Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS), PUNE

Syllabus
for

T. Y. B. Sc. (Physics)

[Pattern 2019]
(B.Sc. Semester-V and VI)

With Effect From
2021-2022

Preamble:

Fergusson College is awarded academic autonomy by the UGC beginning the year 2016-17. This autonomy is for a period of six years. We shall be following the semester pattern for academic transactions and the Credit Based Assessment System will be followed for assessment. The curriculum for the graduate programme in Physics is designed to cater to the requirements of the Autonomy and the Credit system following the UGC guidelines.

Physics is one of the oldest branches of natural sciences. It forms the foundation of the scientific process.

The programme is aimed to be more learning centric than teaching centric. The courses are designed so that a student progressively develops a deeper understanding of various aspects of physics.

Physics is learnt more through experimentation than only through classroom sessions. The experiments are designed to develop logical thinking and analytical ability. Reading between lines is important and some open ended experiments, assignments and small projects are designed to develop these skills.

Continuous assessment is an integral part of the credit system. This will help students learn their subjects systematically and thoroughly.

The under graduate programme in Physics is spread over three years with two semesters every year. There will be two theory courses and one laboratory course each semester for the first and the second year. For the third year, there will be six theory courses and three laboratory courses each semester.

Objectives:

1. To explore different areas of physics.
2. To develop theoretical foundation and experimental skills to study various natural phenomena.
3. To train students for in depth study of physics.
4. To encourage students to explore applications of physics in various walks of life.
5. To inculcate research culture by introducing projects at the final year of the course.

Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS), PUNE 411004
Structure of T. Y. B. Sc. (PHYSICS)
Under CBCS pattern (2019) *effective from June 2021*

Year	Paper No.	Course Code	Title	Credits	CE Max Marks	ESE Max Marks	Total Max Marks
T.Y. B. Sc.	**Semester V**						
	DSE-1A	PHY3501	Mathematical Methods in Physics	2	50	50	100
	DSE-1B	PHY3502	Solid States Physics	2	50	50	100
	DSE-2A	PHY3503	Classical Mechanics	2	50	50	100
	DSE-2B	PHY3504	Atomic and Molecular Physics	2	50	50	100
	DSE-3A	PHY3505	Elements of Materials Science	2	50	50	100
	DSE-3B[#]	PHY3506	**Elective I (Select any One)** LASERS	2	50	50	100
	DSE-1	PHY3507	Physics Practical – I	2	50	50	100
	DSE-2	PHY3508	Physics Practical – II	2	50	50	100
	DSE-3	PHY3509	Physics Practical – III	2	50	50	100
	SEC-1*	PHY3511	Analog Electronics	2	50	50	100
	SEC-2*	PHY3512	Numerical Analysis	2	50	50	100
	DSE-3B[#]	PHY3513	Radiation Physics	2	50	50	100
	DSE-3B[#]	PHY3514	Biophysics	2	50	50	100
			Total credits	**22**			**1100**

[#] Students may select **ANY ONE** subject out of **PHY3506, PHY3513** and **PHY3514**.

Year	Paper No.	Course Code	Title	Credits	CE Max Marks	ESE Max Marks	Total Max Marks
	Semester VI						
T.Y. B.Sc.	DSE-1A	PHY3601	Classical Electrodynamics	2	50	50	100
	DSE-1B	PHY3602	Quantum Mechanics	2	50	50	100
	DSE-2A	PHY3603	Thermodynamics and Statistical Mechanics	2	50	50	100
	DSE-2B	PHY3604	Nuclear Physics	2	50	50	100
	DSE-3A	PHY3605	Astronomy & Astrophysics	2	50	50	100
	DSE-3B[#]	PHY3606	**Elective II (Select any One)** Energy Studies	2	50	50	100
	DSE-1	PHY3607	Physics Practical – IV	2	50	50	100
	DSE-2	PHY3608	Physics Practical – V	2	50	50	100
	DSE-3	PHY3609	Physics Practical - VI **(Project)**	2	50	50	100
	SEC-1*	PHY3611	Digital Electronics	2	50	50	100
	SEC-2*	PHY3612	C-programming	2	50	50	100
	DSE-3B[#]	PHY3613	Biomedical Instrumentation	2	50	50	100
	DSE-3B[#]	PHY3614	Physics of Nanomaterials	2	50	50	100
			Total credits	**22**			**1100**

[#] Students may select **ANY ONE** subject out of **PHY3606, PHY3613** and **PHY3614**.

* ***For SEC courses – CE and ESE exam will be conducted by the department. It will not be conducted centrally***.

Note:

1. **DSE (Department Specific Elective**) - 12 Courses selected by the department. The list provided by UGC CBCS pattern for T. Y. B. Sc. is suggestive in nature and each department has a complete freedom to suggest their own papers under this category based on expertise, specialization, requirements, scope and need.

2. **SEC (Skill Enhancement courses)** - Minimum 4 for T. Y. B. Sc. These courses may be chosen from pool of courses designed to provide value-based and/or Skill-based knowledge and may contain both theory and lab/hands-on-training/field work. The main purpose of these courses is to equip students with Life-Skills/Entrepreneurship/ Professional Ethics/Human Values/ Environment and Sustainability/Research Methodology/Intellectual Property Rights so as to increase their employability. The list provided by UGC is suggestive in nature and each department has freedom to suggest their own papers under this category based on expertise, specialization, requirements, scope and need.

