SIDHO-KANHO-BIRSHA UNIVERSITY
DEPARTMENT OF PHYSICS

CBCS Syllabus for two years M.Sc. Course in Physics
2023

POST GRADUATE PROGRAM IN PHYSICS

Post Graduate program is the gateway to enormous possible entries to research. This program is also structured in that direction.

Program objective:

- Emphasize comprehensive understanding of the fundamental principles and concepts of physics.
- From third semester onward, more & more advanced and special topics are introduced, which have vast area of applications in basic research as well as industry.
- Enhance the ability and confidence of the students to perform in various competitive exams for higher studies.
- Provide a glimpse of research experience.
- Make students aware of their responsibilities to the society in scientific perspective.

Program outcome:

- During the course students would learn to apply the acquired knowledge and concepts in practical problems.
- Experiments in the special topics will provide hand on experiences on advance instruments, cutting edge technology and special techniques. These would develop analytical skills to work in the experimental areas of R&D sector.
- Occasionally arranged lectures on contemporary research topics by various experts would motivate students for higher studies.
- Computational skills acquired would be of immense use while working with theoretical areas of physics as well as experimental physics.
- Students would be geared towards various competitive exams including UGC-CSIR NET/GATE/SET/JEST for future research or professional career.
- The outreach program would improve their communication skills.
- Participation in Project work during the course would develop scientific temper, independent thinking, writing skills, communication skills within the students.

M.Sc. (Physics) Course Structure

Semester	Course	Course Title	Lecture Hrs./Week	Tutorial Hrs./Week	Practical Hrs./Week	Credit	Total Marks
I	MPHYCCT 101	Mathematical Physics	3	1	0	4	50
	MPHYCCT 102	Classical & Relativistic Mechanics	3	1	0	4	50
	MPHYCCT 103	Quantum Mechanics I	3	1	0	4	50
	MPHYCCT 104	Electronics & Instrumentation	3	1	0	4	50
	MPHYCCS 105	Physics Practical I	0	0	8	4	50
	MPHYCCS 106	Physics Practical II	0	0	8	4	50
II	MPHYCCT 201	Classical and Applied Electrodynamics	3	1	0	4	50
	MPHYCCT 202	Quantum Mechanics II	3	1	0	4	50
	MPHYCCT 203	Atomic, Molecular & Optical Physics	3	1	0	4	50
	MPHYCCT 204	Solid State Physics	3	1	0	4	50
	MPHYCCS 205	Physics Practical III	0	0	8	4	50
	MPHYCCS 206	Physics Practical IV	0	0	8	4	50
III	MPHYCCT 301	Nuclear & Particle Physics	3	1	0	4	50
	MPHYCCT 302	Statistical Mechanics	3	1	0	4	50
	MPHYMET 303	Elective I[a]	3	1	0	4	50
	MPHYMES 304	Advanced Experiments	0	0	8	4	50
	MPHYOET 305	Open Elective Course[b]	4	0	0	4	50
	MPHYOPT 306	Outreach Program	4	0	0	4	50
IV	MPHYCCT 401	Numerical Methods & Computational Physics	4	0	0	4	50
	MPHYCCT 402	Relativity, Cosmology, and Astrophysics	3	1	0	4	50
	MPHYMET 403	Elective II[c]	3	1	0	4	50
	MPHYMEP 404	Add-On Course: Fundamentals and Applications of Computer Systems	2/4	0	4/0	4	50
	MPHYCCS 405	Computer Practical	0	0	8	4	50
	MPHYACT 406	Project/Term Paper and Grand Viva	4	0	0	4	50
Grand Total						96	1200

- [a]**Elective – I:** Advanced Electronics I/ Photonics I/ Condensed Matter Physics/ Quantum Field Theory
- [b]**Open Elective Course:** Nature of the Universe/ Concepts of Physics: Inventions and Applications
- [c]**Elective – II:** Advanced Electronics II/ Photonics II/ Nano Science and Technology/ High Energy Physics

FIRST SEMESTER

MPHYCCT 101 - Mathematical Methods

Course requirement:

- Students interact with several mathematical techniques in all branches of physics. The idea is to develop the mathematical basis from the very beginning.
- This course is offered with an aim to strengthen the ability to understand the mathematical treatment of physical problems to be encountered during the entire course.

Syllabus:

Complex analysis

Cauchy-Riemann equations, Analytic and harmonic function. Cauchy's theorem and its converse, Cauchy's Integral Formula and its corollaries; Taylor and Laurent series expansion; Classification of singularities; Branch point and branch cut; Residue theorem and its applications.

Differential Equations

Ordinary second order linear homogeneous differential equation: Singular points; Frobenius method; Fuch's theorem; Linear independence of solutions - Wronskian, Second solution. Basic properties of Legendre, Bessel, Laguerre and Hermite functions.

Inhomogeneous Differential Equations

Green's function and its applications.

Integral Transform

Fourier and Laplace transforms and their inverse transforms, Bromwich integral; Transform of derivative and integral of a function; Solution of differential equations using integral transforms.

Linear Algebra

Linear independence, Gram Schmidt orthogonalisation. Matrices and their types: representation of linear transformations and change of base, Eigenvalues and eigenvectors; Functions of a matrix, Cayley-Hamilton theorem.

Tensor Analysis

Coordinate transformations, scalars, Covariant and Contravariant tensors. Addition, Subtraction, Outer product, Inner product and Contraction. Symmetric and antisymmetric tensors. Quotient law. Metric tensor. Conjugate tensor. Length and angle between vectors. Associated tensors. Raising and lowering of indices. The Christoffel symbols and their transformation laws. Covariant derivative of tensors.

Group Theory

Concept of a group, Definition and examples, Multiplication table and rearrangement theorem, Isomorphism and homomorphism, Direct product of groups, Distinct groups of a given order, Representations of a group – faithful, unfaithful, equivalent, reducible and irreducible representations. Lie groups and Lie algebra with SU(2) and O(3) as example.

Course outcome:

- The knowledge gathered (viz. complex analysis, differential equations, integral transform, linear algebra) during this course would have direct applications in other branches of physics, especially in quantum mechanics, electrodynamics, solid state physics.
- Introduction of Tensor analysis will be effectively helpful while studying general theory of relativity, advanced quantum mechanics as well as advanced electrodynamics.
- The concept of Group Theory will be of immense use in studying various symmetry properties in high energy physics, quantum mechanics as well as condensed matter physics.

Books Recommended:

(1) K.F. Riley, M.P. Hobson, S.J. Bence: Mathematical Methods for Physics and Engineering (Cambridge)
(2) Tulsi Dass and S.K. Sharma: Mathematical Methods In Classical & Quantum Physics(University Press)
(3) G.B. Arfken, H.J. Weber and F.E. Harris: Mathematical Methods for Physicists (Elsevier)
(4) M. R. Spiegel: Complex Variables (Tata McGraw-Hill)
(5) S.L. Ross: Differential Equations (Wiley)
(6) A.W. Joshi: Matrices and Tensors in Physics (New Age)
(7) A.W. Joshi: Elements of Group Theory for Physicists (New Age)

MPHYCCT 102 -Classical & Relativistic Mechanics

Course requirement:

- Study of Physics may be approached in two ways: Macroscopic and Microscopic and the laws of Physics are not very identical in these two cases. It is absolutely essential to have a clear concept of classical mechanics before studying the physics behind a microscopic world.
- This course is offered with an aim to generate the concept of motion of macroscopic object prior to or simultaneously with the introduction of quantum aspect of nature. This would help in connecting the two different approaches.

Syllabus:

Review of Lagrangian and Hamiltonian formalisms

Systems with constraints and Lagrange's undetermined multiplier. Small oscillations and Normal modes. Hamilton's function and Hamilton's equations of motion. Principle of least action. Hamilton's principle.

Canonical transformations

Conditions for transformation to be canonical. Lagrange and Poisson brackets as canonical invariants. Equations of motion in Poisson bracket notation. Infinitesimal contact transformation. Constants of the motion. Symmetry properties. Poisson bracket relations. Liouville's theorem.

Hamilton-Jacobi theory

The Hamilton Jacobi equation for Hamilton's principle function. The harmonic oscillator problem.

Rigid bodies

Independent coordinates. Orthogonal transformations and rotations (finite and infinitesimal). Euler's theorem, Euler angles. Inertia tensor and principal axis system. Euler's equations. Heavy symmetrical top with precession and nutation.

Review of special theory of relativity

Poincare and Minkowski's 4- dimensional formulation; Geometrical representation of Lorentz transformations in Minkowski's space; Length contraction; Time dilation; Causality; Time-like and space-like vectors; 4-vectors; Relativistic Energy and Momentum; Lorentz transformations of four vectors; Relativistic dynamics and kinematics; Lagrangian and Hamiltonian of a relativistic particle.

Relativistic electrodynamics

Relativistic Formulation of Maxwell's Equations; Electromagnetic field tensor, covariance of Maxwell's equations; Maxwell's equations as equations of motion; Lorentz transformation law for the electromagnetic fields; Lorentz Force Equation and Its Generalization; Lagrangian and Equation of Motion

Course outcome:

- Apart from describing the system classically, the Lagrangian and Hamiltonian approaches will be useful in describing a microscopic system too.
- The concept of Hamilton- Jacobi theory will raise the idea of transition of a system from classical to quantum mechanics.
- The concept of point masses as a whole will be generated by studying the dynamics of a rigid body.
- In addition to classical mechanics, the relativistic mechanics will be helpful in studying Special as well as general theory of relativity.
- Dynamical systems would bring the concept of stability of a physical system, linear and non-linear aspects of a system.

