AUS PG Physics Syllabus (as per NEP-2020)

Implemented from 2022-23 session

Semester I				Semester II			
Code	Name of the paper	Type	Credit	Code	Name of the paper	Type	Credit
PHY 500	Orientation	Orientation	0				
PHY 501	Mathematical Physics	Core	4	PHY 551	Electromagnetic Theory	Core	4
PHY 502	Classical Mechanics	Core	4	PHY 552	Advanced Quantum Mechanics	Core	4
PHY503	Quantum Mechanics	Core	4	PHY 553	Atomic, Molecular and Laser Physics	Core	4
PHY 504	A: Scilab (through Spoken Tutorial, IIT-B) B: Learning Electronics through software C: Biomedical Imaging Instrumentation * any other feasible MOOCs course	SEC (Offline/ MOOCs)	3	PHY 554	A: Electronics and Solid State Physics (For Physics and non-physics students) B: Basic Astronomy (For non-physics students) C: Physics at Nanoscale (For non-physics students)	IDC	3
PHY 505	General Laboratory	ALIF	3	PHY 555	Electronics Laboratory	ALIF	3
PHY 506	CCEC	CCEC	2	PHY 556	A.Introduction to ethics, responsibilities, and values in profession * any other feasible MOOCs Course	VBC (Offline/ MOOCs)	2
Semester III				Semester IV			
PHY 601	Advanced Mathematical Physics	Core/ Elective	4	PHY 651	Statistical Mechanics	Core	4
PHY 602	A. Atmospheric Physics B. Physics of Plasma C. Computational Physics * any other feasible MOOCs course	IDC (Offline/ MOOCs)	4	PHY 652	Nuclear & Particle Physics	Core	4
PHY 603	A. Particle Physics B. Astrophysics I C. Condensed Matter Physics I D. Non-Linear Optics * any other feasible MOOCs course	Elective (Offline/ MOOCs)	4	PHY 653	A: High Energy Physics B: Astrophysics II C: Condensed Matter Physics II D: Laser Spectroscopy * any other feasible MOOCs course	Elective (Offline/ MOOCs)	4
PHY 604	A. Lab on Particle Physics B. Lab on Astrophysics I C. Lab on Condensed Matter Physics I D. Lab on non-linear optics * any other lab course corresponding to the MOOCs course 603.	ALIF	3	PHY 654	Research Project – Part II		8
PHY 605	Research Project – Part I	Elective	5				

*Maximum credit that can be earned through MOOCs is 16.

* Lateral exit is allowed after successful completion of first two semesters. Lateral entry to the 3rd semester of the program is subject to the availability of seats.

SEMESTER I

Course: PHY 501: MATHEMATICAL PHYSICS

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 4

(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 well posedness.

Green's function technique for solution of Differential equations.

Legendre, Hermite, Laguerre and Bessel 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.

Fourier transforms and its applications, 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 and Numerical methods

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

Finite difference, Interpolation and extrapolation (forward, backward and central), Roots of functions, Integration by trapezoidal and Simpson's rule, Solution of 1st order differential equation using Euler and2^{nd} 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 502: CLASSICAL MECHANICS

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 4**
(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. 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 II: 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. Hamilton's principle, Lagrange's equations from Hamilton's principle, Hamilton's principle for non-holonomic systems. Symmetry principles and conservation 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 coordinate. 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 503: QUANTUM MECHANICS

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 4**

(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: 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: Time-independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Starkeffect,and other simple cases.
Variational method and applications to helium atom and simple cases.

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: PHY 504:
(SKILL ENHANCEMENT COURSE, IDC)

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 3**
(Two questions of equal marks will be set from each unit. Students require to answer one question from each unit.)

A: Scilab

Course Objectives: Aims at teaching students various aspects of the computational software Scilab and training them in writing codes for numerical scientific computation and simulation.

Course to be conducted by Spoken Tutorial, IIT-B.
Syllabus: https://onlinecourses.swayam2.ac.in/aic20_sp38/preview

+N.B.

The Spoken Tutorial Project is funded by the National Mission on Education through Information and Communication Technology (ICT), launched by Ministry of Education, erstwhile Ministry of Human Resources and Development, Government of India.

Course outcomes: The students are expected to have thorough familiarity with Scilab and write codes for various numerical computations and simulations.

B: Learning Electronics through software

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 3**
(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: (a) learning electronics through software fill the gaps between the theoretical and practical approach of understanding electronic devices. Through this software students can achieve the knowledge about the working of electronic devices without going to the laboratory. (b) To develop the skills of the students in designing and analyzing the electrical/electronic circuit.

UNIT I:
Introduction to MultiSim, characteristics curve of a Diode, different types of rectifier circuit, clipper and clamper circuit, power supply, characteristics curve of a transistor (BJT/FET), Lab based on above topics.

UNIT II:
Single/two stage RC coupled amplifier using the given transistor, frequency response of the given amplifier, OP-AMP and its applications, oscillator, Lab based on above topics.

UNIT III:
Boolean expression, logic gates, Design half and full adder and subtractor, multiplexer, decoder, demultiplexer, flip-flops, countersand shift register using MultiSim, Lab based on above topics.

UNIT IV:
P-N junction model and diode working principle, I-V characteristics of solar cell, Equivalent circuit of solar cell, Fill factor, Fabrication process of semiconductor grade silicon, single crystalline silicon. Thin film deposition techniques, Thin film solar cell: amorphous silicon. Simulation of homo junction solar cells (Si-based solar cell).

UNIT V:
Physics of bulk hetero junction solar cells, Perovskite solar cell, Photophysics of perovskite solar cell, fabrication process, stability, morphology optimization, Single crystal perovskite solar cell. Simulation of hetero junction solar cell (perovskite solar cells).

Expected Learning Outcomes: Students will be able to design, develop, analyze, and model electronic circuits using proprietary/free software.

Texts/ References:
1) Electronic Principles (SIE), Albert Malvino, David J. Bates, McGraw Hill Education; 7th edition (1 July 2017). ISBN: 978-0070634244.
2) Electronics Devices and Circuit Theory Boylestad, Robert L. Pearson Publication, New Delhi, 2015. ISBN: 978-8131727003
3) Solar Cells: Operating Principles, Technology and System Applications, Martin A Green, Prentice Hall, 1981, ISBN-13: 978-0858235809.
4) Solar Cell Device Physics, Stephen J. Fonash, Academic Press, 2009, ISBN 978-0-12-374774-7

C. Biomedical Imaging Instrumentation

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 3**

Course Objectives: To teach the basic principles of biomedical imaging systems and their instrumentation used as diagnostics tools in medical science.

UNIT I: **Marks 14**
Introduction to Biomedical imaging, Signal system review, Image quality metrics.
Working principle of electrocardiograph (EGG), normal ECG waves, application of EGC.
Ultrasonic Imaging Systems: Physics of Ultrasonic waves, Doppler Effect, Types of Ultrasonic Imaging.

UNIT II: **Marks 14**

X- ray Instruments and Digital Radiography: Fundamentals of radiation, Generation of X-ray, detection of x-ray, Instrumentation for diagnostic X-rays, X-ray Images Using special techniques.

X-ray computed tomography: Principle of Computed tomography scan, CTscan of the body. Mathematical basis of Image construction, Limitations of CT scan, its advantages, disadvantages, and application.

UNIT III: **Marks 14**

Magnetic Resonance Imaging: Principle of MRI system, MRI instrumentation, Precautions to be taken before MRI scanning, MRI test procedure, advantages and disadvantages of MRI.

Nuclear Medical Imaging: Radioisotopes in medical diagnosis, physics of radioactivity. Gamma Camera, Principles of SPECT and PET scans - Instrumentation.

UNIT IV: **Marks 28**

Hand-on Training in the use of instruments/machines mentioned in Unit I – III.

Expected Learning Outcomes: Be able to analyse systems physical mechanisms, quality of data generation, acquisition and image formation while handling instruments.

Reference Text Books

1. Medical Imaging Signals and systems, JL Prince and J M Links, Pearson Prentice Hall, 2006
2. Biomedical Instrumentation and measurements, R Anandanatarajan, PHI
3. Handbook of Biomedical Instrumentation, RS Khandpur, Tata McGraw Hill.

Course: PHY 505:

GENERAL LABORATORY

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 3**

Course Objectives: Aims at performing some basic experiments in physics to observe and study some physical phenomena by students.

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.

Expected outcome: The students performing the experiments will experience results that justify theoretical understanding of Physics.

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

Course: PHY 506:

Compulsory Community Engagement

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 2**

- A total 60 hours of direct field work and 15 hours for preparation/ reporting etc.
- Community service to be undertaken by students under the supervision of mentors assigned by the department.
- Mentors may decide at departmental level on the nature of community service the students will engage. Before going to the CCEC program, each student/group of students shall submit a brief proposal to the mentor mentioning the plan of work to be under taken.
- Students require to maintain a field book where they are to keep a record of their readings from e-content and reflection from field visits along with a detail record of the activities undertaken in their entire period and submit the same to the department through their mentors for periodic assessments.
- The evaluation of the course will be done by a committee comprised of the mentor and CCEC teacher in charge of the Department.

SEMESTER II

Course: PHY 551: ELECTROMAGNETIC THEORY

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 4**

(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 introduce some aspects of electromagnetic theory along with special relativity theory and plasma.

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 outcome: The students are expected to get familiarized with basic ideas of electromagnetic radiation and scattering and also to be able to perform relativistic calculations using four vectors

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 San Francisco.

Course: PHY 552: ADVANCED QUANTUM MECHANICS

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 4**

(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 expose students to techniques and ideas of advanced quantum mechanics.

UNIT I:
WKB approximation, connection formulae, quantization condition and its applications, barrier penetration and tunneling,
Time dependent perturbation theory – Fermi Golden rule, Harmonic perturbation – Adiabatic and sudden approximations, Absorption and emission of Radiation–Einstein's A,B coefficients – selection rules.

UNIT II:
Scattering Theory I: Amplitude and cross-section, Scattering from 3-D hard sphere and Rutherford scattering, Laboratory frame and center of mass frame, Quantum theory of scattering: potential waves and phase shifts, n-p scattering at low energies, Resonance scattering-Breit-Wigner formula, s-wave scattering, Ramsauer-Townsend effect, scattering from delta potential,

UNIT III:
Scattering Theory II: Inelastic scattering, general optical theorem, Integral equations for scattering, Green's functions, Born approximation and its validity, Scattering from a square well potential, Coulomb scattering, Scattering of identical particles.

UNIT IV:
Attempt for relativistic formulation of Quantum Mechanics, Klein-Gordon equation and its significance, Klein-Gordon equation in presence of electromagnetic field and its non-relativistic reduction, Dirac equation for a free particle, properties of Dirac matrices and algebra for gamma matrices, Solution of the free particle, orthogonality and completeness relation for Dirac spinors, fine structure of hydrogen atom, interpretation of negative energy solution and hole theory.

UNIT V:
Systems with infinite degrees of freedom, Classical fields, Equations of motion, Hamiltonian. Symmetries and invariance principles – Noether's Theorem.
Canonical quantization of scalar field – creation, annihilation operators, equal time commutation relations. Interpretation of the quantized field – number operator, connection with harmonic oscillator.
Introduction to Quantum entanglement.

Expected learning outcome: This course should create a good base to understand the different physical phenomena at quantum level.

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)
12. D J Griffiths, Introduction to Quantum Mechanics, Cambridge (2018)

Course: PHY 553: ATOMIC, MOLECULAR AND LASER PHYSICS

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 4**
(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 enable students to understand the concepts and theory of different types of atomic and molecular spectra. This course also aims to introduce students to the basics of lasers.

UNIT I:
Hydrogen fine structure, Relativistic correction, Spin-Orbit interaction, Lamb shift. Spectra of alkali atoms: characteristic features, term value and quantum defect, doublet structures, Selection and intensity rules.
LS and JJ coupling schemes, derivation of spectral terms under these schemes, Lande Interval rule. Singlet and triplet series in two valence electron system, Spectra of Helium atom.

UNIT II:
Lande g formula, Zeeman effect, Paschen-Back effect, Stark effect in Hydrogen atom. Hyperfine structure, Zeeman and Back-Goudsmit effects in hyperfine structure.
Breadth of spectral lines: natural broadening, Doppler broadening, collision broadening and Stark broadening. Oscillator strength. Hatree's SCF method for many electron atoms.

