DEPARTMENT OF PHYSICS
Revised PG Syllabus (2021)

Objective of the syllabus

The Assam University PG course in Physics is a 120 credit (2000 marks) course equally spread over 4 semesters under the Choice Based Credit System (CBCS) and is designed to train aspiring students to take up a career in Physics. Accordingly, the syllabus is structured into **core**, **elective** and **open elective course** papers, each with a specific purpose. The contents of **core course papers** are designed to impart fundamental knowledge in Physics and prepare students to compete in CSIR-UGC NET, GATE, SLET and other similar examinations, which are mandatory for aspirants willing to start a career in physics. The combination of **elective papers** gives students a first-hand experience of theoretical and/or experimental fields of Physics in advance stage. The **open elective papers** add a multidisciplinary aspect to the course – wherein a student from a parent department has to take up one paper offered by any other department(s) expect that offered by his/her owndepartment.

Apart from the **laboratory** courses, there is a mandatory **project work** in the syllabus which initiates a student into the basics of research activity.

Program Structure

Semester I			Semester II		
Paper 1 (101)	Classical Mechanics	Core	Paper 1 (201)	Electromagnetic Theory	Core
Paper 2 (102)	Mathematical Physics	Core	Paper 2 (202)	Electronics and Communication	Core
Paper 3 (103)	Quantum Mechanics I	Core	Paper 3 (203)	Open Paper (Non-Physics)	Open Elective
Paper 4 (104)	Solid State Physics	Core	Paper 4 (204)	Open Paper (Physics/ Non-Physics)	Open Elective
Paper 5 (105)	General Laboratory	Core	Paper 5 (205)	Electronics Laboratory	Core
Semester III			**Semester IV**		
Paper 1 (301)	Statistical Mechanics	Core	Paper 1 (401)	Atomic, Molecular & Laser Physics	Core
Paper 2 (302)	Quantum Mechanics II	Core	Paper 2 (402)	Nuclear & Particle Physics	Core
Paper 3 (303)	Elective Paper I (EI)	Elective	Paper 3 (403)	Elective Paper III E(III)	Elective
Paper 4 (304)	Elective Paper II (E II)	Elective	Paper 4 (404)	Elective Paper IV E(IV)	Elective
Paper 5 (305)	Lab on Elective Paper	Elective	Paper 5 (405)	Project/Dissertation	Elective

Open Papers (Non-Physics):

203: (1) Basic Astronomy (2) Building Blocks of Matter (3) Physics at Nanoscale
(4) Electronic devices and circuits

Open Papers (Physics/ Non-Physics):

204: (1) Computational Physics (2) Plasma Physics (3) Instrumentation

Elective papers:

E1: (1) Adv. Math. Phys.
(2) Expt. Techniques

E2: (1) Particle Physics
(2) Astrophysics I
(3) Theory of solids
(4) Non -Linear Optics

E3: (1) Quantum Field Theory
(2) Adv. Electronics
(3) Photonics
(4) Atmospheric Physics
(5) Biophysics

E4: (1) High Energy Physics
(2) Astrophysics II
(3) Condensed Matter Physics
(4) Laser Spectroscopy
(5) Advanced Atomic and Molecular Physics.

Note:

1.Each course paper, including laboratory courses, is of 100 marks (Internal Assessment :30 marks and End Sem. Exam.: 70 marks) and credit 6.

2.Prerequisites may be there for choosing an elective. Students are to check carefully before opting the electives.

3. The electives Astrophysics I in third semester and Astrophysics II in fourth semester should be taken in combination, with a prerequisite for Advanced Mathematical Physics in third semester.

4. Electives in a particular semester in a particular campus will be offered depending upon the availability of teaching faculty members.

5.Allotment of Elective and Open Elective Courses will be based on the choicesindicated by the student, performance of the student in earlier semester(s) andavailability of seats.

6.Project work in Sem IV will be related to one of the electives.

Syllabus

Semester –I

Course: PHY 101: CLASSICAL MECHANICS

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives: The primary objective is to teach the students Classical Mechanics at a level more advanced than what they have learnt in B.Sc. This is a course which forms the basis of Physics of many areas of Physics.

UNIT I: Mechanics of a system of particles: Centre of mass, conservation of linear and angular momentum, energy conservation. Constraints, generalized coordinates, principle of virtual work, D'Alembert's principle, Lagrange's equations. Velocity dependent potential and dissipation function. First integrals of motion and cyclic coordinates.