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	**MATHEMATICAL METHODS IN PHYSICS - PHY3501**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall the knowledge of calculus, vectors, vector calculus.	
CO2	Illustrate methods of solving partial differential equations with the examples of important partial differential equations in Physics.	
CO3	Apply the various methods for solving differential equations in various physical problems such as in quantum mechanics, which they will learn in future courses in detail.	
CO4	Explain the Fourier analysis of periodic functions and reconstruct physical problems such as vibrating strings etc.	
CO5	Determine transformation equations and construct various coordinate systems. Compare cartesian, spherical and cylindrical coordinate systems.	
CO6	Formulate the special functions, such as the Hermite polynomials, the Legendre polynomials and Bessel functions and their differential equations.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Vector Integration and Multiple integrals:** Multiple Integrals: Double and Triple Integrals, Change of Order of Integration. Change of Variables and Jacobian. Applications of Multiple Integrals: (1) Area Enclosed by Plane Curves, (2) Area of a Curved Surface, (3) Volumes of Solids. Ordinary Integral of Vectors. Line, Surface and Volume Integrals. Flux of a Vector Field. Gauss' Divergence Theorem, Green's Theorem and Stokes Theorem.	**8**
II	**Orthogonal Curvilinear Coordinates**: Introduction to Cartesian, Spherical polar and cylindrical coordinate systems, transformation equations, General Curvilinear coordinate system: Coordinate surface, co-ordinate lines, length, surfaces and volume elements in curvilinear coordinate system, metric coefficient. Orthogonal Curvilinear coordinate system, Expressions for gradient, divergence, Laplacian and Curl, special case for gradient, divergence, Laplacian and curl in cartesian, spherical polar and cylindrical coordinate system.	**10**
III	**Partial differential equations**: Frequently occurring partial differential equations, degree, order, linearity and homogeneity (revision), Method of separation of variables, Frobenius method for power series solution of Legendre, Hermite and Bessel differential equations.	**12**
IV	**Fourier series:** Orthogonality of Sine and Cosine Functions. Fourier Series and Fourier transform. Dirichlet Conditions (Statement only). Kronecker's Method for Computation of Fourier Coefficients. Even and Odd Functions.	**6**

References:

1. Mathematical methods for physicists - Arfken and Weber, Academic Press New York.
2. Mathematical Physics - Rajput, Pragati Prakashan
3. Mathematical methods in the physical sciences - Mary L. Boas, John Willy and sons publication.
4. Mathematical Physics - B. D. Gupta, 4th edition. Vikas Publishing House Pvt. Ltd
5. Mathematical Physics - H. K. Dass, Rama Verma, S. Chand & Company Pvt. Ltd.

Title of the Course and Course Code	**SOLID STATE PHYSICS - PHY3502**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	List seven crystal systems.	
CO2	Explain free electron theory and band theory.	
CO3	Calculate lattice parameter from given XRD pattern.	
CO4	Identify the structure of materials.	
CO5	Evaluate the density of state equation in 3D.	
CO6	Specify the importance of magnetic materials.	

Unit. No.	**Title of Unit and Contents**	**No. of Lectures**
I	**Crystal Physics:** Introduction, lattice, basis, crystal structure, unit cell & primitive cell, Translational vectors, Symmetry operations, crystal classes & crystal systems in 2D and 3D, Bravais lattices, atomic packing fraction in cubic systems SC, FCC, BCC. Miller indices, Interplanar spacing. Brillouin zones, Concept of reciprocal lattice and its properties. Crystal structures of diamond, ZnS, NaCl, CsCl, HCP, Structure determination using X-ray Diffraction: Bragg's law and Bragg's Diffraction condition indirect and reciprocal lattice, Ewald's construction.	**14**
II	**Free Electron and Band Theory of Metals:** Free Electron model, Energy levels and Density of orbital in 1D and 3D, Bloch theorem (statement only), Nearly free electron model, Fermi energy, Fermi level, Hall Effect, Origin of energy gap, Energy bands in Solids, Effective mass of electron (with derivation), Distinction between metal, semiconductor and insulator.	**8**
III	**Solid state devices:** Semiconductors, intrinsic, extrinsic, temp dependence, doping, conductivity, hall effect hall coeff. semiconductor devices. e.g. metal semiconductor junction, p-n junction diodes, zener and tunnel diodes, LED's transistor, solar cells.	**6**

IV	**Magnetism:** Diamagnetism, Langevin theory of Diamagnetism, Application of diamagnetic material: (Superconductor), concept, Occurrence of Superconductivity, Critical magnetic field and Meissner effect achievement at low temp, attempts at room temp. Examples, Paramagnetism, Langevin theory of Paramagnetism, ferromagnetism, ferromagnetic domains, Hysteresis, Curie temperature. Ferromagnetism, Ferrites and its applications, antiferromagnetism, Neel temperature.	**8**

References:

1. Solid State Physics - S. O. Pillai, 3rd Edition, New Age International (P.) Ltd., Publisher, (1999).
2. Solid State Physics - Kakani and Hemrajani, S. Chand Publication.
3. Solid State Physics - Saxena, Gupta and Saxena, Pragati Prakashan.
4. Introduction to Solid State Physics - Charles Kittel, John Wiley and Sons, 7th Edition.
5. Solid State Physics - A. J. Dekker, Macmillan India Ltd., (1998).
6. Solid State Physics - R. K. Puri, V. K. Babbar, S. Chand Publication.
7. Problems in Solid State Physics - S. O. Pillai, New Age International (P.) Ltd.
8. Solid State Physics - Palanisamy.
9. Solid State Physics - David, Snoke, Pearson Publication.

Title of the Course and Course Code	**CLASSICAL MECHANICS - PHY3503**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe methods of solving equations of motions.	
CO2	Explain necessity of considering constraints.	
CO3	Apply different techniques to find solutions of problems in Mechanics.	
CO4	Compare and contrast Newtonian, Lagrangian and Hamiltonian approaches.	
CO5	Determine the constraint equations and decide the generalized co-ordinates to be used.	
CO6	Hypothesize rotating frames of references.	