Books Recommended:

(1) H. Goldstein: Classical mechanics(Narosa)

(2) N.C. Rana and P.S. Joag: Classical Mechanics (Mcgraw Hill Education)

(3) S.N. Biswas: Classical Mechanics (Books & Allied)

(4) R. G. Takwale and P. S. Puranik: Introduction to Classical Mechanics (Mcgraw Hill Education)

(5) D. Morin: Introductory Classical Mechanics with Problems and Solutions (Cambridge)
(6) S. Banerji and A. Banerjee: The Special Theory of Relativity (PHI)
(7) R. Hagedorn: Relativistic Kinematics (W.A. Benjamin, Inc.)
(8) L. Meirovitch: Methods of Analytical Dynamics (Dover)

MPHYCCT 103 -Quantum Mechanics I

Course requirement:

- This course is dedicated to have a concept of dynamics and structure (microscopic world) in atomic or sub atomic scale.
- In order to understand several atomic, nuclear phenomena with special kind of explanation or justification, few quantum mechanical phenomena such as tunnel effect, stark effect etc. will be introduced.

Syllabus:

Vector spaces in quantum mechanics

Hilbert space. Kets, bras and operators, Base bras, kets and matrix representation. Hermitian operator (definition and properties). Eigenkets as base kets. Orthogonality. Completeness. Postulates of quantum mechanics. Observable and results of its measurement. The generalized uncertainty relation. Non-commutating observables. Complete set of commuting observables. Change of basis. Unitary operators Discrete and continuous bases. Coordinate and momentum representations. Linear harmonic oscillator by operator method. Coherent states.

Quantum dynamics

Schrödinger, Heisenberg - interaction pictures and equations of motion. Schrödinger equation – coordinate and momentum representation. Evolution operator.

Schroedinger equation and its applications

The interpretation of the wavefunction. Stationary states.

(a) One dimentional problems: The delta-function potential and the Kronig Penney model.

(b) Three dimensional problems: The rigid rotator. The spherical well with impenetrable walls. Spherical square well potential. The harmonic oscillator with Heisenberg's equation of motion.

Approximation methods

Time-independent perturbation theory for non-degenerate and degenerate states. Applications to anharmonic oscillator, Stark effect in hydrogen atom, Landau levels. Variational methods for ground and excited states. Application to the ground state of helium atom. WKB approximation, tunnelling, qualitative discussion of alpha decay.

Identical particles

Symmetry under interchange. Wave functions for bosons and fermions. Slater determinant. Time-dependent perturbation theory Constant and harmonic perturbations. Perturbation coupling two discrete states. Fermi's golden rule. Sudden and adiabatic approximations. Interaction of an atom with electromagnetic wave. Electric dipole radiation.

Generalised angular momentum

Infinitesimal rotation. Generator of rotation. Commutation rules. Matrix representation of angular momentum operators. Spin. Pauli spin matrices. Eigenspinors. Electron in static magnetic field. Larmor precession. Electron in an oscillating magnetic field. Addition of two angular momenta. Simple examples. Clebsch-Gordan co-efficients. Recursion relations.

Course outcome:

- During this course several basic principles, laws and rules will be taught and these would give the idea to understand the behaviour of matter and energy at the sub atomic scale.
- Apart from obtaining proper knowledge about various quantum states and wave functions, students would learn how implement the Schrödinger equation to find out the allowed and forbidden energy level of particles for different kind of potentials.
- Some advanced topics in this course would help the students in understanding several atomic, nuclear phenomena.

Books Recommended:

(1) R. Shankar: Principles of Quantum Mechanics (Springer)
(2) N. Zettili: Quantum Mechanics (Wiley)
(3) R.L. Liboff: Introductory Quantum Mechanics (Pearson)
(4) B.H. Bransden and C.J. Joachain: Quantum Mechanics (Pearson)
(5) J.J. Sakurai: Modern Quantum Mechanics (Pearson)
(6) L.I. Schiff: Quantum Mechanics (Mcgraw-Hill)
(7) C. Cohen-Tannoudji, B. Diu, F. Laloe: Quantum Mechanics Vol I and II (Wiley)
(8) A.K. Saxena: Textbook of Quantum Mechanics (CBS Publishers)

MPHYCCT 104 – Electronics & Instrumentation

Course requirement:

- Electronics plays an inseparable part of modern age. A sound grasp of the concepts of electronics is therefore essential for physicists and learners at post graduate level.
- This course is designed in a fashion that would introduce digital and communication technology based on semiconductor devices.

Syllabus:

Physics of Semiconductor Devices

Intrinsic and extrinsic semiconductor, energy band diagram, carrier concentration in both cases. p-n junction physics, Thermal equilibrium condition, Depletion capacitance, Current-voltage characteristics, Charge storage and transient behaviour; Metal semiconductor junction (Schottky barriers). Characteristics of some semiconductor devices: Photodiode, LED, Solar cell, Tunnel diode, Gunn diode, transistor, operation, characteristics & applications of Field-effect transistor, MOSFET and Bipolar junction.

L-C Filters

LPF, HPF, BPF and BRF type constant-k prototype filters. m-derived filters (principle only). Attenuators. T-type, Pi-type, Bridged-T type lattice attenuators.

High Frequency Transmission Line

Distributed parameters. Primary and secondary line constants; Telegraphers' equation. Reflection co-efficient and VSWR. Input impedance of loss-less line. Distortionless line.

Communications

Comparison among different modulation techniques. Generation of transmitted carrier and suppressed carrier type AM signals. Principles of FM and PM signal generation. Principles of detection of different types of modulated signals (TC and SC types). Modulation techniques in some practical communication systems. VSB modulation. Pulse modulation, Pulse code modulation and quantization error.

Op-Amp Circuits

Characteristics of ideal and practical op-amp. Nonlinear amplifiers using op-amps. Log amplifier, anti-log amplifier, regenerative comparators. Active filters. ADC and DAC circuits. Op-amp based self-oscillator circuits. RC phase shift, Wien bridge, Non-sinusoidal oscillators.

Digital Circuits

Logic functions. Logic simplification using Karnaugh maps. SOP and POS design of logic circuits. MUX - DEMUX as universal building block. RS, JK and MS-JK flip-flops. Registers and counters.

Multivibrators

Timer (IC-555): Internal Structure (Block Diagram), Operation, Astable, Monostable, and Applications.

Course outcome:

- An overview of electronics will facilitate the students to comprehend the key concepts and apply these concepts in problem solving. Introduction to this coursework will help enthusiasts in choosing it as a career also.

- Primarily this course will give a thorough knowledge about semiconductor, its properties and how it has been used in designing several electronic devices.
- Students would come across various electronics circuits (mainly, digital circuits) and their applications, based on Op- Amp and ICs. This knowledge would be directly implemented during the experimental course work.

Books Recommended:

1. S.M. Zee and K.K. Ng: Physics of Semiconductor Devices (Wiley)
2. T.L. Floyd: Electronic Devices (Prentice Hall)
3. R.L. Boylestad and L. Nashelski: Electronic Devices and Circuit Theory (Pearson)
4. M.E. Van Valkenburg: Network Analysis (Pearson)
5. J. Kennedy: Electronic Communication Systems.
6. D. Roddy and J. Coolen: Electronic Communications.
7. R. Gaykwad: Operational Amplifier.
8. H. Taub and D. Schilling: Digital Integrated Electronics (McGraw Hill Education)
9. R.P. Jain: Modern Digital Electronics (Tata McGraw Hill)

MPHYCCS 105 – Physics Practical I

Course requirement:

- This course is a collection of experiments that demonstrate an extensive range of physical concepts and processes. These motivational experiments would sharpen the capability of observation, stimulate questions and help in developing new understanding and terminology.

Syllabus:

1. Verification of Bohr's atomic theory (discreteness of the atomic orbital) of Ar atom by Franck Hertz Experiment.
2. Determination of the Lande g factor for the DPPH sample using the Electron Spin Resonance (ESR) setup.
3. Study of temperature dependence of resistivity for a given semiconductor using Four Probe setup and determine its energy band gap.
4. Determination of Hall Coefficient of a given semiconductor sample using variable DC magnetic field.
5. Study the I-V characteristics of light emitting diodes (LEDs) and hence determine the Planck's constant along with finding the ac resistances of the LEDs (using at least four different LEDs).
6. Determination of Planck's constant by Photoelectric effect.
7. Using a radioactive source and a Geiger-Müller (GM) counter (i) determine the relative efficiency of the GM counter as a function of source-to-detector distance, and (ii) perform analysis of statistical fluctuations at low count rates.
8. Determination of (i) wavelength of He-Ne laser light, (ii) the refractive index of a given transparent thin film, and (iii) refractive index of air at different pressures using Michelson's Interferometer.
9. Experiments using Jamin's interferometer.

Course outcome:

- Selected experiments of physics will enhance knowledge, and assist in learning and clarification and consolidation of theory.
- Students would become familiarised with various instruments utilised for experiments in physics, and would learn to properly operate and handle them.
- During laboratory experimental classes students would be motivated towards using personal computer facility for data analysis and plotting of graphs related to the data.

MPHYCCS 106 – Physics Practical II

Course requirement:

- This course is a collection of experiments that demonstrate an extensive range of physical concepts and processes. These motivational experiments would sharpen the capability of observation, stimulate questions and help in developing new understanding and terminology.

Syllabus:

1. Study the characteristics of a light dependent resistance (LDR)
2. Design and study of CC amplifier.
3. Study of OPAMP (IC 741) characteristics and its use as an inverting amplifier, non-inverting amplifier, adder and differential amplifier.
4. Study of the different gate characteristics using IC and discrete components.
5. Design and study of logarithmic and antilogarithmic amplifier.
6. Transistor based monostable, as table multi-vibrator circuits.
7. Half and full wave rectifier circuit.
8. Clippers and clampers circuits.
9. Design and study of current mirror biasing.