UNIT II: Hamilton's principle, Lagrange's equations from Hamilton's principle, Hamilton's principle for non-holonomic systems. Symmetry principles and conservation laws.
Two-body central force problem: reduction to one body problem, equations of motion, classification of orbits, differential equation of the orbit, Kepler's laws.

UNIT III: Hamilton's equations of motion, Hamilton's equations from variational principle, Integrals of Hamilton's equations. Principle of least action.
Canonical transformation, infinitesimal canonical transformation, Poisson brackets, fundamental properties of Poisson brackets, equations of motion in Poisson bracket form. Lagrange brackets.

UNIT IV: Hamilton-Jacobi theory, Hamilton's characteristic function, Harmonic oscillator in Hamilton-Jacobi method, separation of variables in Hamilton-Jacobi equation. Action and angle variables, Kepler problem in action-angle variables.

UNIT V: Motion of rigid bodies: Angular momentum and kinetic energy, inertia tensor, principal axes and moments of inertia. Euler's angles, Euler's equations of motion. Coriolis force. Force-free motion of a symmetrical top.
Small oscillations: equilibrium and potential energy, frequencies of free vibration and normal coordinates. Longitudinal vibration of linear triatomic molecule

Expected Learning Outcomes: Students will be equipped for advanced and specialized courses.The student learns to deal with particle mechanics at an advanced level and to learn the foundations of the classical theory of fields.

Text Books:

1. Goldstein, Classical Mechanics Narosa Publishing, Delhi
2. Landau &Lifshitz, Course of theoretical Physics, Vol-10, Oxford University, Press
3. Joag& Rana, Classical Mechanics, Mc Graw Hill

Reference Books:

1. Berger, Classical Mechanics A modern Perspective, Mc Graw Hill International
2. Awqhmare, Classical Mechanics, Prentice Hall
3. Sommerfield, Lectures on theoretical Physics. Vol-I, Academic Press, NY 1952
4. Hestness, New foundations for classical Mechanics, Kluwer Academic Publisher
5. R. Resnik, Introductions of Relativity, Wiley Eastern 1967
6. Corben&Stehle, Classical Mechanics, Wiley NY 1974
7. Einstein, The meaning of relativity 5th Ed. Princeton University Press
8. K. Fock, Theory of space time and Gravitational 2nd Ed., Peragon 1964
9.Schwartz, Introduction on to special relativity, Mc Graw Hill, 1968

Course: PHY 102: MATHEMATICAL PHYSICS – I

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives : The primary objective is to teach the students basic mathematical methods that will be used in many of the other courses in the M.Sc. Syllabus.

UNIT I: **Linear Vector Space , Matrices and Tensors**

Vectors in n-dimension, Linear independence, Basis and Dimension, Scalar product, Norm and Orthogonality, Schwartz inequality, Gram-Schmidt orthogonalization technique.

Linear operators and their Matrix representation, Eigen values and Eigen vectors of a matrix, Cayley-Hamilton theorem, Orthogonal, Unitary and Hermitian matrices.

Infinite dimensional space, Hilbert space.

Definition of Tensor, Covariant and Contravariant tensor, Fundamental operation with tensors, Metric tensor, Covariant differentiation and Christoffel symbols

UNIT II: **Differential Equations & Special functions**

Second order linear differential equations, Series solution, Ordinary and Singular points.

Partial differential equations: Classification. Boundary value problems. Concept of wellposedness.

Green's function technique for solution of Differential equations.

Nonlinear systems, Dynamical flow, Fixed points and stability, Periodic solutions: The Poincare-Bendixon Theorem.

Hermite, Laugerre and Bessel Functions.Hypergeometric functions, Confluent Hypergeometric functions,

UNIT III: **Complex Variables and Integral Transforms**

Analytic functions, Cauchy-Riemann conditions, Cauchy integral theorem for simply and multiply connected regions, Cauchy integral formula, Taylor and Laurent series, Poles, Residue theorem, Evaluation of integrals, Conformal mapping, Harmonic function.

Integral transforms: three dimensional Fourier transforms and its applications to PDEs (Green function of Poisson's PDE), convolution theorem, Parseval's relation, Laplace transforms, Laplace transform of derivatives, Inverse Laplace transform and Convolution theorem, use of Laplace's transform in solving differential equations.

UNIT IV:

Theory of Probability and Statistics: Random Variables, Binomial, Poisson and Normal Distributions. Central Limit Theorem, Law of Large numbers. Hypothesis Testing

Numerical Techniques: Finite difference, Interpolation and extrapolation (forward, backward and central), Roots offunctions, Integration by trapezoidal and Simpson's rule, Solution of 1st order differentialequation using Euler and 2nd order Runge-Kutta method. Introduction to programming.