UNIT III:
Born-Oppenheimer approximation, Origin of molecular spectra.
Microwave Spectroscopy: Rotational Spectra (Rigid and non-rigid rotator approximations) of diatomic molecule, Isotopic effect on rotational spectra.
IR Spectroscopy: Vibrational spectra (Harmonic and anharmonic approximations) in diatomic molecules, Isotopic effect, Rotational-Vibrational spectra.

UNIT IV:
UV Spectroscopy: Electronic spectra in emission and absorption, progressions and sequences of vibrational bands, Frank-Condon Principle.
Vibrational and rotational structures of electronic bands, Isotopic effect on electronic spectra, Molecular electronic states.
Classical theory of Raman effect, Vibrational Raman spectrum, selection rules, Stokes and anti-Stokes lines, Rotational Raman spectrum, selection rule.

UNIT V:
Lasers: Basic elements, properties of laser light, Einstein's coefficients, Requisites for producing laser light, threshold condition for lasing.
Laser rate equations: two, three and four level systems, Optical resonators. Ammonia beam maser, He-Ne laser, Solid state laser, Gas lasers, Free electron laser, Semiconductor lasers, Laser applications.

Expected Learning Outcomes: After the completion of the course, students will be able to (1) explain the hydrogen fine-structure and spectra of alkali atoms. (2) explain the coupling schemes and derive spectral terms (3) know to the effect of external fields (electric and magnetic) on atomic spectra (4) explain the origin of molecular spectra and different types of molecular spectra (5) know the basics of lasers, types of lasers and their applications

References:
1. H E White, Introduction to Atomic Spectra, McGrawHill Book Company.
2. B H Bransden and C J Joachain, Physics of atoms and Molecules, Pearson Education
3. C N Banwell, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill
4. BPStraughan and SWalker, Spectroscopy Volume I, John Wiley & Sons, Inc, New York.
5. K Thyagarajan and A K Ghatak, Lasers: Theory and Application, Plenum Press, New York and London.
6.SL Gupta, V Kumar, RC Sharma, Elements of Spectroscopy, Pragati Prakashan, Meerut.
7. Raj Kumar, Atomic & Molecular Spectra: Laser, Meerut.

Course: PHY 554:

A. **ELECTRONICS AND SOLIDSTATE PHYSICS** (For Physics and non-physics students)

Marks: 100 (Internal Assessment 30; Final: 70) Credit:3
(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.)

ELECTRONICS

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:
Direct and indirect band gap semiconductors, Band structure of p-n junction; Homo and hetero-junction devices. Field Effect Transistor: JFET, MOSFET construction, operation and characteristics. SCR, UJT: construction, working and applications. Opto Electronic Devices: Construction, operation and characteristics of Solar Cell, Photodetectors, LED, Laser Diodes. Quantum mechanical phenomenon and tunnel diode, transferred electron effect and Gunn Diode; Noise in electronic devices.

UNIT II:
OP AMPS: block diagram and pin configuration, elementary idea of Differential Amplifier Circuit, CMMR, Slew rate. DC offset parameters, frequency parameters, inverting amplifier, concept of virtual ground, non - inverting amplifier. OP AMP as adder, substractor, differentiator, integrator, differential amplifier, unity gain amplifier, logarithmic amplifiers, comparator, Schmitt Trigger, Activefilters. 555 timer and its use as an astable, monostable and bistable multivibrator.

UNIT III:
Logic gates: RTL, DTL, TTL, ECL, CMOS families, Adder and subtractor (half and full), Multiplexer and Demultiplexer, encoder and Decoder, Flip flops: RS, JK, Master slave, D and T. Clocked Flip-flops, Preset and Clear Operations, Race-around condition in JK Flip - Flop. Register: Counters: ripple Counters, Synchronous counters, Ring Counters. A/D and D/A counters,Microprocessor and microcontroller basics.

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.

SOLID STATE PHYSICS

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. 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. Defects and dislocation in crystals: Lattice defects, Point defects, Colourcentres, dislocations, Burgers vector.