Unit. No.	**Title of Unit and Contents**	**No. of Lectures**
I	**Mechanics of system of particles:** Revision of Newton's laws of motion. Applications of Newton's laws of motion to solve problems of projectile motion in resistive medium, Rocket motion, Motion of a charged particle in constant electric, magnetic and electromagnetic field, Systems of particles, center of mass, conservation of linear and angular momentum, energy of system of particles	**6**

II	**Motion in Central Force Field:** Central force, equivalent one body problem, Motion in central force field, General features of motion, equation of orbit, Deduction of Kepler's laws of planetary motion and their applications, tidal force field.	**8**
III	**Scattering of particles:** Laboratory and centre of mass system. Scattering, Relation between scattering angles in laboratory and centre of mass system. Differential cross-section, impact Parameter, total cross-section, Rutherford scattering.	**8**
IV	**Langrangian and Hamiltonian formulation:** Limitations of Newtonian formulation, Types of constraints, degrees of freedom, generalized coordinates, configuration space, D'Alembert's principle of virtual work, Langrangian equation from D'Alembert's principle, Hamilton's equations.	**8**
V	**Non Inertial frames of systems:** Coordinate systems moving with constant velocity, constant acceleration, uniformly rotating frames of references, Effects of Earths motion on acceleration due to gravity, Effect of Coriolis force, Motion of a particle on the earth.	**6**

References:

1. Introduction to Classical Mechanics - R. G. Takawale, P. S. Puranik, Tata McGraw Hill Publishing Company Ltd.
2. Classical Mechanics- N. C. Rana, P. S. Joag, Tata Mc Graw Hill Publishing Company Ltd.
3. Principles of mechanics, J. L. Synge, B. A. Griffith, Tata McGraw Hill Publishing Company Ltd.
4. Classical Mechanics - Herbert Goldstein, Narosa Publishing House.
5. Classical Mechanics - J. C. Upadhyaya, Himalaya Publishing House.
6. Problem solution of classical mechanics - P. V. Panat, Narosa Publishing House.

Title of the Course and Course Code	**ATOMIC AND MOLECULAR PHYSICS - PHY3504**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall and recognize the gradual development of the Atomic theory and describe various atomic models.	
CO2	Explain the effect of magnetic field on atomic spectra.	
CO3	Solve problems in Atomic theory.	
CO4	Relate atomic theory to analyze spectra.	
CO5	Evaluate spectroscopic data to identify elements using atomic spectra.	
CO6	Develop mathematical treatment for the Bohr atom, Zeeman effect and Raman spectra.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Atomic Structure**: Evolution of the vector atom model from Dalton, Atomic excitation and atomic spectra, One and two valence electron systems Pauli Exclusion principle and electron configuration, quantum states, Spectral notations of quantum states. Spin-Orbit Interaction (Single valence electron atom), selection rules, spectra of sodium atom, sodium Doublet., LS and JJ coupling schemes. Lande's Interval rule, Frank-Hertz experiment	**12**
II	**Zeeman Effect:** Early discoveries and developments Experimental arrangement, Normal and anomalous Zeeman Effect Problems, Stark effect (Qualitative discussion)	**4**
III	**X-ray:** Nature of X-rays, Discrete and continuous X-ray spectra, Duane and Hunt's Rule, X-ray emission spectra, Mosley's law and its applications Auger effect, Problems	**6**
IV	**Molecular Spectroscopy:** Rotational energy levels Vibrational energy levels Rotational and Vibrational Spectra Electronic spectra of molecules Problems. Raman effect, stokes and antistokes lines, classical theory of Raman effect, experimental set up.	**8**
V	**Spectroscopic Techniques:** UV-visible spectroscopy, IR spectroscopy, x-ray spectroscopy, Raman spectroscopy, Spectroscopy applications in areas like Astrophysics, Geology, Archaeology, Materials Science, Medical science.	**6**

References:

1. Concepts of Modern Physics 4th edition - Arthur Beiser (McGraw Hill International edition)
2. Atomic physics - J. B. Rajam
3. Introduction to Atomic spectra - White. H. E. (McGraw Hill International edition)
4. Fundamentals of Molecular spectroscopy - C. N. Banwell and E. M. Mc Cash (McGraw Hill International edition)
5. Modern Physics - J. B. Rajam.

Title of the Course and Course Code	ELEMENTS OF MATERIALS SCIENCE - PHY3505	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe types of materials, their properties and identify types of defects.	
CO2	Explain functional properties of ceramic bulk materials and different nanomaterials.	
CO3	Apply knowledge of mathematics and advanced science and engineering principles to materials systems.	
CO4	Explain applications of Polymers for research and industrial applications. Determine concentration, purity of material and molecular weight.	
CO5	Select materials for design and construction. Test materials using different characterization methods with the fundamental principles underlying and connecting the structure and properties.	
CO6	Design and construct different Phase Diagrams under different combination and thermodynamic states.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Materials and their properties:** Types of materials: Conductors, Semiconductors and Insulators, Materials properties: Mechanical, Electrical and thermal, Impurities in solids. Defects in solids: Point, Line, Surface and Volume. Deformation: Elastic deformation and Plastic deformation. Mechanism of Plastic deformation by slip, Critical resolved shear stress (CRSS), Introduction to Diffusion in Solids.	**8**
II	**Phase Diagrams; Molecular Phases:** Basic terms: System, Surrounding, Component, Coordinates, Phase, Equilibrium. Solid solutions in metals, Rules of solid solubility. Phase Diagram: definition, importance and objective, Lever rule, Gibb's phase rule. Phase diagram of a) Sugar water b) NaCl water. Types of phase diagrams with construction - Type-I Lens type CuNi phase diagram, Type-II Only introduction, Introduction to Type-III Phase diagram.	**10**
III	**Ceramic Materials and Introduction to nanomaterials:** Ceramic Phases, Classification of ceramic materials, Ceramic crystals (AX), Mechanical behavior of ceramics, Electromagnetic behavior of ceramics -Electric properties: dielectrics, semiconductors, piezoelectric, Magnetic Properties: Magnetic Ceramics, hard and soft ferrites. Nano-sized structures and materials, classification of nanomaterials (0D,1D,2D and shape effects, surface to volume ratio), properties and applications of nano materials	**10**
IV	**Characterization Techniques:** Introduction and basic principle only, Introduction to X-Ray diffraction, UV-Visible spectroscopy,	**8**

	Photoluminescence, Thermal gravimetric analysis (TGA), Electron microscopy (SEM, TEM), Scanning probe microscopy, X-Ray photoelectron spectroscopy.	