UNIT V: **Group Theory**

Abstract groups: subgroups, classes, cosets, factor groups, normal subgroups, direct product of groups; Homomorphism & Isomorphism.

Representations: reducible and irreducible, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations.

Introduction to continuous groups: Lie groups, rotation and unitary groups.

Representation of SO(3), SU(2).

Expected Learning Outcomes: Students will learn the required Mathematics techniques that may have not been covered in depth in the courses in B.Sc. CBCS program and which will be useful in many other courses in MSc.

References:
1. Murry R Speigel, Vector Analysis Mc Graw Hill
2. Murry R Speigel, Complex variables Mc Graw Hill
3. A W Joshi, Elements of Group Theory for Physicists New Age International
4. A W Joshi, Matrices and tensors in physics New Age International
5. I Snedden, Elements of partial differential equations Mc Graw Hill
6.Landau and Lifshitz, Classical Theory of Fields Butterworth Heinemann
7.G B Arfken, Mathematical Methods for Physicists Academic Press
8. Corte S.D. and de Boor, Elementary Numerical analysis, 3rd Ed, McGraw Hill, 1980.
9. James B. Scarborough,Numerical Mathematical Analysis, Oxford.
10. F.B. Hildebrand, Introduction to Numerical Analysis, McGraw Hill, 1956.
11. L.A. Pipes and L.R. Harwill, Applied Mathematics for Physicists and Engineers, McGraw Hill.

Course: PHY 103: QUANTUM MECHANICS-I

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives : The primary objective is to teach the students the physical and mathematical basis of quantum mechanics for non-relativistic systems

UNIT I: Revision and General Formalism:
Inadequacies of Classical Mechanics, Wave-particle duality, Postulates of Quantum Mechanics. Wave functions and Operators in co-ordinate and momentum representations, Ehrenfest theorem. Dynamical variables and linear operators. Commutation relations. Generalized uncertainty principle and its applications. Introduction of Hilbert space. Dirac's bra and ket notation.

UNIT II: Schroedinger's equation (Time-dependent and time-independent), Stationary states, potential well problems, harmonic oscillator, step potential problems, Tunnel effect, hydrogen atom.

UNIT III: Representation of states and dynamical variables, completeness and closure property. Schroedinger, Heisenberg and Interaction pictures. Matrix representation of an operator, change of basis, unitary transformation. Eigen values and eigen functions of simple harmonic oscillator by operator method.

UNIT IV: Symmetry transformations: Space – time translations and rotations, Invariance under the transformations and conservation laws. Central force problem, orbital angular momentum, angular momentum algebra, spin. Addition of angular momenta, Clebsch Gordon coefficients.

UNIT V: Approximation Methods:
Time-independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Stark effect, and other simple cases. Variational method and applications to helium atom and simple cases. WKB approximation.

Expected Learning Outcomes : Students will learn the mathematical formalism of Hilbert space, hermitian operators, eigen values, eigen states and unitary operators, which form the fundamental basis of quantum theory. Application to simple harmonic oscillators, hydrogen-like atoms and angular momentum operators will teach the students how to obtain eigen values and eigen states for such systems elegantly. The topic of density matrices that plays significant roles in quantum information theory and statistical mechanics will also help the students considerably.

References:

1. R.L.Liboff, Introductory Quantum Mechanics, Pearson Education(2006)
2. L.I. Schiff, Quantum Mechanics, Mc Graw Hill (1998)
3. A.K. Ghatak and S. Lokanathan: Quantum Mechanics, Macmillan (2000)
4. J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley (1990)
5. E. Merzbacher, Quantum Mechanics, John Wiley & Sons (1999).
6. Satya Prakash, Advanced Quantum Mechanics, Kedar Nath (1990)
7. V.K. Thankappan, Quantum Mechanics, New Age Intl. Pub (1996)
8. S. Gasiorowiz, Quantum Mechanics, Wiley (1995)
9. P M Mathews and S Venkateswan, Quantum Mechanics, Tata McGraw Hill (1976)
10. N Zettili, Quantum Mechanics, John Wiley (2001)
11. John L Powell and B Crasemann, Quantum Mechanics, Narosa (1991).

Course: PHY104: SOLID STATE PHYSICS

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 6**

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives : This course intends to provide knowledge of conceptual solid-state physics. In addition, this course aims to provide a general introduction to theoretical and experimental topics in solid state physics.

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,Geometrical structure 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.

UNIT III: Failure of free electron theory, Sommerfield modification, Particle in a box,Fermi Dirac statistics and electronic distribution in solid, density of states and Fermi energy,Fermi distribution function,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.

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 tunnelling, Josephson effect, High temperature superconductivity.

Expected Learning Outcomes : The students should be able to elucidate the important features of solid state physics by covering crystal lattices and binding, lattice dynamics, band theory of solids and semiconductors.

Text Books:

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

PHY105: GENERAL LABORATORY

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

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 Interferometer.
7. Study of Hall Effect (general model)
8. Determination of velocity of ultrasonic wave liquid using Ultrasonic Interferometer.
9. Determination of velocity of ultrasonic wave in liquid by study of diffraction of light by the wave.
10. Determination of Stefan's Constant.
11. Determination of Plank Constant using photo cell.
12. Determination of Dielectric Constant (general model).
13. Study of plateau of a Geiger –Muller counter and carry out statistical analysis of the data.
14. FORTRAN programming based on the optional paper "Numerical methods and computer programming".

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. *****

Course: PHY 201: ELECTROMAGNETIC THEORY

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives: This course aims to introduce the student to topics in Electromagnetic Theory, Relativity and the Relativistic formulation of electromagnetism. The course reviews and builds on the students' knowledge of Relativity and introduces the formulation of relativity in 4-vector notation. It also builds up a covariant formulation of electrodynamics and includes a study of motion of charges in fields as well as radiation from moving charges as well as antennae.

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, Retarded potentials, Lienard-Wiechert potentials, field of a system of charges at large distances. Dipole radiation, Quadrupole and magnetic dipole radiation.

UNIT V: Scattering: coulomb collision due to a harmonically bound charge , Thompson scattering, Rayleigh scattering, Mie Scattering and phase function formulation – consideration of a large particle- Other scattering formulations (expressions only) : T-matrix , Discrete Dipole Approximation .

Expected Learning Outcomes : A student having taken this course is expected to have a fair degree of familiarity with tensors and tensorial formulation of relativity and electrodynamics. In addition, s/he is expected to be 27 able to solve problems of motion of charged particles in various field formations as well as find the radiation patterns from different time varying charge and current densities.

Text Books:

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

Reference Books:

1. Berestetkii, Lifshit, Pitaevski, Quantum Electrodynamics, ,Pergaman Press.
2. Miah M.A.W, Fundamentals of Electromagnetic, Tata Mc Graw Hill.
3. Cook D.M , Theory of Electromagnetic Fluids, Prentice Hall.
4. Lorrain &Corson, Electromagnetic field and waves, Freeman & Company Sanfrancisco.

Course: PHY202: ELECTRONICS AND COMMUNICATION

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives: To build up on the basic knowledge of electronics with the introduction of advanced topics like circuit analysis and applications of semiconductor devices in analog and digital circuits.

UNIT I: Semiconductor Devices-I

Avalanche and Zener Breakdown, Zener diode as a voltage regulator, Bipolar Junction Transistor: stability factor and different types of baising and modes of operation, application of BJTas an amplifier and switch, h-parameters, RC coupled amplifier, frequency response of BJT, Field Effect Transistor: JFET, MOSFET constructions and characteristics curve.

UNIT II: Semiconductor Devices-II

Feedback in amplifier, different tropologies of negative feedback with examples, Oscillators (Hertly, Phase shift and Wein bridge) , UJT: construction and applications, 555 timer and its use as an astable, monostabe and bistable multivibrator.

UNIT III: OP AMPS basics

OP AMPS: block diagram and pin configuration, elementary idea of Differential Amplifier Circuit, DC offset parameters, frequency parameters, inverting amplifier, non inverting amplifier, op amp as adder, substractor, differentatior, intregrator, differential amplifier, unity gain amplifier.

UNIT IV: Digital Circuits

Boolean operation, simplification of Boolean expression, Logic gates:RTL, DTL, TTL, ECL, CMOS families, Karnaugh maps, De Morgans theorem, Adder and subtractor (half and full), Multiplexer and Demultiplexer, encoder and Decoder, Flip flops: RS, JK, Master slave, D and T.

UNIT V: Communication Electronics

Modulation and demodulation, needs for modulation , Amplitude modulation: Modulated wave equation, spectrum, band width, Power, methods of AM, SSB, DSBSC,VSB, ISB (Pilot carrier). demodulation of AM wave, super hetrodyne receiver. Frequency modulation: modulated wave equation, spectrum, band width, reactance method for producing FM, demodulation of FM wave, FM receiver. Pulse modulation: Sampling theorem, PAM, PWM, PCM.

Expected Learning Outcomes :A student of this course is expected to be able to understand the design and functional performance of electronic circuits using various semiconductor devices. In addition, the student will understand the functional properties and characteristics of semiconductor devices in analog & digital circuits using analog and digital signals.

Text Books :

1. Electronics: Fundamentals and Applications, D. Chattopadhyay and P. C. Rakshit, New Age International Pvt. Ltd.
2. Integrated Electronics : Analog andDigital Circuit and Systems, Millman & Halkias, Mc Graw Hill
3. Electronic Principles, Albert Malvino, McGraw Hill Education
4. Electronics Devices and Circuit Theory, Robert L. Boylestad, Pearson
5. Hand Book of Electronics, Gupta Kumar, Pragati Prakashan
6. Modern Digital Electronics, R. P. Jain, McGraw Hill Education

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

Course: PHY 203: OPEN CHOICE (FOR NON PHYSICS STUDENTS)

PHY 203A: BASIC ASTRONOMY

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives: Since this course is an open elective, with students from diverse background opting for it, theprimary objective is to impart a basic knowledge about the oldest branch of physical sciencethrough a conceptual mode, relying less on mathematics and more on physicalunderstanding. Since exciting new developments have been taking place in the astronomyof 20-th and 21-st centuries, with India playing crucial roles, the idea is to enable students tohave a flavour of both historical and modern aspects so that they acquire a perspective oftheir place in the universe.

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 Telescopes**
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. Variable stars as distance indicators.
Basic optics and optical telescopes, Detectors: photographic plate, Photo Multiplier Tube (PMT), Charge Coupled Device (CCD).

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, Classification scheme for external galaxies, Hubble's law.
The origin and evolution of universe, Standard and Alternate cosmologies.

Expected Learning Outcomes:A historical perspective of the development of Astronomy. Conceptual understanding of basicprinciples involved. A flavour of current developments in this field and India's role in them.Appreciation of laws of nature that are discovered on Earth but which explain successfullydistant cosmic objects and the universe as a whole.

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

PHY203B: BUILDING BLOCKS OF MATTER

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objective: The course is going to introduce the learners to the world of subatomic physics. This introduces the fundamental building blocks of matter along with an historical account of our understanding about them. The basic interactions in the universe are also going to be discussed along with theories those attempt to explain them. The open issues in this area is also going to be introduced.

UNIT I:
Historical Introduction: Discovery of electron, nucleus (idea of proton), neutron, neutrino.
Special Relativity: Lorentz transformation and covariance, relativistic momentum and mass-energy equivalence ($E = mc^{2)}$,
Quantum Mechanics: Wave-particle duality, wavefunction and probability, wave equations. Antiparticles. Natural Units

UNIT II:
Matter microscopes: Accelerators and colliders. Detectors, LHC, SuperKamiokande, LIGO

UNIT III:
Fundamental Interactions: Four fundamental forces, Quantum numbers. Conservation laws, Feynman diagrams, Particle decays.
Classification: Bosons and Fermions, Leptons and Hadrons. Mediators.
Quark Model:

UNIT IV:
The Standard Model od Particle Physics: QED, QCD, GWS,Higgs boson. Unification.
The motivation for going beyond Standard Model.
Theories beyond Standard Model: SUSY, Quantum Gravity, String theory.

UNIT V:
Big bang theory and evolution of the universe. Early universe, baryonic matter. Stellar evolution. Neutron stars and black holes. Galaxies, Dark matter. Accelerating universe, Dark energy.

Expected Learning Outcome: After completion of this course, the students are expected to have clear understanding at a qualitative level about the fundamental building blocks and also the basic interactions in nature.

Suggested reading:

1. D J Griffiths, Introduction to elementary particles, Wiley, 2008.
2. M Thomson, Modern Particle Physics, Cambridge, 2013.
3. P A Zyla et al (Particle Data Group), Review of Particle Physics, Prog. Theor. Exp. Phys. 2020, 083C01, 2020; see http://pdg.lbl.gov for particle listings, complete reviews, etc.
4. M K Sundaresan, Handbook of Particle Physics, CRC Press, 2001.
5. R J Bin-Stoyle, Eureka! Physics of Particles, Matter and the Universe, IOP Publishing, 1997.

PHY203C: PHYSICS AT NANOSCALE

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives:To introduce knowledge on basics of nanoscience and the fundamental concepts behind size reduction in various physical properties. More specifically, the student will be able to understand the different properties of materials in reduced scales.

UNIT I: Fundamentals of nanomaterial and nanotechnology. Concept of strong and weak quantum confinement. Semiconductor, metal nanomaterials, and their properties. Many-Body Finnis and Sinclair (FS) potentials, Many-Body Embedded-Atom Model (EAM) potentials.

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

UNIT III: Different characterization techniques. UV/VIS/IR spectroscopy, Photoluminescence, X-Ray diffraction, Microscopy techniques (TEM, SEM, AFM).

UNIT IV: Swift ion irradiation. Phase transitions in nano systems: Gibbs phase rule, comparison of phase transitions between small and large systems. Phase transition in small systems: Evaporation of water, micellization, crystallization.

UNIT V: Applications of nano materials: Light emitting and detecting device. Filter, photo voltaic cell, gas sensor, antibacterial element, drug delivery system, use of carbon nanotubes.

Expected Learning Outcomes : The learner will be able to comprehend the significance of nanoscience and nanotechnology and its applications in various fields. The students will have in-depth knowledge on the behavior of various class of materials in reduced dimensions.

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.
6. P. J. F. Harris, Carbon Nanotube Science - Synthesis, Properties and Applications, Cambridge University Press: Cambridge UK, 2009.

Reference books:

1. G. 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, Willey-VCH, 2003.

PHY203D: ELECTRONIC DEVICES AND CIRCUITS

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives:

The objective of this course is to introduce the learners to the basic concepts of semiconductor physics, understanding of semiconductor devices, and implementation of semiconductor devices in electronic circuits.

UNIT I: **Semiconductor**

Energy Bands in Crystals: Metal, Insulator, and Semiconductor; Intrinsic and Extrinsic Semiconductors; Current flow in semiconductors, Hall Effect, Diffusion.

UNIT II: **Semiconductor Devices**

P-N junction diode, Zener diode, LED, photodiode; BJT construction: PNP and NPN; Transistor operation: CB, CE and CC configuration.

UNIT III: **Rectifier, Amplifier and Oscillators**

Half wave, Full wave and Bridge rectifier; BJT amplifier, Op-Amp as amplifier; Colpitt's oscillator, Hartely oscillator, Phase shift oscillator, Wein bridge oscillator.

UNIT IV: **Digital Electronics**
Analog and digital signals; Binary number system, Decimal to binary conversion, Binary to decimal conversion; Logic gates: OR, AND, NOT and NAND gate; Boolean algebra, Boolean theorem; Sequential logic circuits: Flip flops: RS, JK, Master slave, D and T.

UNIT V: **Basic Communication System**
Need for modulation, Amplitude modulation: Analysis of amplitude modulated wave, sideband frequencies, Transistor AM modulator, Power in AM wave, Limitations of amplitude modulation, Demodulation: Essentials in demodulation, AM diode detector.
Frequency modulation: Theory of frequency modulation, Comparison of AM and FM; Pulse modulation: PAM, PWM, PCM. Elementary idea about radio communication

Expected learning outcome:
At the end of the course, student is expected to understand the working principle of different types of semiconductor devices and their implementation in electronic circuits.

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. J.G. Prokis, Digital communication 3rd Edn. Mc Graw Hill International.
5. H.S. Kalsi, Electronic Instrumentation, Tata McGraw-Hill, Company, New Delhi.

PHY204A: COMPUTATIONAL PHYSICS

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

UNIT I: **Introduction**
Process of numerical computing, characteristics of numerical computing, computing environment, introduction to computers and computing concepts, different number system, representation of integers and real numbers in computers, floating point representation, approximation and errors in computing.

UNIT II: **Linux and FORTRAN 77**
Introduction to Linux, simple Linux command, introduction to Fortran 77, structured programming, constants and variables, variable declaration, Input/ Output statements, control statements, intrinsic functions, file handling, simple Fortran programs.

UNIT III :**Roots of Non-linear Equations**
Evaluation of polynomials, Bisection method, false position method, Newton–Raphson method, secant method, fixed point method, multiple roots by Newton’s method, complex roots by Baristow method, Muller’s method.

UNIT IV: **Direct solution of Linear equations, Interpolation and Curve Fitting**
Basic Gauss elimination method, Gauss elimination with pivoting, Gauss-Jordan method, LU decomposition methods, matrix inverse method, Langrage interpolation, Newton interpolation, least square regression.

UNIT V: **Numerical Integration and Solution of differential equations**
Integration through Langrage's polynomial interpolation, trapezoidal, Simpson's rule, Gaussian integration, solution of differential equation by Taylor's method, Picard's method,
Fourth order Runge-Kutta method.

Reference Books:

1. Fortran 77 and Numerical methods C Xavier, New Age
2. Numerical methods E. Balagurusamy, Tata McGraw Hill
3. Numerical recopies in Fortran W.H. Press et. al, Cambridge University Press

PHY204B: PLASMA PHYSICS

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 6**

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives: Plasma physics is an important subject for a large number of research areas, including space plasma physics, solar physics, astrophysics, controlled fusion research, high-power laser physics, plasma processing, and many areas of experimental physics. The primary learning outcome for this course is for the students to learn the basic principles and main equations of plasma physics, at an introductory level, with emphasis on topics of broad applicability.

UNIT I
Definition and properties of plasma, Plasma production in laboratory and diagnostics. Microscopic description, Motion of a charged particle in electric and magnetic fields-curvature, gradient and external force drifts. Controlled thermonuclear devices, magnetically confined open and closed systems (linear pinch, mirror machine and Tokamak). Laser-plasmas: inertially confined system.

UNIT II
Statistical description of plasmas, B.B.G.K.Y. hierarchy of equations, Boltzmann-Vlasov equation, Equivalence of particle orbit theory and the Vlasov equation, Boltzmann and landau collision integral H-theorem, B.G.K. model, Fokker-Planck term, Solution of Boltzmann equation (brief outline), Transport coefficient-electrical conductivity, diffusion.

UNIT III
Small amplitude plasma oscillations. Oscillations in warm field free plasma. Landau damping. Nyquist method-Penrose criterion of stability. Two stream stability (linear and quasi linear theory). Vlasov theory of magnetized plasma. Loss cone instabilitly. Quasilinear theory of gently bump instability. Non-linear electrostatic waves, BCK waves.

UNIT IV
Fluid description of plasmas, Moment equations. MHD equations. Generalized Ohm's law, flux conservation, Decay of fields. Pressure balanced and force free fields. Alfven waves, Dissipative effect, Magneto-acoustic waves, Hydro-magnetic shocks, KDV equation, Linear and nonlinear ion-acoustic waves, dusty and strongly coupled Plasma

UNIT V
Magneto-hydrodynamic instabilities, Energy principle, Normal mode analysis and its application to Rayleigh-Tayler and Kelvin Helmholtz instabilities, Pinch instability, Jean's instability.

Course Learning Outcomes :
On completion of the course the student shall be able to: Define, using fundamental plasma parameters, under what conditions an ionised gas consisting of charged particles (electrons and ions) can be treated as a plasma. Distinguish the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena.

Suggested Readings :
1. Introduction to Plasma Physics, F. F. Chen (Plenum Press, 1984)
2. Principles of Plasma Physics, N. A. Krall and Trivelpiece (San Fransisco Press, 1986)
3. Physics of High temperature Plasmas, G. Schimdt (2ndEd., Academic Press, 1979)
4. The framework of Plasma Physics, R.D. Hazeltine & F.L. Waelbroeck (Perseus Books, 1998)
5. Introduction to Plasma Physics, R.J. Goldston and P.H. Rutherford (IOP, 1995)
6. Fundamentals of Plasma Physics J ABittencourt (Springer

PHY204C: INSTRUMENTATION

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 6

(All units carry equal marks of 14. Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

Course Objectives: The aim of this course is to train the students on the workings of various instruments that are routinely used during research in different branches of experimental physics.

UNIT I: **Basics of Circuits and Measurement Systems**
Kirchoff's laws, mesh and nodal Analysis. Circuit theorems. One-port and two-port Network Functions. Static and dynamic characteristics of Measurement Systems. Error and uncertainty analysis. Statistical analysis of data and curve fitting.

UNIT II**: Transducer and digital signal processing**
Transducer: classifications, ideal characteristics. Different types of transducers: Optoelectronic transducer, Temperature sensor, Pressure sensor, Flow meter, Displacement transducer and Humidity sensor**.**

UNIT III: **Electrical and Electronic Measurements**
Bridges and potentiometers. Electromechanical indicating instruments – AC/DC current and voltage meters, ohmmeter; Loading effect; Measurement of power and energy; Instrument transformers; Measurement of resistance, inductance and capacitance; Q-meter and waveform analyser; Cathode ray oscilloscope.

UNIT IV: **Analytical Instrumentation**
Spectroscopy and spectral methods of analysis. Spectrophotometers- basic principle and uses: UV/VIS, Photoluminescence, FT-IR, Raman spectroscopy, X-Ray diffraction, NMR, AAS. Electron Microscope: Basic principle, different types of Electron Microscopes (SEM, TEM), their advantages and uses.

UNIT V: **Vacuum Systems**
Introduction, different types of pumps: rotary, diffusion, turbo molecular and cryo pumps. Measurement of low pressure: Pirani, penning, hot cathode gauges, partial pressure measurements, leak detection, gas flow through pipes and apertures.

Expected learning outcome: After completion of the course, students will be well versed in various experimental techniques that will be of immense help while pursuing research in experimental physics.

Text Books:

1. D. Patranabis, Principle of Industrial Instrumentation, Tata McGraw-Hill, Publishing Company, New Delhi.
2. D.V.S Murthy, Transducers and Instrumentation, Prentice – Hall of India.
3. Albert D. Helfrick& William D. Cooper, Modern Electronic Instrumentation & Measurement Techniques, Prentice – Hall of India.
4. D. Patranabis, Sensors and Transducers, Prentice – Hall of India.
5. Hermann and Neubert, Instrument Transducers an Introduction to their Performance and design, Oxford University Press.
6. H.S. Kalsi, Electronic Instrumentation, Tata McGraw-Hill, Company, New Delhi.
7. C.S. Rangan, G.R. Sarma, V.S.V. Mani, Instrumentation, Devices and System, Tata McGraw-Hill, Company, New Delhi.
8. A. Roth, Vacuum Technology, Elsevier: Amsterdam, 1998.
9. V. V. Rao, T. B. Ghosh, K. L. Chopra, Vacuum Science and Technology, Allied Publishers: New Delhi, 2008.
10. R.L. Boylestad and L. Nasheisky, Electronic Devices and Circuit Theory, PHI, 6e, 2001.
11. R.J. Smith and R.C. Dorf, Circuits, Devices and Systems, John Wiley & Sons, 1992.

Course: PHY 205: ELECTRONICS LABORATORY

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 6**

1. To study the following Diode characteristics
   a) Si
   b) LED
   c) Photo diode
2. To study the characteristics of a Zener diode and its use as a voltage regulator
3. To study series voltage regulator using CL-100, BC-547 (OP-AMP 741)
4. To study a fixed/variable power supply using (78XX, OP-AMP 723) with current booster.
5. To study Transistor characteristics of CE configuration and to find the parameters for the same.
6. To study the Drain and Transfer characteristics for the given FET and to find the Drain resistance and trans-conductance.

7. To design and implement the RC coupled single stage amplifier and to find
   a) Cut-off frequencies
   b) Band width
   c) Mid band gain
   d) Input/output impedance
8. To design and implement the JFET single stage (common drain) amplifier and to find
   a) Cut-off frequencies
   b) Band width
   c) Mid band gain
   d) Input/output impedance
9. To design and test the (current series/voltage series/current shunt / voltage shunt) feedback and calculate the following parameters with and without feedback
   a) Cut-off frequencies
   b) Band width
   c) Mid band gain
   d) Input/output impedance
10. To design and construct a (Wein bridge/phase shift) oscillator for a given cut-off frequency.
11. To determine the following characteristics of an OP-AMP
   a) Input off-set voltage
   b) Input bias current
   c) Slew rate
   d) Bandwidth
12. To study the following linear application of OP-AMP
   a) Voltage follower
   b) Inverting amplifier
   c) Non-inverting amplifier
   d) Adder
   e) Substractor
   f) Differential amplifier
   g) Instrumentation amplifier
13. To design a suitable circuit to study the following non-linear applications of OP-AMP
   a) Comparator
   b) Schmitt trigger
14. To study OP-AMP as
   a) Sine wave generator
   b) Square wave generator
   c) Triangular wave generator
15. To design and test a 2nd order low pass and high pass filter using OP-AMP
16. To study the operation of DAC using IC 741
17. To study IC 555 as astable multivibrator.
18. To study various Logic gate circuits and Simplify Boolean Expression using Karnaugh maps and realize the resultant expression using logic gates.
19. To study the truth table of half adder and full adder using logic gates also add two two bits

numbers like 11 and 10.

20. To study the truth table of half subtractor and full subtractor using logic gates also subtract two bits numbers like 11 and 10.

21. To study the truth table of a encoder and a decoder using logic gates.

22. To design and implement a 4:1 Multiplexer and 1:4 Demultiplexer using Logic gates.

23. To study the operation of the following Flip Flops and verify their truth table

    a) SR F/F

    b) JK F/F

    c) D F/F

    d) T F/F

    e) JK Master Slave F/F

24. To Study the truth table of 2 bits,3 bits and 4 bits ripple counter