Course outcome:

- Selected experiments of physics will enhance knowledge, and assist in learning and clarification and consolidation of theory.
- Students would become familiarised with various instruments utilised for experiments in physics, and would learn to properly operate and handle them.
- During laboratory experimental classes students would be motivated towards using personal computer facility for data analysis and plotting of graphs related to the data.

SECOND SEMESTER

MPHYCCT 201 –Classical and Applied Electrodynamics

Course requirement:

- Electrodynamics is one among the core areas of physics. Therefore, a physics student must have proper knowledge about it to understand the electromagnetic responses of nature.

Syllabus:

Electromagnetic theory

Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance, Lorentz invariance of Maxwell's equation. Electromagnetic waves in free space. Poynting's theorem. Dynamics of charged particles in static and uniform electromagnetic fields, Transmission Lines, Waveguides, TE and TM modes.

Solution of Inhomogenous wave equation

Vector and scalar potential, Green's function, retarded solution.

Radiation from moving point charges

Lienard- Wiechert potentials; Fields due to a charge moving with uniform velocity; Dipole antenna; Fields due to an accelerated charge; Radiation at low & high velocity; Larmor's formula and its relativistic generalisation; Radiation when velocity (relativistic) and acceleration are parallel, Bremsstrahlung; Radiation when velocity and acceleration are perpendicular, Synchrotron radiation; angular distribution of radiated power. Radiation from an oscillating dipole, radiation from a linear antenna.

Radiation in material media

Cherenkov effect (qualitative treatment only), Scattering from a free electron, Thomson and Rayleigh Scattering, dispersion and absorption, Kramer Kronig dispersion relation.

Plasma Physics

Quasineutrality of a Plasma. Plasma production, Debye screening length, Charged particles in homogeneous and inhomogeneous magnetic fields. Adiabatic invariance of flux through an orbit. Magnetic mirror. Plasma as a conducting fluid. Short wavelength limit. Plasma oscillations, Propagation of electromagnetic wave in plasma.

Course outcome:

- Students would encounter field theory for the first time while studying classical electrodynamics.

- This course will provide a unique understanding of origin of electric and magnetic fields as well as their unification.
- Students would gain a sound knowledge about electromagnetic radiation and its features.
- The preliminary concepts of plasma physics would introduce the students to relatively new domain of research in physics.

Books Recommended:

(1) D. J. Griffiths: Introduction to Electrodynamics.
(2) W. K. H. Panofsky and M. Phillips: Classical Electricity and Magnetism.
(3) J. D. Jackson: Classical Electrodynamics.
(4) M. A. Heald and J.B. Marion: Classical Electromagnetic radiation.
(5) Satya Prakash: Electromagnetic Theory and Electrodynamics.
(6) Y. K. Lim: Problems and Solutions on Electromagnetism.
(7) F. F. Chen: Introduction to Plasma Physics and Controlled Fusion.
(8) J. A. Bittencourt: Fundamentals of Plasma Physics.

MPHYCCT 202 – Quantum Mechanics II

Course requirement:

- This advanced course will cover quantum mechanics with applications drawn from new age physics.
- Topics covered in this course include the advanced theories of quantum mechanics which are applicable in advanced research area including material science and high energy physics.

Syllabus:

0.1 Discrete and continuous space-time symmetries

Invariance principles and conservation laws. Space translation. Time translation. Space rotation. Irreducible spherical tensor operators. Wigner- Eckert theorem (no proof) and applications. Space inversion. Time reversal. Kramers degeneracy.

Time-dependent perturbation theory

Constant and harmonic perturbations. Perturbation coupling two discrete states. Fermi's golden rule. Sudden and adiabatic approximations. Interaction of an atom with electromagnetic wave. Electric dipole radiation.

Scattering theory

Scattering amplitude. Differential and total cross sections. Integral equation for potential scattering. Green's function. Born approximation, its validity and some applications (square well potential, Yukawa potential). Method of partial waves. Phase shifts. Optical theorem. Scattering by hard sphere. Coulomb Scattering - Rutherford formula, Scattering with WKB.

Relativistic quantum mechanics

The Klein-Gordon equation. Covariant notation. Probability density. Negative energy solution. The Dirac equation. Properties of the Dirac matrices. A spin zero particle in EM field, The Dirac particle in an electromagnetic field. The magnetic moment of the electron.

Covariant form of the Dirac equation

Lorentz covariance. Rotation, parity and time reversal operations on the Dirac wave function. Conjugate Dirac spinor and its Lorentz transformation. The $\Gamma 5$ matrix and its properties. Bilinear covariants and their transformation under parity and infinitesimal Lorentz transformation.

Plane wave solutions

Plane wave solutions of the Dirac equation and their properties Energy and projection operators. Dirac's hole theory. Charge conjugation. Feynman- Stuckelberg interpretation of negative energy states and the concept of antiparticles.

Non-relativistic limit of the Dirac equation

Large and small components. Spin- orbit interaction from Dirac equation. Electron in a central electrostatic potential. Hyperfine structure of hydrogenic atoms.

Course outcome:

- Apart from enhancing knowledge about quantum world this would motivate the post graduate level students to the cutting edge research in physics.
- Students would learn about space- time symmetries, time dependent perturbation theory, scattering theory and their applications.
- Relativistic cases, Dirac equation, concept of particle and its antiparticle etc. would motivate post graduate students for further study of field theory, particle physics research.

Books Recommended (including books from Quantum Mechanics I course):

(1) E. Merzbacher: Quantum Mechanics.
(2) F. Schwabl: Advanced Quantum Mechanics.
(3) Y.V. Nazarov: Advanced Quantum Mechanics.
(4) R. Dick: Advanced Quantum Mechanics – Materials and Photons.
(5) J.J. Sakurai: Advanced Quantum Mechanics.
(6) A.K. Ghatak and S. Lokenathan: Quantum Mechanics.
(7) Satya Prakash: Advanced Quantum Mechanics.

MPHYCCT 203 -Atomic, Molecular and Optical Physics

Course requirement:

- This course is focused on imparting knowledge of the concepts of the properties, dynamics and interactions of the basic building blocks of matter i.e. in the atomic or molecular scale.

- The optical physics section will give idea about the generation and behaviour of electromagnetic radiation.

Syllabus:

Atomic Spectra

Quantum states of one electron atoms. Spin-orbit interaction and fine structure. Relativistic correction to spectra of hydrogen atom. Lamb shift. Lande g factor. Normal and anomalous Zeeman effect, Paschen- Back & Stark effects.

Two electron systems. Singlet and triplet states. Helium spectra, Alkali spectra. Interaction energy in L- S and j- j coupling. Hyperfine structure and Isotopic Shift of monovalent atoms. Line broadening mechanisms. Electron spin resonance. Nuclear magnetic resonance. Chemical shift.

Molecular Spectra

Concept of molecular potential. Born-Oppenheimer approximation.Types of molecules - Diatomic linear symmetric top, asymmetric top and spherical top molecules. Rotational spectra of diatomic molecules as a rigid rotor. Energy levels and spectra of non-rigid rotor. Intensity of rotational lines.

Vibrational energy of diatomic molecules. Diatomic molecule as a simple harmonic oscillator. Energy levels and spectra. Morse potential energy curve. Molecules as vibrating rotator. Vibrating spectrum of diatomic molecule. P-, Q- and R- branches.

Transition matrix elements, Vibration-rotation spectra. Electronic transitions, Selection rules, Franck- Condon principle, Fortrat diagram, Band head, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra of diatomic molecules.

Lasers

Emission broadening, Absorption and Gain. Homogeneous broadening, Doppler broadening, Threshold requirements, Population rate equations. Population inversion. Creation of population inversion in 3 level and 4 level lasers. Pumping requirements. Laser cavity modes, Fabry Perot resonator, Laser cavity modes and its properties, Q switching, Mode-Locking, Modes of resonators and coherence length, Ruby Laser, He-Ne Laser, Gas Laser. CO_2 laser. Solid State Laser. Nd: YAG laser. Liquid laser. Dye laser. Semiconductor junction laser, Fiber Laser.

Nonlinear Optics

Origin of nonlinearity. Nonlinear optical materials. Nonlinear polarization. Nonlinear susceptibilities. Self-focussing. Self-phase modulation. Cross-phase modulation. Second harmonic generation. Phase matching. Three-wave mixing. Parametric amplification and oscillation.

Course outcome:

- The theoretical and experimental (LASER) components of this group would give the general idea about dynamics of electron - atom or electron- molecule systems.

- This course would also motivate students to pursue research careers especially in material sciences and associated fields.

Books Recommended:

(1) B.H Bransden and C.J. Joachain: Physics of Atoms and Molecules (Pearson).
(2) R. Kakkar: Atomic and Molecular Spectroscopy (Cambridge University Press).
(3) S.N. Thakur and D.K. Roy: Atom, Laser and Spectroscopy (PHI).
(4) G. Aruldhas: Molecular Structure and Spectroscopy (PHI).
(5) O. Svelto: Principles of Lasers (Springer).
(6) K. Thyagarajan and A.K. Ghatak: Lasers - Fundamentals and Applications (Springer).
(7) B.B. Laud: Lasers and Non-linear Optics.
(8) D. Mills: Nonlinear Optics.

MPHYCCT 204 – Solid State Physics

Course requirement:

- The world has witnessed a revolution in material sciences and technology in the last century. In order to understand and appreciate these developments, a basic idea of different materials, their structures & properties is absolutely essential. Hence, solid state physics has been included at introductory level to cultivate a sound knowledge base for postgraduate learners during their course and further research related to material sciences.

Syllabus:

Crystal Structure and Diffraction from Periodic Structure

Reviews of fundamental ideas, Crystal class, Symmetry operations and classification of 2- and 3-dimensional Bravais lattices; Point group and Space group (information only); Common crystal structures; Reciprocal lattice and Brillouin zone; Bragg- Laue formulation of X-ray diffraction by a crystal; Ewald construction; Atomic and crystal structure factors; Experimental methods of X-ray diffraction: Laue, Rotating Crystal, and Powder diffraction methods; Electron and Neutron diffraction by crystals (qualitative discussion only).

Lattice Dynamics and Specific Heat

Classical theory of lattice vibration under harmonic approximation; Vibrations of linear monatomic and diatomic lattices, acoustical and optical modes, long wavelength limits; Optical properties of ionic crystals in infrared region (one-dimensional model); Adiabatic approximation (qualitative discussion); Normal modes and phonon lattice heat capacity, models of Debye and Einstein, comparison with electronic heat capacity; Anharmonic effects in crystals - thermal expansion and thermal conductivity.

Band Theory of Solids

Energy bands in solids; Periodic potential and Bloch's theorem; Kronig- Penney model; Brillouin zones; Number of states in the band; Band gap in the nearly free electron model; Tight binding method; Electron dynamics in an electric field; Effective mass of an electron in a band; Concept of holes; Energy band in one dimension - reduced zone scheme; Classification of metal, semiconductor and insulator; Limitations of band theory: metal- insulator transitions.

Magnetic Properties of Solids

Fundamental concepts; Quantum theory of paramagnetisn, Spin paramagnetism – Pauli theory; Ferromagnetism: Curie-Weiss law, Temperature dependence of saturated magnetization, Heisenberg's exchange interaction, Ferromagnetic domains; Ferrimagnetism and antiferromagnetism; Spin Waves; Magnetic resonance phenomena.

Superconductivity

Phenomenological description of superconductivity – occurrence of superconductivity, critical temperature, destruction of superconductivity by magnetic field, Meissner effect; Type-I and type-II superconductors; Heat capacity, energy gap and isotope effect; London equations, London penetration depth; Outlines of the BCS theory; Josephson effect (qualitative), High temperature superconductors (qualitative).

Defects in Solids and Optical Properties

Frenkel and Schottky defects; Defects in growth in crystals, Colour centers and luminescence; Alloys – order-disorder phenomena, Bragg- Williams theory.

Course outcome:

- A thorough understanding of solid state physics will help in developing the concepts of new materials compatible with modern technology.
- This vibrant branch of physics will open up new arenas of professional and academic career of the students.

Books Recommended:

(1) F.C.Phillips: An Introduction to Crystallography
(2) N. Ashcroft and N. Mermin: Solid State Physics
(3) M. Ali Omar: Elementary Solid State Physics
(4) C. Kittel: Introduction to Solid State Physics
(5) J. Christmaan: Fundamental of Solid State Physics
(6) A.J. Dekker: Solid State Physics
(7) J.P. Srivastava: Elements of Solid State Physics
(8) S.P. Kuila: Essentials of Solid State Physics
(9) Rajnikant: Applied Solid State Physics

MPHYCCS 205 – Physics Practical III

Course requirement:

- This course is a collection of experiments that demonstrate an extensive range of physical concepts and processes. These motivational experiments would sharpen the capability of observation, stimulate questions and help in developing new understanding and Terminology.

Syllabus:

1. Using a radioactive source and a Geiger-Müller (GM) counter (i) determine the plateau and optimal operating voltage of the GM counter, and (ii) perform analysis of statistical fluctuations at high count rates.
2. Study of alpha scattering from metal targets and verification of the Rutherford scattering formula and identification of the target element.
3. Experiment with Laser.
4. Experiment with Optical Fibre.
5. Experiments using Fabry- Perot Interferometer.
6. Determination of refractive index of solid.
7. Characteristic study of Diode laser.
8. Determination of the particle size of a material (supplied).
9. Determination of diameter of a wire.

Course outcome:

- Selected experiments of physics will enhance knowledge, and assist in learning and clarification and consolidation of theory.

MPHYCCS 206 – Physics Practical IV

Course requirement:

- This course is a collection of experiments that demonstrate an extensive range of physical concepts and processes. These motivational experiments would sharpen the capability of observation, stimulate questions and help in developing new understanding and Terminology.

Course outcome:

- Selected experiments of physics will enhance knowledge, assist in learning and clarification and consolidation of theory.

THIRD SEMESTER

MPHYCCT 301 -Nuclear and Particle Physics

Course requirement:

- Nuclear & Particle Physics during post graduate course involve advanced study of matter at the atomic and sub-atomic levels, including analysis of the structure and behaviour of nuclei within atoms.
- The high energy particle physics would deal with the fundamental constituents of the Universe.

Syllabus:

General properties and Structure of nuclei

Nuclear size, shape and charge distribution, spin, parity and symmetry. Electron scattering and Form factors, Charge and Matter radius, Magnetic dipole moment, Electric quadrupole moment and nuclear shape, Anomalous magnetic moments of nucleons and qualitative discussions about their origin.
Binding energy, Semi-empirical mass formula and its applications, Liquid drop model, Fermi gas model, Bohr-Wheeler theory of fission. Evidence of shell structure, Single-particle shell model, its validity and limitations. Collective model: Vibrational and Rotational spectra (qualitative discussion).

Nuclear Interactions and Nuclear Reactions

Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron. Spin, isospin dependence and the necessity of tensor forces. Two nucleon scattering, Partial wave analysis, Effective range theory. Nature of nuclear forces: charge symmetry, charge independence, exchange properties, velocity dependence. Isospin formalism. Meson theory of nuclear forces.
Reaction mechanisms: Compound- nucleus formation, Direct-interaction, Cross-sections in terms of partial wave amplitudes –Scattering and reaction cross-sections. Compound nucleus, Scattering matrix, Reciprocity theorem. Resonance scattering and reactions.
Special nuclear reactions: Neutron induced fission, fusion, Heavy ion reactions, Photon-nuclear reactions.

Nuclear decay

Gamow's theory of alpha decay and Geiger- Nuttal law. Qualitative discussion about Nuclear Transition Matrix Element and Estimates of Transition rates. Fermi's theory of beta decay, Selection rules, Parity violation, Neutrino detection. Gamma-decay, Multipole transitions, Selection rules. Experimental method for determination of half-life, Estimation of half-life from theory and systematics.

Elementary particle physics

Classification of fundamental forces - typical strengths and time scales. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.).

Symmetry, Conservation laws and their applications to particle reactions. Relativistic kinematics. C, P, and T invariance. Quark model: Color charge and strong interactions, confinement. Gell-Mann-Okubo mass formula for octet and decouplet hadrons.

Course outcome:

- This course gives a holistic view of nuclear & particle physics and develops proper knowledge about our Universe.
- Students would learn about the structure of nuclei and its properties.
- They would have proper idea about nuclear reactions and interactions.
- The idea of four fundamental forces and their interaction will be introduced.
- The knowledge and skills obtained during this course are suitable for a wide range of professional careers, including that of an academic researcher.

Books Recommended:

(1) K.S. Krane: Introductory Nuclear Physics (Wiley)
(2) S.S.M. Wong: Introductory Nuclear Physics (PHI)
(3) B.R. Martin: Nuclear and Particle Physics – An Introduction (Wiley)
(4) M. Thompson: Modern Particle Physics (Cambridge University Press)
(5) R. Prasad: Nuclear Physics (Pearson)
(6) J. Varma, R.C. Bhandari, D.R.S. Somayajulu: Fundamentals of Nuclear Physics (CBS Publishers)
(7) S.N. Ghosal: Nuclear Physics (S. Chand)
(8) D.J. Griffiths: Introduction to Elementary Particles (Wiley)
(9) W. D. Ehmann, D. E. Vance. Radiochemistry and Nuclear methods of Analysis (John Wiley and Sons)

MPHYCCT 302– Statistical Mechanics

Course requirement:

- Statistical mechanics plays a vital role in describing a physical system with large number of degrees of freedom. The primary idea is to familiarize the students with various statistical methods and probability theory.

Syllabus:

Introduction

Objective of statistical mechanics. Transition from thermodynamics to statistical mechanics. Reviews of the ideas of macrostates, microstates, phase space and ensembles. Ergodic hypothesis, postulate of equal a priori probability and equality of ensemble average and time average. Boltzmann's postulate of entropy. Entropy of ideal gas: Sackur-Tetrode equation and Gibbs' paradox. Liouville's Theorem, Stationary ensembles.

Micro-canonical and canonical ensembles

Micro-canonical ensembles; System in contact with heat reservoir in canonical ensemble, canonical partition function, Helmholtz free energy, Equilibrium properties of ideal systems: Ideal gas, Harmonic Oscillators; Concept of negative temperature, Fluctuation of internal energy.

Grand Canonical Ensemble

System in contact with a particle reservoir, chemical potential, grand canonical partition function and grand potential, fluctuation of particle number; Chemical potential of ideal gas.

Quantum statistical mechanics

Density Matrix; Quantum Liouville theorem; Statistical and quantum mechanical approach, pure and mixed states, Density matrix for stationary ensembles. Simple examples of density matrices - one electron in a magnetic field, a free particle in a box, density matrix for a beam of spin 1/2 particles.

Systems of indistinguishable particles

B-E and F-D distributions; Ideal Bose and Fermi gas; Statistics of occupation number, general equation of state; Bose-Einstein condensation, Fermi gas at finite temperature, theory of white dwarf stars , Saha ionization.

Strongly interacting systems

Ising model; Idea of exchange interaction and Heisenberg Hamiltonian; Ising Hamiltonian as a truncated Heisenberg Hamiltonian.;Exact solution of one-dimensional Ising system (Matrix method); Bragg- William's approximation (Mean field theory) and the Bethe-Peierls approximation.

Phase transition

General remarks; Critical relations and scaling relations; Landau's order parameter theory of phase transition; Calculation of exponents from mean field theory and Landau's theory.