References:

1. Materials Science and Engineering - V. Raghavan (5th Edition)
2. Elements of Materials Science and Engineering - L. H. Van Vlack (6th Edition)
3. Elements of X-Ray diffraction - B. D. Cullity.
4. Fundamentals of Molecular spectroscopy - C. N. Banwell and E. M. McCash
5. Solid State Physics - A. J. Dekker.

Title of the Course and Course Code	**LASERS - PHY3506**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the requirements for a system to act as a laser.	
CO2	Explain concept of Laser fundamentals, pumping mechanism pumping schemes.	
CO3	Demonstrate potential applications of Lasers.	
CO4	Differentiate the various types of Lasers and their means of excitation.	
CO5	Compare three level and four level Laser systems.	
CO6	Design and development of different laser systems.	

Unit. No.	**Title of Unit and Contents**	**No. of Lectures**
I	**LASER fundamentals I:** Ordinary light and Lasers, Brief history of Lasers, Interaction of radiation with matter, Energy levels, Population density, Boltzmann distribution, Transition Lifetimes, Allowed and Forbidden Transitions, Metastable states Stimulated Absorption, Spontaneous Emission and Stimulated Emission, Einstein's Coefficients, Einstein's relations Condition for large stimulated emission, Population inversion	**8**
II	**LASER fundamentals II:** Condition for light amplification, Gain coefficient Active medium, Optical feedback, round trip gain, threshold gain, critical population inversion, Optical resonator, condition for steady state oscillations, cavity resonance frequencies. Pumping schemes: three level and four level.	**10**
III	**Types of LASERs:** Solid State Lasers – Ruby Laser, Diode Laser, Nd: YAG laser, Gas Lasers – He-Ne Laser, CO_2 Laser Liquid Lasers: Tunable dye laser	**8**

IV	**Applications of LASERs** Nuclear Science – laser isotope separation, laser fusion Defence Applications Medical – Introduction to nonthermal Lasers for medical applications, Eye surgery, Photodynamic therapy Optical - Holography, supermarket scanners, compact discs, Nonlinear Optics, SHG	**10**

Reference Books:

1. Lasers, Fundamentals and Applications, K. Thyagarajan and, Ajoy Ghatak, Springer
2. Laser Fundamentals, William T. Silfvast, Cambridge
3. An introduction to Lasers – Theory and applications, M. N. Avadhanulu, S. Chand and Co. New Delhi.

Title of the Course and Course Code	**RADIATION PHYSICS - PHY3513**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe interaction of radiations with matter.	
CO2	Discuss radiation sources and radiation shielding.	
CO3	Classify different radiation detectors and specify their application.	
CO4	Explain different radiation units for measurement of radiation exposure.	
CO5	Evaluate safety protocols for radiation protection.	
CO6	Specify application of radiation sources in different area.	

Unit. No.	**Title of Unit and Contents**	**No. of Lectures**
I	**Interaction of Radiation with Matter** Interaction of different types of radiation with Matter-Ionizing & Non ionizing radiations, excitation, ionization, radioactive losses-Energy loss by collision, range energy relation, Bethe-Bloch formula collision stopping power, radiation stopping power, Straggling. Energy classification, Photoelectric effect, Compton scattering, Pair production, Rayleigh scattering, Neutron interactions, Neutron sources, elastic and inelastic scattering, nuclear reaction, neutron activation and induced activity, radioisotope production, Nuclear fission.	**10**
II	**Radiation Detectors** Characteristic curve of Gas-filled detectors. Ionization chamber, Proportional counter, Gas filled detectors (G. M. counter), Characteristics of organic and inorganic scintillation detectors, Scintillator detector, Semiconductor detector.	**6**
III	**Radiation units and Measurement of radiation exposure** Units for radiation exposure- Roentgen, Becquerel, Gray, Sievert, RAD, REM, KERMA. Radiation exposure, Absorbed Dose,	**6**

	Equivalent Dose, Effective Dose, Ambient and directional equivalent dose, Relative biological effective dose, Quality factor, Personal dosimeters, Film badge dosimeters, Thermoluminescent dosimeter. Calibration of dosimeters. Measurement of dose delivered by an electron accelerator and high strength Cobalt -60 source.	
IV	**Radiation Sources and Radiation Shielding** Natural & Artificial radioactive sources, Alpha, Beta, Gamma Sources, Neutron sources and accelerator based radiation sources. Basic concept of radiation shielding, linear and mass absorption coefficient, stopping power, materials for shielding of gamma and neutron, shielding interaction cross section, concept of the mean free path for shielding.	**5**
V	**Radiation Protection:** Time, Distance, Shielding, Radiation Protection and Safety rules as per the regulatory guidelines of the Government of India, Safety codes for handling radioactive sources. Monitoring of radiation levels around an open radioactive source, ICRP, NCRP, AERB recommended limit.	**4**
VI	**Radiation Applications:** Production of radioactive nuclides in nuclear reactors and by charged particle beams from accelerators. Radioactive pharmaceuticals and labelled compounds. Radioactive nuclei used in diagnostic applications. Applications of gamma-rays in sterilization of medical instruments, medication items and preservation of food.	**5**

References:

1. Nuclear and Radiation Physics in Medicine. Tony Key. World Scientific. 2014
2. Introduction to Radiological Physics and Radiation dosimetry. Frank H. Attix. Wiley. 1986
3. Medical Physics by Glasser O, Vol 1, 2, 3 Year Book Publisher Inc Chicago.
4. Radiation Protection and Health Science. Marilyn E. Noz. World Scientific. 2007.
5. Introduction to Radiation Protection. Grupen C. Springer. 2008.
6. Radiation Physics for Medical Physicists. Podgorsak Ervin B. Springer. 2005.
7. Techniques for Nuclear and Particle Physics experiments. Leo. W. R. Springer. 2005.

Title of the Course and Course Code	BIOPHYSICS - PHY3514	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall and identify physical properties related to biological systems.	
CO2	Discuss types of transducers used for processing bioelectric signals.	
CO3	Solve qualitative and quantitative problems.	
CO4	Explain the working of bioinstruments and other techniques used for analysing biological signals.	
CO5	Evaluate bioelectric signals.	
CO6	Integrate physics concepts with biological systems for better understanding.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Introduction of Biophysics** Definition and History of Biophysics [Physical properties applied to biology- Surface tension, Viscosity, adsorption, diffusion, osmosis, dialysis and colloids] Cell: Animal and plant cell, types of cell and composition, Functional aspects of cell membrane, cytoplasm, nucleus, mitochondria, chloroplast (Bioenergetics of mitochondria and chloroplast), Protein structure (Primary, Secondary, Tertiary and Quaternary structure): Amino-acids structure (Specify types), Bond length, Bond angles, peptides, and Bond-Rigid planer peptides. Cis and trans configuration, torsion angle, Ramchandran plot. Photosynthesis Process: - electron transport, Gibbs's free energy, Redox couple. [Redox potential, Oxidation and reduction, Examples of redox potential in biological system.] Genetic code- symmetry, DNA structure	**15**
II	**Bio potentials** Bioelectric signals: structure of neuron, resting potential, action Potential, Nernst equation, Bio-potential amplifier: input impedance, frequency characteristics, gain, CMRR, Calibration, Noise, Temperature sensitive stability. Compound action potentials of the human body ECG, EEG, ERG, EOG (in brief), Transducers: Definition, types- resistive, capacitive and inductive transducers, LVDT, photo diode, Bio electrodes- Half cell potential, polarizable and non-polarizable electrodes, metal and glass electrodes, types and electric characteristics	**13**

III	**Bio instruments** Basic principle, Construction and working of colorimeters, spectrophotometer, ECG machine, PH meter, Centrifuge measurement. (10L), Electro microscope: SEM, TEM. (**2L**)	**4**
IV	**New Fields** Biostatistics and Biometry, Definition and concept in brief, Mathematical modeling and Computational biology (Concept only)	**4**

References:

1. Introduction to Biophysics - by P. Narayanan.New Age P.
2. Medical Instrumentation - by Khandpur, TMH
3. Laboratory Manuals of Biophysics Instruments - by P.B. Vidyasagar
4. Biophysics -by VatsalaPiramal, Dominant Publisher and Distributors, New Delhi-110002
5. Textbook of Biophysics - by R.N. Roy
6. Photosynthesis - by Hall and Rao.

Title of the Course and Course Code	**Physics Practical Paper – I PHY3507**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe different experimental techniques to determine values of various constants, coefficients, parameters.	
CO2	Arrange the apparatus as per the requirements of the aims and objectives of the experiment.	
CO3	Demonstrate the procedure to perform the experiments and the skills required for the particular experiment.	
CO4	Explain the theory behind the formulae used and Validate the hypotheses.	
CO5	Standardize the entire procedure to obtain reliable, repeatable results.	
CO6	Perform the experiment, tabulate the data, identify the sources of errors, and show how to minimize the errors.	

Sr. No.	**Experiment Title**
1	Viscosity of Oil by Rotating Cylinder Method
2	Study of X – ray diffractograms of various materials
3	Michelson interferometer
4	Surface tension of liquids using Fergusson Method
5	Study of Hall Effect
6	Energy Gap of Semiconductor
7	Four Probe Method
8	Platinum Resistance Thermometer
9	Adder and Subtractor using Op-AMP 741
10	Integrator and Differentiator using Op-AMP 741
11	Determination of diameter of the Sun
12	Magneto Resistance

Title of the Course and Course Code	Physics Practical Paper – II - PHY3508	Number of Credits :2
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe different experimental techniques to determine values of various constants, coefficients, parameters.	
CO2	Arrange the apparatus as per the requirements of the aims and objectives of the experiment.	
CO3	Demonstrate the procedure to perform the experiments and the skills required for the particular experiment.	
CO4	Explain the theory behind the formulae used and Validate the hypotheses.	
CO5	Standardize the entire procedure to obtain reliable, repeatable results.	
CO6	Perform the experiment, tabulate the data, identify the sources of errors, and show how to minimize the errors.	

Sr. No.	Experiment Title
1	Refractive index of liquids using hollow cylinder
2	Lloyd's Mirror
3	Forbe's Method
4	Thermal Conductivity of Rubber Tube
5	e/m by Thomson's Method
6	Plank Constant
7	Self-Inductance by Anderson Bridge
8	Magnetic Properties of material using Hysteresis Loop Tracer
9	Factorial of a number, First 100 Prime Numbers
10	Graphics – Line , Circle, arc, ellipse, rectangles, concentric circles
11	Fraunhafer Lines in Solar spectrum
12	Frequency response of Human Ear

Title of the Course and Course Code	Physics Practical Paper – III - PHY3509	Number of Credits :2
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe different experimental techniques to determine values of various constants, coefficients, parameters.	
CO2	Arrange the apparatus as per the requirements of the aims and objectives of the experiment.	
CO3	Demonstrate the procedure to perform the experiments and the skills required for the particular experiment.	
CO4	Explain the theory behind the formulae used and Validate the hypotheses.	
CO5	Standardize the entire procedure to obtain reliable, repeatable results.	
CO6	Perform the experiment, tabulate the data, identify the sources of errors, and show how to minimize the errors.	

Sr. No.	Experiment Title
1	Wavelength of He-Ne Laser by Reflection Grating
2	Beam Divergence of a Diode Laser
3	Magnetic Susceptibility of $FeCl_3$
4	Specific Heat of Graphite
5	Resolving Power of Telescope
6	Optical Fibre - Loss Measurement
7	IC 555 Astable Multivibrator
8	Regulated Power supply using IC 723
9	Wein Bridge Oscillator
10	Use of Pointers, Arrays and Loops
11	Matrix multiplication, Ascending / Descending Numbers using Arrays
12	G. M. Tube characteristics

Title of the Course and Course Code	ANALOG ELECTRONICS - PHY3511	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall basic knowledge of physical and electrical conducting properties of semiconductors.	
CO2	Explain the effect of negative feedback on different parameters of an Amplifier and different types of negative feedback topologies.	
CO3	Apply the knowledge to build, and troubleshoot Analog circuits using IC555, VCO, etc.	
CO4	Explain the effect of positive feedback and design and working of different Oscillators using BJTS and operational amplifier.	
CO5	Evaluate the working of BJT / FET amplifiers.	
CO6	Design amplifier circuits using BJT's and FET's and observe the amplitude and frequency responses of common amplifier circuits.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Circuit Theorems and Power Supplies:** Statements of Thevenin's Theorem, Norton's Theorem, Superposition Theorem and Maximum Power Transformer Theorem (Without proofs) and solutions of numerical problems based on these theorems. Study of half wave, full wave rectifiers. Calculations of output dc and ripple voltage, ripple factor, efficiency, transformer utilization factor, PIV Line and load regulation. Zener diode as a voltage regulator.	**9**

	Series and shunt regulators, short circuit protection. Block diagram of IC 723 and design of basic low and high voltage regulator using it.	
II	**Basic Electronic devices and circuits:** Construction, working and characteristics of P-N junction diode, LED, Photo Diode, Optocouplers and Varactors. BJT: Construction, study of I-V characteristics and transfer characteristics in CE, CB and CC configurations. Different methods of transistor biasing and thermal stability. Frequency response of transistor amplifier. Concept of feedback and study of phase shift, Wein bridge, Hartely and Colpitt's oscillators. Applications of Hartley and Colpitt's oscillators in AM transmitters, Construction, working, characteristics and applications of UJT and SCR.	**9**
III	**Operational Amplifiers:** Differential amplifier. Block diagram of Op-amp. Study of parameters of op-amp. Inverting and Non Inverting amplifiers, adder, subtractor using op-amp. Applications of op-amp as Integrator, Diffrentiator, exponential and logarithmic amplifiers, multiplier, divider, I to V convertor, high impedance voltmeter, comparator, Schmitt trigger, oscillators, astable and monostable multivibrator, square wave, triangular wave generator.	**9**
IV	**Special Function ICs:** IC 555 - Block diagram and functions of various pins. Astable operation: Circuit diagram, frequency of oscillations and duty cycle. Monostable Operation and application of one-shot multivibrator in water level control, touch switch and frequency divider. VCO 566 - Block diagram and working. PLL 565 - Block diagram, working and applications in AM and FM detection, Frequency divider and FSK demodulation.	**9**

References:

1. OP Amps and Linear Integrated Circuits - Gaikwad - PHI
2. Integrated Circuits - Botkar PHI

Title of the Course and Course Code	NUMERICAL ANALYSIS - PHY3512	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Identify modern numerical methods and describe the extent and limitations of computational methods in physics,	
CO2	Discuss the characteristics of various numerical methods.	
CO3	Solve the problem using numerical methods techniques and computationally solve a selection of problems in physics.	
CO4	Explain and solve the physics problem using numerical methods, write a program for it using leading-edge tools,	
CO5	Compare the tools, methodologies, language to test various physics problems.	
CO6	Design the physics system and solve it, collect the result and discuss, justify and communicate ideas and explanations.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Iterative Methods:** Beginning an iterative method, The method of successive bisection, The method of false position, Newton-Raphson iterative method, The secant method, The method of successive approximations, The Gauss elimination method, Comparison of direct and iterative methods	**10**
II	**Interpolation:** Lagrange interpolation, Difference tables, Truncation error in interpolation, Linear regression, Algorithm for Linear regression, Polynomial regression, Fitting exponential and trigonometric functions, Taylor series representation	**10**
III	**Integration:** Numerical integration, Simpson's rule, Trapezoidal Rule, Errors in integration formulae, Algorithms for integration of tabulated function, Algorithms for integration a known function, Comparison of integration formulae	**8**
IV	**Solving Differential equations:** Euler's method, Taylor series method, Runge-Kutta methods, Runge-Kutta fourth order formula, Predictor-corrector method, Higher order differential equations, Comparison of predictor-corrector and Runge-Kutta methods	**8**

References:

1. Computer Oriented Numerical Methods, by V. Rajaraman (PHI Learning Publications)
2. Numerical methods for scientists and engineers, by H. M. Antia (Hindustan Book Agency)
3. Computational Physics, by N. J. Giordano and Hisao Nakanishi (Pearson Education India

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	**CLASSICAL ELECTRODYNAMICS PHY3601**	**Number of Credits :2**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Define electric fields, electric potential, displacement vector, electric Polarization	
CO2	Articulate concepts of evaluating electric fields due to line charge, surface charge and volume charge using Coulomb's law and Gauss's law. Explain mechanism of polarization in dielectrics.	
CO3	Demonstrate special techniques to calculate potential due to some charge distribution.	
CO4	Explain motion of charged particle in electromagnetic field. Deduce Biot Savart's law from Ampere's law.	
CO5	Compare magnetic properties of material on the basis of total spin of electrons in atom. Distinguish between diamagnetic and paramagnetic materials	
CO6	Compile Maxwell's set of equations and develop electromagnetic plane wave equation.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Electrostatics:** Electric field, discrete and continuous charge distribution, Field lines, flux and Gauss 's law, Applications of Gauss's law Divergence and curl of electrostatic field, Electric Potential, Boundary Conditions in electrostatics, Work and energy in electrostatics, the energy of point charge and continuous charge distribution. Uniqueness theorem, Method of Images.	**10**
II	**Magnetostatics:** Magnetic field, Magnetic forces, Lorentz Force Law, Currents and current densities, steady currents, The magnetic field of a steady current, The Biot-Savart Law, The Divergence and Curl of Magnetic Field, Ampere's law, Applications of Ampere's law, Magnetic Vector Potential.	**8**
III	**Electrostatic Fields in Matter:** Dielectrics, Induced dipoles, Polarization, Electric field of a polarized object, Physical interpretation of bound charges, The electric displacement, linear dielectrics. **Magnetostatic Fields in Matter:** Torques and forces on magnetic dipoles, Paramagnetism, effect of magnetic field on atomic orbits, diamagnetism, Magnetization, Field of magnetized object, Bound currents, Ampere's law in magnetized material.	**9**

IV	**Electrodynamics** Electromotive force, Motional emf, Flux rule, Faraday's law, Inductance, Electrodynamics before Maxwell, Maxwell's correction in Ampere's law, Maxwell's equations, Electromagnetic Waves in Vacuum, The wave equation for E and B, Monochromatic plane wave.	**9**

References:

1. Introduction to Electrodynamics, David J Griffiths, 4th edition, Pearson.
2. Concepts of Physics, Volume II, H. C. Verma, Bharati Bhavan (P & D).
3. Electricity and magnetism, Reitz, Milford and Christie, Narosa Publishing House.
4. Feynman Lecture Series, Volume II, The New Millenium Edition.

Title of the Course and Course Code	**Quantum Mechanics - PHY3602**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe and learn theoretical aspects at Quantum Level.	
CO2	Clarify more about the insight of the microscopic world.	
CO3	Apply Schrodinger's equation for different cases of potential (V).	
CO4	Explain concept of operators and apply it in Quantum mechanics.	
CO5	Review Hydrogen atom model and quantum numbers n, l, m_l, m_s and degeneracy.	
CO6	Write Schrodinger's equation in spherically symmetric polar co-ordinate system.	

Unit. No.	**Title of Unit and Contents**	**No. of Lectures**
I	**Towards Quantum mechanics** The Schrodinger equation: Physical interpretation of wave function, Schrodinger time dependent equation. Schrodinger time independent equation. (Steady state equation), Requirements of wave function. Probability current density, equation of continuity, and its physical significance	**12**
II	**Operators in Quantum Mechanics** Definition of an operator in Quantum mechanics. - Eigen function and Eigen values. Expectation value - Ehrenfest's theorem Hermitian operator. Position, Momentum operator, angular momentum operator, and total energy operator (Hamiltonian). Commutator brackets- Simultaneous Eigen functions. Commutator algebra. Commutator brackets using position, momentum and angular momentum operator. Raising and lowering angular momentum operator. Concept of parity, parity operator and its Eigen values.	**12**

III	**Applications of Schrodinger (Steady state equation)** Free particle. Particle in infinitely deep potential well (one - dimension). Particle in three-dimension rigid box. Step potential. Potential barrier. (Qualitative discussion). Barrier penetration and tunneling effect. Harmonic oscillator (one-dimension) Spherically symmetric potentials: i) Schrodinger's equation in spherical polar co-ordinate system. ii) Rigid rotator (free axis). iii) Hydrogen atom: Qualitative discussion on the radial and angular parts of the bound state energy, energy state functions, Quantum numbers n, l, m_l, m_s–Degeneracy	**12**

References:

1. Introduction to Quantum Mechanics. - By D. Griffiths Published by Prentice Hall.
2. Quantum Mechanics of Atoms, Molecules, Solids, Nuclei and particles. - By R. Eisberg and R. Resnik Published by Wiley.
3. Concepts of Modern physics. - By A. Beiser Published by Mc. Graw Hill. Chapter 2, 3, 5, 6.

Title of the Course and Course Code	**THERMODYNAMICS AND STATISTICAL PHYSICS - PHY3603**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define thermodynamic quantities and functions.	
CO2	Estimate the probabilities in statistical processes.	
CO3	Apply the knowledge of Entropy and density of states to understand the concept of temperature.	
CO4	Explain the quantum statistics and differentiate between classical and quantum statistics.	
CO5	Compare the MB, BE and FD statistics and classify particles according to them.	
CO6	Design statistical tools to study thermodynamical interactions in ensembles.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Transport Phenomena and Thermodynamics** Mean free path, Transport Phenomenon, Viscosity, Thermal conductivity, Diffusion, First and Second TdS Equations, Specific heat and latent heat Equations. Joule Thomson Effect	6
II	**Basic Concepts of the Theory of Probability** Random events, Probability, Probability and frequency, Probability from an ensemble, Some basic rules of probability theory, Mean value of a discrete variable, Variance: Dispersion, Probability distribution, Binominal distribution, Mean value when the distribution is binominal, Fluctuations, Stirling approximation, Poisson distribution, Mean value and standard deviation in the case of Poisson distribution, Gaussian distribution, Standard deviation in the case of Gaussian distribution, Random walk problem.	12
III	**Macroscopic states and Microscopic states (Statistical Description of System of Particles) Statistical Ensembles** Macroscopic states, Microscopic states, Phase space, μ-space, Γ- space, Postulate of equal a priori probabilities, Behaviour of the density of states, quasi static processes, Thermal interaction, Mechanical interaction, General interaction, Distribution of energy between systems in equilibrium, The approach to thermal equilibrium. Microcanonical ensemble, Canonical ensemble, Mean value and fluctuations	12
IV	**Quantum Statistics of Ideal gases** Identical particles and symmetry requirements, Formulation of the statistical problem, the quantum distribution functions, Maxwell-Boltzmann statistics, Bose-Einstein statistics, Fermi-Dirac statistics,	6

References:

1. Fundamentals of Statistical and Thermal Physics - F. Reif - McGraw Hill Publications
2. Fundamentals of Statistical Mechanics - B. B. Laud - New Age International Publishers
3. Perspectives of Modern Physics- A. Beiser - McGraw Hill Publications
4. Statistical Mechanics - Gupta, Kumar - Pragati Prakashan

Title of the Course and Course Code	NUCLEAR PHYSICS - PHY3604	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define and describe basic properties of nucleus.	
CO2	Explain the concept of radioactivity. Classify different radiation detectors and nuclear models.	
CO3	Solve problems related to nuclear and particle physics.	
CO4	Explain nuclear reaction dynamics, nuclear reactors and accelerators.	
CO5	Compare the nuclear energy with other energy sources.	
CO6	Specify applications of accelerators and detectors. Compile knowledge of elementary particles to understand nuclear phenomena.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Basic Properties of Nucleus** Composition, charge, size, density of nucleus, Mass defect and Binding energy, packing fraction, Nuclear Angular momentum, Nuclear magnetic dipole moment, Electric quadrupole moment, parity and symmetry, classification of nuclei, stability of nuclei (N vs Z curve).	**8**
II	**Radioactivity** Radioactivity disintegration (concept of natural and artificial radioactivity, Properties of α, β, γ rays, laws of radioactive decay, activity, half-life, mean life, specific activity and its units, Beta decay, successive disintegration, radioactive equilibriums, radioisotopes. Application of radioactivity (Agricultural, Medical, Industrial, Archaeological).	**8**
III	**Nuclear forces** Properties of nuclear forces, Meson theory of nuclear forces, properties of deuteron system, Elementary particles, Quarks model for elementary particles.	**6**
IV	**Particle Accelerator and Detectors** Introduction to particle accelerators, Linear accelerator (LINAC), Cyclotron. Applications of accelerators, Classification of Nuclear detector, Gas filled detectors (G. M. counter) Solid state detectors (NaI scintillation counter)	**6**
V	**Nuclear Reactions** & **Nuclear Energy** Introduction to Nuclear reactions, Compound nucleus, Conservation laws in nuclear reactions, Q value equation, Exothermic and Endothermic reactions, Threshold energy, Nuclear cross-section, Nuclear fission, chain reaction and critical mass, nuclear reactor and its basic components, homogeneous and heterogeneous reactors, power reactor, fast breeder reactor, nuclear fusion, stellar energy.	**8**

References:

1. Introduction to Nuclear Physics H. A. Enge (Addition Wesley Co.)
2. The Atomic Nucleus R. D. Evans (Tata McGraw Hill Co.)
3. Concepts of Nuclear Physics – B. L. Cohen (Tata McGraw Hill Co.)
4. Schaum's Outline Series Modern Physics R. Gautrearu (McGraw Hill Co.)
5. Nuclear Physics an Introduction, 2nd edition, S. B. Patel, New Age International Publishers.
5. Nuclear Physics, D. C. Tayal, Himalaya Publishing House.
6. Atomic and Nuclear Physics, Shatendra Sharma (Pearson Education, 1st Edition)

Title of the Course and Course Code	**ASTRONOMY AND ASTROPHYSICS - PHY3605**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Identify, classify and locate celestial objects, the vastness of Space and familiarize with the components of the Universe. Relate with observational astronomy and tools used for the purpose.	
CO2	Explain nuclear reactions in stars and synthesis of elements in the universe and various cosmologies.	
CO3	Apply skills in identifying spectra of celestial objects and data analysis.	
CO4	Analyze and classify stellar spectra.	
CO5	Measure stellar distances.	
CO6	Prepare sky charts and make meteor observation logs.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Fundamentals of Astronomy and Observational Astronomy:** Introduction: Components of the Universe; Stars, Planets, Asteroids, Meteors, Comets, Galaxies, Solar System: Age, Origin Basic measurements: Planetary orbits, distances, physical size, mass, density, temperature, rotation period determination, Kepler's laws, EM Spectrum: radiation from heated objects, Wien's law, radiation curves, Doppler effect. Distance measurements: Parallax. Units of distance- light-years, parsec, Co-ordinate system, Celestial hemisphere, Concept of time, Magnitudes: apparent and absolute, constellations, Optical telescopes, mounts, light gathering power, magnification, and resolution. Spectroscopes, CCD camera, photometer, filters, Radio telescopes, interferometry, Need of telescopes in orbit: HST, Chandra.	**8** **6**

II	**Star and Star Systems:** Sun a typical star: Sun: Hydrostatic Equilibrium, Pressure and temperature in interior, Atmosphere, Solar Cycle, Solar Activity, Butterfly diagram, Coronal Mass ejections and effect on Earth's Atmosphere. Stars life cycle: Energy generation in a star. (Nuclear), Spectral classification of stars, O, B, A, F, G, K, M. HR diagram: Significance. Colour, Temperature and Radii of stars. Cepheids /RR Layrae variables as distance indicators, Neutron stars. Evidence of black holes, Qualitative treatment of Chandrasekhar limit - superficial treatment.	**10**
III	**Galaxies, AGNs, Dark Energy:** Galaxy types, formation and evolution. Galaxy clusters. Active Galactic Nuclei – AGNs their types. AGN - the central engine.	**6**
IV	**Cosmology:** Olbers' Paradox. Big Bang and Expanding Universe. Cosmic Microwave Background. Hubble's law with equation, its significance. Concept of space time, