:** Nature of bonding in Molecules, Molecular orbital and valence bond theories, LCAO treatment of H2+ & H2 molecules, Bonding and anti-bonding orbitals, Bond order, Correlation diagram, Molecular orbital picture of some homo and heteronuclear diatomic molecules.

UNIT.II. **Spectra:** Born-Oppenheimer approximation, Origin of molecular spectra, Fluorescence and phosphorescence, Rotational Spectral (Rigid and non-rigid rotator approximations), Rotational spectra of Polyatomic molecules, Isotopic effect on rotational spectra.

UNIT. III. **IR Spectroscopy:** Vibrational spectra (Harmonic and anharmonic approximations), Isotopic effect, Rotational-Vibrational spectra, Raman spectroscopy.

UNIT. IV**. UV Spectroscopy:** Electronic spectra in emission and absorption, Vibrational and rotational structures of electronic bands, Frank-Condon Principle and its applications, Isotopic effect on electronic spectra, Molecular electronic states.

UNIT. V. **Electronic structure methods:** Hartree-Fock (HF) method, Electron correlation, Post HF methods (concepts), Density functional theory (DFT), Hohenburg-Kohn theorem, Kohn-Sham idea, Elementary idea of density functionals.

Text Books:

1. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachain, Pearson Education
2. Fundamentals of Molecular Spectroscopy, C N Banwell, Tata McGraw Hill.
3. Spectroscopy Volumes II&III, B. P. Straughan and S. Walker, John Wiley & Sons, Inc., New York.
4. Valence, C A Culson, Oxford University Press.
5. Quantum Chemistry, I N Levine, Prentice Hall

Reference Books:

1. Molecular Structure and Molecular Spectra (Vol. - 1,2,3) by G. Herzberg.
2. High Resolution Spectroscopy by J.M. Hollas.
3. Density functional theory of atoms and molecules by Robert G Parr and Weitau Yang.

PHY 404 (A): ASTROPHYSICS II Marks : 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. **Star High Energy Radiative Processes in Astronomy:**
Synchrotron emission for a single particle and an ensemble of particles – Energy loss and electron scattering-Compton scattering-Bremstrahlung radiation.

UNIT. II. Star formation in ISM, clusters, variable and binary stars, Interstellar medium(ISM)-various nebula-Jeans condition for collapse-Protostars –star formation.
Stellar Clusters : open and Globular- IMF.
Variable stars-period luminosity relations and distance determination Binary stars-types of binaries.

UNIT. III. **Galaxies:** The Milky way Galaxy- kinematics- Hubbles classification scheme for external galaxies- spirals and ellipticals –irregulars-Normal galaxies and AGNs-Quasi-stellar objects-Unified Model-Gamma Ray burst.

UNIT. IV. **General Theory of Relativity:**
Principle of Equivalence- Gravity and Geometry. Metric Tensor and its properties-curved space time-tensor calculus –co-variant differentiation-parallel transport- Bianchi Identities -particle trajectories in Gravitational field- Einstein's field Equations- - Schwa child metric.

UNIT. V. **Large scale Structure and Cosmology:**
Hubble's law- angular size- friedmann Robertson-Walker Model, cosmological constants-the early universe- thermodynamics of early universe- nucleo-synthesis-Microwave Background radiation- elementary ideas on structure formations- age of universe. Big Bang and Steady State Theory.

Text Books:

1. Astrophysics, K S Krishnaswamy, CUP.
2. Astrophysics, Baidyanath Basu, Prentice Hall.
3. Astrophysics, K D Abhaynakar, Orient Longman.
4. Electronic Imaging Astronomy, Melean, Wiley.
5. The classical theory of Fields Vol-2, Landau and Lifshitz, Butterworth Heinemann
6. Introduction to cosmology, J V Narlikar, CUP.
7. General relativity and cosmology, J V Narlikar, Mcmmillan.
8.Text Book on Astrono and Astrophysics with Elements of cosmology, V B Bhatia, Narosa.

Reference Books:

1.Observational Astrophysics, Smith, CUP.
2. Physical Universe, F Shu, OUP.
3.Astrophysical quantities, Allen, Willey.
4. Astrophysical quantities, K R Lang, Springer Verlag.

404 (B): CONDENSED MATTER PHYSICS II

Marks : 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT. I. Transport Properties:
Boltzmann Transport equation, Electrical conductivity, Thermal conductivity of metals, Variation of Electrical and thermal conductivity with temperature, Thermoelectric Power, Wiedmann –Franz law, Hall effect, Free electron in a magnetic field, Magnetoresistance, Viscosity from Boltzmann equation,

UNIT.II. Band Theory of Solids:
Electronic Energy bands in solid, Tight-binding method, Applications to simple cubic crystals, Basics of Density Functional Theory (DFT), Hohenberg Kohn theorem, Kohn Sham method, Exchange correlation, Plane wave method, Augmented Plane Wave (APW) methods, Orthogonalized Plane Wave (OPW) method.

UNIT. III. Dielectrics:
Polarization of Dielectrics, Dielectric Relaxation, Debye's theory of dielectric relaxation, Cole-Cole plot, Onsager-Kirkwood theory, Ferroelectricity, polarization catastrophe in ferroelectric crystal, Theory of ferroelectricity, ferroelectric crystal types, Barium Titanate.

UNIT. IV. Magnetism:
Classifications of Magnetic materials, Diamagnetism and Paramagnetism, Classical and Quantum Theory of Diamagnetism, Origin of permanent magnetic moment in Paramagnetism, Langevin Theory and Quantum Theory of Paramagnetism, Paramagnetic Cooling.

UNIT.V. Magnetic Relaxation and Magnetic resonance:
Basic theory, Spin-Spin and Spin-Lattice relaxation processes, Bloch equations and Susceptibilities, Line width, Motional Narrowing, Nuclear Magnetic Resonance (NMR): Basic principle and experimental method, Electron Spin Resonance (ESR): Basic principle and experimental method, Ferromagnetic and Cyclotron resonance.

Text Books:

1. Basic Notions of condensed Matter Physics, Anderson, Narosa Publishing House.
2. The theory of super conductivity, Schrieffer, Narosa Publishing House.

3. Vacumm Technology Thin Film & Sputtering an introduction, Stuart, Kluwer Academic press, 1989.

Reference Books:

1.Solid State Physics, N.W. Ashcroft & N.D. Mermin, Harcourt Asia, 2001.
2.Quantum theory of solids, C. Kittel, Academic.
3.Introduction to Solid State Physics, Charles Kittel, 7th ed. Wiley.
4.Solid Sate Physics, M. S. Rogalski and Stuart B. Palmer, Gordon and Breach, 2001.
5.Solid State Physics, M. A. Wahab, Narosa, 2006.
6.Solid State Physics, H.Ibachs & H. Luths, Springer, 1996.
7.Elementary electronic structure, W.A.Harrison, World Scientific, 2004.

PHY 404 (C): ADVANCED QUANTUM FIELD THEORY II

Marks : 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT.I. The photon propagator, local gauge invariance, Coulomb scattering of electrons, Mott cross section.
The electromagnetic vertex and form factors, physical interpretation of form factors, electron – proton scattering.

UNIT.II. Compton scattering – Klein-Nishina formula, $e^- e^+$ pair annihilation into γ-rays, $e^- e^+$ scattering, ultraviolet divergences, vacuum polarization, self-energy of the electron Lamb shift.

UNIT.III. Yang-Mills theory of non-abelian gauge fields, equations of motion and conserved currents, quantization of non-abelian gauge fields, QCD.

UNIT.IV. Deep inelastic scattering, Bjorken scaling and parton model, scaling violation, QCD improved parton model, DGLAP equations, solution of DGLAP equation for non-singlet case. Idea of colour confinement.

UNIT.V. Divergences, dimensional regularization, counter terms, renormalization, renormalization group.
Divergences and dimensional regularization in QED, running coupling constant, asymptotic behavior, renormalisability of QED.

Text Books:

1.Quantum Mechanics, L I Schiff, McGraw Hill
2.Advanced Quantum Mechanics, J J Sakurai, Pearson Education, 2001
3.Quantum Field Theory, L H Ryder, Academic Publisher
4.A First Book on Quantum Field Theory, A Lahiri and P B Pal, Narosa, 2007
5.Field Quantisation, W Greiner and Reinhardt, Springer
6.Relativistic Quantum Mechanics, J D Bjorken and S D Drell, McGraw Hill
7.Relativistic Quantum Fields, J D Bjorken and S D Drell, McGraw Hill
8.Quarks and Leptons, F Halzen and A D Martin, John Wiley and Sons
9.Introduction to Quantum Electrodynamics and Particle Physics, D C Joshi, I K International Publishing House Pvt Ltd, 2007
10.Introduction to High Energy Physics, D H Perkins, Addison-Wesley
11.Gauge Theory of Elementary Particle Physics, T P Cheng and L F Li, Oxford University Press, 1988
12.The Quantum Theory of Fields, Vol I, II, Steven Weinberg, Cambridge University Press, 1995

PHY 404 (D): NON-LINEAR OPTICS AND LASER SPECTROSCOPY II

Marks: 75   Credit: 5

(All units carry Equal Marks. Two questions of equal marks are to be set from each unit. Students require to answer at least one question from each unit.)

UNIT.I. Stimulated scattering processes: Spontaneous and stimulated scattering, Stimulated Brillouin Scattering, General theory of stimulated Brillouin and Rayleigh scattering, Stimulated Raman scattering, Quantum theory, coupled wave description of SRS. Stokes-anti stokes coupling, Inverse Raman effect. Four wave mixing and Coherent Anti-stokes Raman scattering (CARS). Basic principal of non-linear Raman Spectroscopy. SRS and CARS as techniques of non-linear Raman Spectroscopy.

UNIT.II. High resolution non-linear optical spectroscopy (theory and applications): non-linear absorption, saturation of inhomogeneous line profiles, saturation spectroscopy - lamb dip, hole burning, quantum beats. Two photon and multi photon absorption – theory; multiphoton ionization, optical damage. Two photon Doppler free absorption spectroscopy.

UNIT.III. Rate equations and lasing criteria, laser gain, line width, threshold for lasing, calculation of threshold gain.
Rate equation analysis for 3- and 4- level systems, gain, saturation, pump power and efficiency.

UNIT.IV. Resonating cavity, gain and loss in cavity, longitudinal modes, Characterisation of resonator, properties of Gaussian beam, single and multimode oscillation, resonator stability, common cavity configuration. Spatial energy distribution: transverse modes.

Concepts of Q-switching, techniques and mode locking, generation of pulsed laser.

UNIT.V. Ultrashort pulse propagation equations, interpretations, intense field non-linear optics-generation of 3rd and high harmonics.

Laser radiation force, applications – optical levitation, scattering of atomic beams, optical cooling and ion trapping.

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Text Books:

1. Principles of Non-linear optics, Y.R. Shen
2. Non-linear optics, N. Bloembergen, World scientific publishing co.
3. Non-linear optical spectroscopy, S. Mukamel, OUP
4. Non-linear optics, R. W. Boyd, Elsevier.
5. Laser Spectroscopy, W. Demtrider, Springer.
6. Essentials of laser and Non-linear Optics, G.D Baruah, Pragati Prakashan.
7. Non-Linear Optics and Laser, B B Laud

PHY 405 (A) : PROJECT – 100 MARKS (15 CONTACT HOURS PER WEEK)

PHY 405 (B) : PROJECT – 100 MARKS (15 CONTACT HOURS PER WEEK)