Irreversible Thermodynamics

Thermodynamic fluctuations, Flux and affinity, Spatial correlations in a fluid, Brownian motion.

Course outcome:

- Students would come across the idea of various ensemble systems, distribution statistics, phase transition during this course.
- The concept of indistinguishable particle will be introduced in statistical approach.
- Students would learn about strongly interacting system and its characteristics during this course.
- The knowledge gathered in this section would assist in understanding the probabilistic concept of quantum mechanics, condensed matter physics etc.

Books Recommended:

(1) F. Reif: Fundamental of Statistical and Thermal Physics.

(2) R. Pathria and P. Beal: Statistical Mechanics.

(3) R. Kubo: Statistical Mechanics.

(4) K. Huang: Introduction to Statistical Mechanics.

(5) S. Bowley: Introductory Statistical Mechanics.
(6) S. Salinas: Introduction to Statistical Mechanics.
(7) F. Mandl: Statistical Physics.
(8) H.E. Stanley: Introduction to Phase Transitions and Critical Phenomena.
(9) J.M. Yeomans: Statistical Mechanics of Phase Transitions.
(10) L.D. Landau and E. M. Lifshitz: Statistical Physics.

MPHYMET 303– Elective I

Course requirement:

- Students can choose one among these subjects or units based on their interests or based on topics that would help them in building their research or professional career in future.

Unit A: Advanced Electronics I

Syllabus:

Review of Field-effect transistor

FET, MOSFET, MISFET: Design, characteristics and operations, calculations of mobility.

IC Technology

Hybrid and monolithic IC. Semiconductor processing: Diffusion, implantation, Oxidation, Epitaxy, lithography. Si IC technology: MOS and Bipolar. Packaging and testing.

Analog Integrated Circuits

Differential amplifier, OP-AMP comparator. Continuous time filters. Switched capacitance implementation of sample data filters. Analog multiplexers. PLL and frequency synthesizer.

Digital Integrated Circuits

Logic families – TTL, ECL, MOS, MESFET. Design of combinational and sequential circuits – MUX, decoder/ encoder, registers, counters, gate arrays. Programmable logic devices – PAL, GAL, PLA. Programmable gate arrays.

Linear modulation, Exponential modulation

FM and PM; AM and FM modulators and demodulators.

Pulse Modulation and Demodulation Techniques

Sampling the rein PAM, PWM, PPM, Pulse code modulation – coding technique. Modulation and demodulation.

Digital Modulation Techniques

Principles of ASK, FSK, PSK, DPSK, QPSK, MSK. Modulators and demodulators.

Effect of Noise on Communication System

Characteristics of additive noise; Performance of AM, FM and PCM receivers in the face of noise. Multi-path effect.

Optical Communication

Types of optical fibres, numerical aperture and pulse broadening, propagation of EM waves in planar optical wave guide, V-parameter, power associated with modes, Multiplier and demultiplexer, Fibre optic communications, direct and coherent detections, signal-to-noise ratio. LIDAR and submarine communication (idea only).

Books Recommended:

(1) Geiger, Allen and Strader: VLI – Design Techniques for Analog and Digital Circuits.

(2) Gray and Meyer: Analysis and Design of Analog Integrated Circuits.

(3) A. Carlson: Communication Systems.

(4) S. Haykin: Communication Systems.

(5) D. Roddy and J. Coolen: Electronic Communications.

Unit B. Photonics I

Syllabus

Coherence of light

Mutual coherence function. Complex degree of coherence. Quasi-monochromatic fields and visibility. Spatial coherence of ordinary and laser light. Photon statistics. Poissonian photon statistics. Classification of light by photon statistics. Photon statistics of thermal and laser sources. Brown- Twiss correlations. Photon bunching and antibunching.

Interferometry & Holography

Fabry-Perot interferometer, Mach-Zehnder interferometer, Basic holography equations; Use of coherent light in holography recording ; Advantages of holographic recording over photo graphic recording; Recording and reconstruction processes.

Polarization

Zones Calculus, Mueller Calculus, Poincare sphere.

Optical/Optoelectronic Sources

Direct band gap semiconductors for optical/optoelectronic sources ; Principle of operation of LED and Semiconductor junction Laser diode ; Internal and External quantum efficiencies of LED, DHLED; Different types of quantum and other efficiencies of Semiconductor junction Laser diode, Equations relating the light intensity of LED and Semiconductor

Laser with applied current; Quantum well laser, Principle of operation of quantum well Laser; Quantum dot.

Optical/optoelectronic detectors

Vacuum photodiodes and photomultipliers; PN junction detectors and its disadvantages; PiN detectors and its principle of operation ; Quantum efficiency of PiN detectors ; Avalanche photo detector(APD); Equations relating the applied light intensity with received photo current of a PiN detector and also that of a Avalanche photo detector; Dark current of a photo detector; Shot noise of PiN detector; Signal to noise ratio of a photo detector; Photo conductor and its function; Photo transistor and its principle of operation.

Optical modulators

Optical Q- Switching, Different processes of Q-Switching, Optical Mode locking; Pockels effect and Kerr effect; Electro-optic modulation by pockels materials; Phase modulation and Amplitude modulations in Electro-optic modulators; Modulation of light using optical Kerr effect ; Self focusing, self defocussing ; All- optical switches using Kerr effect , Optical Faraday effect.

Books Recommended:

(1) John Gower: Optical communication systems.
(2) Franz and Jain: Optical Communication Systems.
(3) Gerd Keiser: Optical Fiber Communication.
(4) John M. Senior: Optical Fiber Communications.
(5) Selvarajan and Kar: Optical Fiber Communications.
(6) Ghatak and Thyagrajan: Introduction to Fiber Optics.
(7) Wilson and Hawkes: Optoelectronics.
(8) Keneth E Jones: Introduction to Optical Electronics.
(9) Djafer K Mynbaev and Lowell L Scheiner: Fiber Optic Communication Technology.
(10)Ralf Menzel: Photonics Linear And Nonlinear Interactions Of Laser Light And Matter.
(11) B. E. A. Saleh M. C. Teich: Fundamentals of Photonics .

Unit C: Condensed Matter Physics I

Syllabus:

Many Body Techniques

The basic Hamiltonian; Jelium Mode; Hatree and Hatree-Fock equation; Interacting electron gas; Hatree-Fock approximations for the electron gas; Excahnge hole and exchange energy; Static screening; Thomas Fermi approximation; Plasma Oscillations; Bohm Pines theory – Random Phase Approximation, plasma oscillations, dielectric function of an electron gas; Linhard dielectric function.

Electric and Magnetic Transport Properties of Solids

Boltzmann transport equation and its linearization; The relaxation time approximation; Variational method for the solution of the linearized Boltzmann equation; Ideal resistance in metals - Mattheissen's rule; Transport coefficients of metals and semiconductors in presence of magnetic field; Limitations of the Boltzmann transport equation; Kubo formula for electrical conductivity.

Optical Properties of Solids

The dielectric function – the dielectric function for a harmonic oscillator, dielectric losses of electrons, Kramers-Kronig relations; Interaction of phonons and electrons with photons; Interband transition – direct and indirect transition; Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect.

Magnetic Properties of Solids

Spin Waves: Magnons; Magnetism of free electron gas: Ahronov-Bohm effect; Origin of ferromagnetism: Hitler-London calculation; Ferromagnetism in transition metal: Stoner model; Kondo effect: Scaling theory, Order-disorder transition in alloys and spin glasses; Quantum Hall effect (qualitative).

Energy Bands

Different methods of calculation of energy bands in solids – Nearly free electron model, Tight binding approximation, Orthogonalised plane wave (OPW) method and Pseudopotential methods; Phillops-Kleiman's cancellation: Qualitative discussions of band structures of semiconductor, semi-metal and insulator, Dynamics of an electron in a crystal, Effective mass tensor.

Crystal Physics

Crystal structure determination
X-ray scattering by atoms: atomic scattering factor; X-ray diffraction by ideal crystal: Crystal structure factor; Crystal structure analysis: Fourier synthesis and Patterson function; Experimental method: Powder method; Indexing procedure for known and unknown crystal systems; Analysis crystallite size and residual stress.
Imperfections in crystals
Different types of imperfections; Point imperfections: Schottky defects, Frenkel defects, Diffusion, Colour centers, F-centers, excitons; Line imperfections (mainly dislocations): Edge dislocations, Screw dislocations, Stress field of dislocations; Planer imperfections: Grain boundaries; Alloys –order-disorder phenomena, shape memory alloys.

Books Recommended:

1. N.W. Ashcroft and N.D. Mermin – Solid State Physics.
2. C. Kittel – Introduction to Solid State Physics.
3. J.M. Ziman – Principles of the Theory of Solids.
4. O. Madelung – Introduction of Solid State Theory.
5. M. Sachs – Solid State Theory.
6. A. L. Fetter and J.D. Walecka – Quantum Theory of Many Particle Systems.
7. S. Raimes – Many Electron Theory.
8. N.H. March and M. Parrinello – Collective Effects in Solids and Liquids.
9. C. Kittel – Quantum Theory of Solids.
10. D. Pines – Elementary excitations in solids.