UNIT II:

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. Distinction between metals, insulators and semiconductors. Hall effect, Application of Hall Effect.

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. 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
7. Digital Computer Electronics , A.P. Malvino, Tata- McGraw Hill

B. BASIC ASTRONOMY (For non-Physics students)

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 3**

(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 course aims to provide students with a comprehensive understanding of Basic Astronomy.

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: Upon completion of the course, students will be able to demonstrate an understanding of the fundamental principles and concepts in the field, as well as the ability to apply them to analyze and interpret astronomical observations and data. They will also gain proficiency in using telescopes and detectors, and be able to communicate effectively about astronomical topics.

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.

C. PHYSICS AT NANO SCALE (For non-Physics students)

Marks: 100 (Internal Assessment 30; Final: 70) **Credit: 3**

(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 teach fundamentals of nanomaterials and nanotechnology, the physical phenomena occurring at the nanoscale, various synthesis methods of nanomaterials and their characterization techniques, and some of the potential applications of these materials.

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 students are expected to get familiarized with the fundamentals of nanomaterials and nanotechnology.

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

Course: PHY 555: ELCETRONICS LABORATORY

Marks: 100 (Internal Assessment 30; Final: 70) Credit: 3

Course Objectives: To learn and understand electronics circuit components and applications of these components to design analog and digital circuits.

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) Substractorf) 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) SRF/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

Expected outcome of course: After completing this course, a student is expected to design, develop, and analyze some of the basic electronic circuits in the laboratory.

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

Course: PHY 556

A. Introduction to ethics, responsibilities and values in profession

Marks: 100 (Internal Assessment 30; Final: 70) Credit:2

(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 aims to train students with some essentials of ethics, responsibilities, management and values in professional and day to day life.

UNIT I: Ethics

Ethics and Human Values: Ethics and Values, Ethical Vision, Nature of Ethics, Profession and Professionalism, Professional Ethics, Code of Ethics, Ethical Decisions, Human Values – Classification of Values, Universality of Values

CSR: Conceptual bases, socially responsible leadership and CSR' role in corporate governance, Basic initiatives in the field of CSR and sustainable development. Features of CSR of multinational corporations.

Professional ethics - Profession and its moral value in life, Profession- skill needed, Profession and ethics- commitment, honesty, accountability, Professional integrity, transparency, confidentiality, objectivity, respect, obedience to the law and loyalty.

UNIT II: Ethics in Science and Research

Intellectual Honesty & Research Integrity: Scientific Misconducts, Publication Ethics, Conflict of Interest; Publication Misconduct, Violation of Publication Ethics, Authorship and Contributor ship; Identification of Publication Misconduct, Complacent & Appeals Predatory Publishers & Journals

Vice of Plagiarism, the concept of Fair Use and Fair Dealing in Copyright, Need for awareness of values and ethics in Scientific Research , Laboratory Ethics

Ethical issues in Physics.

UNIT III: Self-Management

Self-Evaluation, Self-Discipline, Self-Criticism, Recognition of one's own limits and deficiencies, Independency, Thoughtful & Responsible, Identifying one's strengths and weakness, Planning & Goal setting, Managing self – emotions, ego, pride.

Therapeutic Measures for control over the mi nd : (a)Simple physical exercise (b) Meditation – Objectives, types, effect on body, mind and soul (c) Yoga – Objectives, Types, Asanas (d) Activities: (i) Sublimation of Desires (ii) Neutralisation of Anger (iii)Eradication of Worries (iv)Benefits of Blessings

UNIT IV: Gender issues

Sex-differences, Gender Bias. Sexual harassment of women in workplace and other public places, Domestic violence against women, Violation of the rights of women.

Gender issues in academics and academic institutions with special reference to STEM. Gender bias in Physics.

UNIT V: Climate Change and our responsibilities
Climate change. Tracers. Climate change science: early discoveries, energy balance model with GHGs. Introduction to Impacts – Impacts, adaptation, and vulnerability, Role of human. Climate policies, Sustainability and development

Expected Learning Outcomes: After completion of the course a student will be able to step into professional world equipped with right attitude and values**.**

Suggested Readings:

Open sources.

B. MOOC course to be selected by the department based on availability.