11. M. Tinkham – Introduction to Superconductivity.

Unit D: Quantum Field Theory

Syllabus:

Introduction to fields:
Lagrangian and Hamiltonian formulation of continuous systems, introduction to relativistic field theories, Noether's theorem, Four-vector notations, Lorentz transformations, natural units.
Many particle systems:
Non-relativistic quantum systems, free fields, Klein-Gordon equation, nonrelativistic many particle systems, relativistic free scalar fields, Dirac equation, antiparticles, free Dirac fields.
Field quantization:
Action principle, quantization of scalar fields, quantization of Dirac fields, quantization of vector fields, Lorentz transformation and invariance, parity, charge conjugation and time reversal, CPT theorem.
Interactions among fields:
Interactive pictures, S-matrix, Wick's theorem, second-order processes, position space Feynman rules, momentum space Feynman rules; cross-sections. Classical electromagnetic fields Quantization of electro-magnetic fields, Electron-electron scattering, Compton scattering, vacuum polarization, electron self-energy, zero temperature Fermi and Bose systems.
Path Integral Formalism
Hamiltonian path integrals, Scalar field theories, Dyson-Schwinger equation, Femion systems.
Gauge theories
Path integral formalism and Maxwell fields, Yang-Mills fields, path integral and Feynman rules, renormalization of QED, non-Abelian gauge theories, gauge field self-energy, spontaneous breaking of symmetry, Higgs mechanism; renormalization group.

Books Recommended:

1. Advanced Quantum Mechanics, J J Sakurai, Pearson Education, 2001
2. Quantum Field Theory, L H Ryder, Academic Publisher
3. A First Book on Quantum Field Theory, A Lahiri and P B Pal, Narosa, 2007
4. Quantum Field Theory - Claude Itzyksen and Jean-Bernard Zuber, McGraw Book Co. (1985)
5. Quantum Field Theory in a nutshell - A. Zee, Princeton University Press (2003)
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.The Quantum Theory of Fields, Vol I, II, Steven Weinberg, Cambridge University, Press, 1995

Course outcome:

- This elective course would help students in developing skills to increase in depth knowledge of a particular field within their specialization.
- All units offered in this course would enable a post graduate student to enhance their awareness related to a particular subject.

MPHYMET 304 Advanced Experiments

Unit A

1. Design and study of ECL OR/NOR circuit.

2. Design of analog computer to solve differential equation using OP-AMP.
3. Design and study of shift register
4. Design and study of 4-bit ripple counter.
5. Microwave characteristic study using klystron tube
6. Design and study of Wien bridge oscillator.
7. Design and study of RC phase shift oscillator.
8. Design and study of active phase shifter.
9. Experiments on microprocessor interfacing.
10. Problems on assembly language programming using 8085 microprocessor.

Unit B

1. Optical fiber: mode field diameter and numerical aperture, bend loss measurement;
2. Atomic spectra by constant deviation spectrometer
3. To verify the Malus law
4. Measurement of Brewster angle of a substance and hence determine the refractive index.
5. Experiments using Mach-Zehnder interferometer
6. Holography: construction of the hologram and reconstruction of the object beam
7. To determine the distance between the grooves of a compact disk.
8. To find the wavelength of an unknown light source using compact disk.
9. Determination of spot size and angle of divergence of a given laser source.

Unit C

1. Determination of the spectroscopic splitting factor of a given sample using electron spin resonance (ESR) spectrometer.
2. Determination of saturation magnetization, retentivity, and coercivity of given ferromagnetic samples using hysteresis loop tracer.
3. Study of the variation of Hall Coefficient of a given semiconductor as a function of temperature.
4. Study of colour centers and thermoluminiscence of alkali halides.
5. Study of the electrical properties of given thin films of different materials (metal, insulator or semiconductor) using four probe technique.
6. Determination of magnetoresistance of a given semiconductor for different magnetic fields.
7. Determination of Miller indices and lattice parameter of a polycrystalline material using X-ray diffractometer.
8. Determination of the dielectric constant of a solid using ellipsometer.
9. Determination of the film thickness of a film using ellipsometer.
10. Measurement of absorption spectrum and determination of the band gap energy and thickness of a given semiconductor film using dual beam UV-VIS spectrophotometer.

11. Determination of energy band gap of semiconductor by studying the photoluminescence spectra.
12. Measurement of absorption spectrum in the infra-red region and determination of vibrational energy levels of a given semiconductor using FTIR spectroscopy.
13. Preparation of micro- and nano-particles using Planetary Ball Mill and their characterization.
14. Experimental verification of tunnelling of electrons using STM spectroscopy.
15. Surface imaging of single crystalline materials using STM.
16. Determination of the spectroscopic splitting factor of a given sample using electron spin resonance (ESR) spectrometer.

Unit D

1. Use nuclear magnetic resonance (NMR) for the study of solids.
2. Determination of saturation magnetization, retentivity and coercivity of given ferromagnetic samples using hysteresis loop tracer.
3. Determination of magnetic susceptibility of paramagnetic salts by Guoy Balance method.
4. Study of colour centers and thermoluminiscence of alkali halides.
5. Determination of Miller indices and lattice parameter of a polycrystalline material using X-ray diffractometer.
6. Determination of grain size and lattice strain of polycrystalline material applying MARQ2 software and Scherrer equation.
7. Determination of phase transition temperatures of a binary liquid crystal mixture at different concentrations.
8. Alpha particle absorption using surface barrier detectors and multichannel analyser.
9. Alpha particle spectroscopy with ^{241}Am source and calculation of branching ratio.
10. Measurement of half life of ^{40}K using beta counting.
11. Study of conversion electron spectrum of ^{57}Co.
12. Gamma spectroscopy: (a) study of energy resolution at different amplifier gains, (b) energy calibration for a fixed gain, (c) study of ^{22}Na source spectrum and determination of the activity from sum peak analysis.
13. Beta-gamma coincidence measurements: study of decay schemes and lifetime of nuclear levels

MPHYOET 305 Open Elective Course

Unit A: Nature of the Universe

Syllabus:

The solar family

Our motion in the Universe. The night sky, basic concepts in astronomy such as distances, constellations and the celestial sphere, Asteroids & Comets, Formation of our solar system, Sun-Moon-Earth configurations that result in Moon phases and Solar and Lunar eclipses.

Instruments in astronomy

Light as a tool to probe the Universe. Properties of light. The wave particle nature of light. Atoms and spectroscopy. The thermal spectrum. Stellar classification: Hertzsprung-Russell diagram. Composition of a star's outer layers and its surface temperature, The Inverse square law. Telescopes, detectors to learn about astrophysical phenomena.

The Sun

Origin of solar energy, Nuclear fusion, Solar cycle, Solar activity, Solar wind. Solar missions. Main-Sequence lifetime.

Stellar Evolution

Post-main-sequence evolution of a Sun-like star. Planetary nebulae. White dwarfs. Neutron Stars, Difference between stars, brown dwarfs and giant planets. Supernova explosions. Neutron stars and black holes. Color-magnitude diagrams, Binary star systems, stellar nucleo synthesis.

Galaxy and Cosmos

Populations of stars and star clusters. Galaxy types and the formation and interaction of galaxies. The Milky Way, Active galactic nuclei, The rotation of our galaxy. Dark matter. The expansion of the Universe and the Big Bang Theory.

Books Recommended:

1. Introduction to Astronomy, Franck H Shu, (University Science Books).
2. Astronomy: The evolving Universe, Michael Zeilik, (Wiley).
3. Practical Astronomy, Peter D Smith, (Cambridge Press).
4. An introduction to Galaxies and cosmology, Mark Jones, Lambourne, (Cambridge).
5. Steller structure and Evolution, Kippenhahn, (sringer).
6. Observational Astrophysics, Lena, Rounan, (Springer).

Unit B: Concepts of Physics: Inventions and Applications

Syllabus:

Important Developments of Physical Science before 20th century

Archimedes' principle, Inertia: Galileo Galilei, Laws of motion and law of gravity: Newton, Concept of Classical Mechanics, Wave theory of light: Young, Atomic theory of matter: Dalton, Electrical resistance, etc.: Ohm, Electromagnetic induction: Michael Faraday, Electromagnetic waves: Hertz, Electron: Thomson.

Progress of Physics in 20th century

Introduction, Photoelectric effect: Einstein, Discovery of the atomic nucleus: Rutherford, Superconductivity: Kamerlingh Onnes, Concept of Quantum Mechanics, Radioactivity, Introduction to electronics, chip, Crystal, Nano materials, Glass, fibre optics, Advancement of technology in 20th century,

Physics in daily life

Working principle of Optical camera, Valve radio, Transistor radio, AM and FM radio, Television, Digital Camera, Mobile, Smart Phone, Electric heater, Microwave oven, Induction oven, Fan, electric generator, Refrigerator.

Development of different light sources: Incandescent bulb, Vapour lamp, Arc Lamp, Fluorescence Lamp (Tube light, CFL), Light Emitting Diode (LED), LASER, Field emission.

Medical Instrumentation

X-ray, Electrocardiograph (ECG), Ultrasonography(USG), Magneto Resonance Imaging (MRI), Photodynamical Therapy (PDT), Spectrophotometry, Chromatology, Electrophoresis.

Physics of Nature

Blue sky, Scattering of light, Colour of Sun, Rainbow, Halo, Refraction and reflection of light, Mirage.

Books recommended:

1. Bowler, Peter J. and Iwan Rhys Morus (2005), Making Modern Science: a Historical Survey (Chicago: University of Chicago Press).
2. History of Science, Samarendra Nath Sen (Saibya Prakasan Bibhag, in Bengali).
3. Itihase Bijnan, J.D. Barnal(Ananda Publishers, in Bengali).
4. Medical Instrumentation Application and Design,John G. Webster(Editor) (Wiley).
5. Handbook of Biomedical Instrumentation, Dr R.S. Khandpur, (McGraw Hill Education).
6. Introduction to Light: The Physics of Light, Vision, and Color, Gary Waldman, (Dover Publications).

MPHYOPT 306 Outreach Programme

Students will undertake one Outreach Programme involving the visit to a national experimental facility. On the other hand they will be motivated to design and build scientific models, generate tables, charts, figures and finally demonstrate these in various schools in the locality as well as in the department. Students would be involved in organising school level seminar on physics in general. This would give post graduate students to interact with the society and develop their concerns with the society.

FOURTH SEMESTER

MPHYCCT 401 –Numerical Methods and Computational Physics

Course Requirement:

- Both the theoretical and experimental physicists require a high level of computational facility to handle huge number of data sets in order to pursue various aspects of their work. Also, numerical simulation techniques are increasingly dominating our approaches in studying physical systems leading rise in computational capabilities. Therefore, it is absolutely essential to train or familiarize post graduate students with computation facility.

Syllabus:

Computer fundamentals

Functional units. CPU. Memory. I/O units. Information representation. Integral and real number representation. Character representation. Alphanumeric codes. BCD. Gray. ASCII codes. Computer Software and Operating Systems: System software and application software. Classification of operating systems. Elements of DOS and Windows. Basic commands. CPU. RISC and SISC. Storage system- primary and secondary memory. Semiconductor, magnetic and optical memory. Cache memory. Virtual memory. Memory management. IO Units – keyboard, mouse, VDU, printers; (principle of operation only).

Elements of C Programming Language

Algorithms and flowchart. Structure of a high level language program. Features of C language. Constants and variables. Expressions. Input and output statements. Conditional statements and loop statements. Arrays. Functions. Character strings. Structures. Pointer data type. List and trees. Application to solve eigen value equations and some electronic circuits.

Numerical Analysis

Approximation of numbers, Significant figures, Absolute, Relative & Percentage errors, Round off errors and significant errors. Solution of Polynomial equations – Bisection, Regula-Falsi and Newton-Raphson algorithms. Solution of a system of simultaneous equations- Gauss elimination, Gauss-Seidel algorithms. Interpolation - Newton's Forward & Backward interpolation formulae, Newton Lagrange equation, Hermite difference equations. Numerical integration – Trapezoidal formula, Simpson's 1/3rd & 3/8th formula. Numerical solution of differential equations- Euler and Runge-Kutta formulae. Numerical solution of partial differential equations - discussion of algorithms only. Matrix inversion, diagonalization, eigenvalue and eigenvector determination. Least square technique: Problems of linear least squares fit, applications.

Data Analysis

Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting.

Course outcome:

- This course will enable the students to learn to implement numerical methods in solving physical problem using computer programming language.
- The course prepares students for a career in industry or for further research activities.

Books recommended:

(1) P.K. Sinha and P. Sinha: Computer Fundamentals.

(2) Anita Goel: Computer Fundamentals.

(3) B. Gottfried: Programming with C.

(4) E. Balaguruswamy: Programming in ANSI C.

(5) H.M. Antia: Numerical Methods for Scientists and Engineers.

(6) S. Sastry: Introductory Methods of Numerical Analysis.

(7) W.H. Press et al: Numerical Recipes in C.

(8) S.A. Mollah: Numerical Analysis and Computational Procedures.

MPHYCCT 402 -Relativity, Cosmology and Astrophysics

Course requirement:

- Astrophysics is one among the esteemed branch of physics that science students admire. Mainly, early universe, big bang, black hole draw special kind of attraction of a physics students. Therefore, the idea of this course is to develop the concept of our universe introducing Einstein's General Theory of Relativity and provide scope to know the universe more scientifically.

Syllabus:

Tensor calculus

Idea of Euclidean and non-Euclidean space. Meaning of parallel transport and covariant derivatives. Geodesics and autoparallel curves. Curvature tensor and its properties. Bianchi Identities. Vanishing of Riemann-Christoffel tensor as the necessary and sufficient condition of flatness. Ricci tensor. Einstein tensor.

Einstein's field equations

Inconsistency of Newtonian gravitation with the special theory of relativity. Principles of equivalence. Principle of general covariance. Metric tensors and Newtonian Gravitational potential. Logical steps leading to Einstein's field equations of gravitation. Einstein's equation from action principle, Linearised equation for weak fields. Poisson's equation.

Applications of general relativity

Observational tests of Einstein's theory, gravitational lensing, Schwarzschild's exterior solution. Singularity. Event horizon and black holes. Isotropic coordinates. Birkhoff's theorem. static and rotating black holes (Schwarzschild and Reissner-Nordstrom). Kerr metric (derivation not required), event horizon. Kerr-Neumann Metric (no derivation). No hair theorem. Cosmic censorship hypothesis.

Cosmology

Cosmological principles. Weyl postulates. Robertson-Walker metric (derivation is not required). Cosmological parameters. Static universe. Expanding universe. Open and closed universe. Cosmological red shift. Hubble's law. Olber's paradox. Brief discussions on: Big bang, Early universe (thermal history and nucleosynthesis), Cosmic microwave background radiation, Particle horizon.

Astrophysics

Luminosity, Effective Temperature, Stellar Magnitudes. Boltzmann and SahaIonizationEquations. Spectral Classification of Stars. Hertzsprung-Russel (H-R) diagram. Hydrostatic Equilibrium, Equilibrium of a gas of Non-relativistic and Ultra-relativistic particles. Gravitational energy and Virial theorem. Jeans criteria for Star Formation, Fragmentation of Collapsing clouds. Free-Fall Times. Heat transfer by random motion and convection, Temperature gradient in stars. Equations of stellar structure and evolution. Polytropic stellar model, Lane-Emden equation. Thermonuclear reactions in stars, PP chains and CNO cycle. Solar Neutrino problem. Helium and advanced burning phases. Nucleosynthesis beyond iron, r- and s- processes. Evolutionary tracks in the H–R diagram of low mass and massive stars. Novae and Supernovae. Compact stars, Equation of state and degenerate gas of fermions. White dwarf and Chandrasekhar limit. Neutron Stars and Pulsars. Black Holes.

Course outcome:

- During this course students would gather proper knowledge of gravity and space time.
- They will be introduced to a new geometry i.e. Riemannian geometry.
- Learning sophisticated tensor calculus would familiarize them with a new mathematical method.
- Overall, the concepts and interests grown in this section may lead students to the vast arena of fundamental research.

Books recommended:

(1) J.B. Hartle: Gravity (Pearson).

(2) B. Schutz: A First Course in General Relativity (Cambridge University Press).

(3) Ray D'Inverno: Introducing Einstein's Relativity (OxfordUniversity Press).

(4) S. Banerjee and A. Banerjee: General Relativity and Cosmology (Elsevier).

(5) S. Weinberg: Gravitation and Cosmology (Wiley).

(6) B.W. Carroll and D.A. Ostlie: An Introduction to Modern Astrophysics (Pearson).

(7) A.C. Phillips: The Physics of Stars (Wiley).

(8) V.B. Bhatia: Textbook of Astronomy and Astrophysics (Narosa Book House).

(9) S. Palen: Theory and Problems of Astronomy (Schaum's Outlines) (McGraw-Hill).

MPHYMET403 Elective II

Course requirement:

- Students can choose one among these subjects or units based on their interests or based on topics that would help them in building their research or professional career in future.

Unit A: Advanced Electronics II

Syllabus:

Memories

Sequential and Random access memories. RAM bipolar and MOS static and dynamic memories. Programmable memories: PROM, EPROM, EEPROM.

Microprocessors and their applications

Architecture of 8 bit (8085) and 16 bit (8086) microprocessors. Addressing modes and assembly language programming of 8085 and 8086. Machine cycles and their timing diagrams. Interfacing concepts. Memory and I/O interfacing. Interrupts and interrupt controllers. Microprocessor based system design. Comparison of different microprocessors.

Microwave Devices

Klystron, Reflex Klystron, magnetrons, Travelling wave tubes, Gunn, Impatt, Trapatt, transistors, GaAs-InP FET, HEMT, BARITT.

Elements of Information Theory

Information, average information, information rate, Effect of coding on average information per bit. Shanon's theorem; Channel capacity. Optimum modulation system in AWGN channel.

TV Systems

Color TV standards – NTSC, PAL, SECAM; Transmission format of intensity and color signal. Transmitter and receiver systems of broadcast TV. Advanced TV. Cable TV.

RADAR System

Types of RADAR (CW, MTI, FM & Chirp pulse radar), Radar system and range equation.

Satellite communication: Orbits, Station keeping, Satellite attitude, Path loss calculation, Link equation, Multiple access techniques, Transponders, Effects of nonlinearity of transponders.

Specialized Communication Systems

Mobile Communication – Concepts of cell and frequency reuse description of cellular communication, development of mobile generation 1G to 5G (idea only). Computer communication – Types of networks. Circuit message and packet switched networks. Features of network, design and examples of ARPANET, LAN, ISDN, Medium access techniques – TDMA, FDMA, Basics of protocol.

Books recommended:

(1) A Mathur: Microprocessors.

(2) R. Gaonkar: Microprocessor Architecture, Programming and Applications with 8085/8085A.

(3) Lin and Gibson: Microprocessor.

(4) S Soelof: Applications of Analog Integrated Circuits.

(5) B. Brey: Intel Microprocessors Architecture, Programming and Interfacing.

(6) Franz and Jain: Optical Communication Systems.

(7) A. Dhake: Television and Video Engineering.

(8) Gulati: Monochrome and Color TV.

(9) Kennedy and Davis; Electronic Communication Systems.

(10) Taub and Schilling: Principle of Communication Systems.

(11) B. P. Lathi: Modern Digital and Analog Communication Systems.

Unit B: Photonics II

Syllabus

Nonlinear optics

Review of Nonlinear optics, Parametric generation of light, Crystal optics, Nonlinear optics in Crystals, 2HG in KDP, Pockels cell and Pockels effect, Stimulated Raman Scattering.

Non-linear Optical fiber

Step index optical fiber; Concept of TEM modes in cylindrical fiber; Optical communication through wave guide; Types of optical fiber; Losses in optical fiber: Propagation of electromagnetic radiation through a planar waveguide; concept of TE and TM modes; Propagation of electromagnetic radiation through 3-dimensional cylindrical waveguide, Dispersion in optical fiber; multi-mode dispersion, material dispersion, and wave guide dispersion; Derivation of the expressions of the three dispersions; Dispersion free fiber and dispersion compensated fiber; Propagation of electromagnetic radiation through nonlinear wave guide; Nonlinear Schrodinger equation; Optical soliton formation; Wavelength division multiplexing and demultiplexing.

Optical amplifiers

Semiconductor Optical Amplifier (SOA) and its operation; Self phase modulation, cross phase modulation , Cross gain modulation and wavelength conversion of SOA ; Erbium doped fiber amplifier (EDFA) and its principle of operation.

Photonic measurement systems

Homodyne and Heterodyne detectors for phase and intensity measurements of light, Optical time domain reflectometer (OTDR).

Optical devices and sensors

Principle of operation of Liquid Crystal Display; Charge Coupled Devices; Fiber optic displacement, current, pressure and temperature sensors. optical directional coupler, optical biological sensor.

Optical Communication

Optical free space communication; Components of coherent communication systems; Coherent signal, Transmitter, transmission channel, coherent receivers; Probability error and bit error rate; Calculation of Worst-case bit error rate; maximum bit rate and bit error rate in digital communication through optical fiber; Power budget equation and Time budget equation. LIDAR, Optical free-space communication, Optical submarine communication.

Optical Networks

Local area network, Broadcast and distribution network; Optical Bus topology (Single fiberand dual fiber bus topologies).

Books recommended:

(1) A. Yariv and P.Yeh (Oxford University Press , 2007)- Photonics : Optical electronics in modern communication.

(2) J. Wilson and J.F.B.Hawkes(Prentice Hall Europe, 1998)- Optoelectronics : An introduction.

(3) C.K. Sarkar (New Age international (p) Limited , 2004)- Opto Electronics And Fiber Optics Communication.

(4) J Franz and V K Jain(NAROSA ,1996)-Optical Communication Systems.

Unit C: Nano Science and Technology

Syllabus

Background to Nano Science and Technology

Scientific revolution: Atomic structures-Molecular and atomic size-Bohr radius; Emergence of Nanotechnology: Challenges in Nanotechnology; Carbon age: New form of carbon (from Graphene sheet to Carbon Nanotubes).

Types of Nanostructures and Size Effects

Definition of a Nano system; Types of Nanocrystals: Zero dimensional (0D), One Dimensional (1D), Two Dimensional (2D), and Three Dimensional (3D) nanostructured materials (Quantum Dots, Wires and Wells); Conduction Electrons and Dimensionality; Properties Dependent on Density of States; Bulk to Nano Transitions.

Nucleation

Influence of nucleation rate on the size of the crystals; macroscopic to microscopic crystals and nanocrystals; large surface to volume ratio; grain boundary volume in nanocrystals; defects in nanocrystals; surface effects on the properties.

Synthesis of Nanoparticles

Bottonm up and Top down approaches; Method of Synthesis: Physical Vapour Deposition, RF Plasma Chemical Methods, Thermolysis, Pulsed Laser Methods, Biological Methods.

Nanomaterials and properties

Carbon Nanotubes (CNT); Metals (Au, Ag); Metal oxides (TiO_2 ,ZnO), Semiconductors (Si, Ge); Composites; Dilute magnetic semiconductor; Biological system: DNA, RNA and – Lipids; Size dependent properties - Mechanical, Physical and Chemical properties.

Bulk Nanostructured Materials

Methods of Synthesis: Compaction & consolidation, and Ion implantation, Solid Disorders Nanostructures: Mechanical and Electrical Properties, Nanostructure Multilayers, Metal Nanocluster Composite Glasses, Porous Silicon.

Analysis Techniques for Nano Structures/Particles

Scanning Probe Microscopes (SPM): Scanning Tunneling Microscopes (STM) and Atomic Force Microscope (AFM); Diffraction Techniques: X-ray Diffraction (XRD), Transmission Electron Microscope (TEM); Spectroscopic Techniques: Optical absorption, Photoluminescence and Raman spectroscopies, Magnetic Measurements.

Applications of Nanomaterials

Molecular electronics and nanoelectronics; Quantum electronic devices; CNT based transistor and Field Emission Display; Biological applications; Biochemical sensor; Membrane based water purification.

Books recommended:

1. Poole and Owners: Introduction to Nanotechnology.
2. M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Nanotechnology: Basic.
3. Jacak, Hawrylak and Wojs: Quantum Dots.
4. H S Nalwa (Editor): Handbook of Nanostructured Materials and Nanotechnology.
5. S K Kulkarni : Nano Technology/ Principles and Practices.
6. Silvana Fiorito : Carbon Nanotubes.
7. R Booker and El Boysen: Nanotechlongy.
8. C.S.S.R.Kumar, J.Hormes, C.Leuschner, Nanofabrication towards biomedical applications.
9. W. Rainer, Nano Electronics and information Technology.
10. G.Cao, Naostructures and Nanomaterials: Synthesis, properties and applications.

Unit D: High Energy Physics

Syllabus:

Conservation laws:

Strong, weak and electromagnetic interactions; invariance under charge (C), parity (P) and time (T) operators, non-conservation of parity in weak interactions.

Quark model:

Quark model of mesons and baryons; quarks, gluons and colours, colour factors, symmetry groups - SU(2), SU(3), eightfold way of classification, discovery of J/Ψ, quark masses.

Parton Model:

Probing charge distribution with electrons, form factors, electron-proton scattering - proton form factor, elastic electron-proton scattering, Partons, Bjorken scaling Structure of hadrons: Quantum chromodynamics - dual role of gluons, gluon emission cross-section, scaling violation.

Weak Interactions:

V-A theory, nuclear β-decay, neutrino-quark scattering, Cabibbo angle, weak mixing angle, CP violation.

Gauge theory:

Local and global gauge theory, non-Abelian gauge theory, spontaneous symmetry breaking, Higg's mechanism, Goldstone theorem.

Unification of interactions:

Electro-weak interaction, Weinberg-Salam model, grand unified theories, proton decay, neutrino oscillations and neutrino masses, elements of super-symmetry, elements of string theories, present experimental status.

Books recommended:

1. Introduction to particle Physics, D J Griffiths

2. Quarks and Leptons, F Halzen and A D Martin, John Wiley and Sons

3. Introduction to Quantum Electrodynamics and Particle Physics, D C Joshi, I K International Publishing House Pvt Ltd, 2007

4. Introduction to High Energy Physics, D H Perkins, Addison-Wesley

5. Gauge Theory of Elementary Particle Physics, T P Cheng and L F Li, Oxford University Press, 1988.

Course outcome:

- This elective course would help students in developing skills to increase in depth knowledge of a particular field within their specialization.
- All units offered in this course would enable a post graduate student to enhance their awareness related to a particular subject.

MPHYACT 404 Add-On Course: Fundamentals and Applications of Computer Systems

Fundamentals of Computer:

Introduction, History, Block Diagram, Characteristics, Types, Applications, Input, Output and Central Processing Unit (CPU), Basics of Hardware and Software, Types of Software, Computer Memory, Types of Memory, Security Tools, Viruses and its Utilities.

Number Systems and Basic Logic Gates:

Introduction to Number System, Types of Number System, Base Conversation, Binary Arithmetic

Microsoft Office Applications:

Microsoft Word: Introduction, Windows Interface, Word Applications, Viewing Documents, Basic and Advanced Formatting, Navigating through a Word Document, Printing Documents, Preview. *Microsoft Excel:* Introduction, Workbook and Worksheet, Formatting, Advanced Formatting, Printing Worksheets, Basic Excel Functions. *Microsoft PowerPoint:* Introductions, Creating Presentations, Basic and Advanced Formatting, Templates, Inserting Charts and Tables.

Operating Systems:

Definition, Program and Process, Process Scheduling, Installation, Basics of Windows XP, Linux.

Networking and Communications:

ICT: General Abbreviations and Terminology. Basic of Computer networks, LAN, MAN, WAN, Internet and its Applications, E-mail, Audio and Video- Conferencing, Intranet, connecting to Internet, ISP, World Wide Web, Understanding URL, Web Browser, Search Engines, Domain, IP Addressing, p2p Networking, Network Topology, Introduction to Network Security.

Data handling and Database Management Systems:

Sources, Acquisition and Classification of Data, Quantitative and Qualititative Data, Graphical representation (Bar-chart, Histograms, Pie-chart, Table-chart and Line-chart) and mapping of Data, Data Interpretation. Data, Database, DBMS, RDBMS, Advantages, Data Dictionary, data Model, SQL, Entity, Attribute, Tuple, Relationships.

Books recommended:

1. Let Us c by Yashavant Kanetkar.
2. Computer Fundamentals: Concepts, Systems and Applications by P. Sinha, Pradip K. Deep, Sinha.
3. Database System Concepts by Abraham Silberschatz, Henry F. Korth.
4. Data Communications and Networking by Behrouz A. Forouzan.
5. Operating System Concepts by Abraham Silberschatz, Peter B. Galvin, Gerg Gagne.
6. Digital Design by M. Morris Mano, Michael D. Ciletti.

MPHYCCS 405 Computer Practical

Basic programming in C, Several numerical methods will be tasted in the computer lab namely, numerical differentiation and integration, solution of first-order differential equations, interpolation and extrapolation, least square fitting, Monte Carlo Technique etc.

MPHYMEP 406– Project/Term Paper and Grand Viva

Project/Term paper to be made on the basis of subject-interest of the students in different areas of Physics discipline and under the supervision of a teacher of the department. Seminar talk based on the Project/Term paper work to be conducted by the department. Record to be maintained by the department.

Grand Viva is to be conducted by the Department. At least one external examiner should be appointed for the Grand-Viva. Students may be asked questions from any part of the M.Sc. syllabus. However, any relevant question outside the mentioned syllabus may also be asked.
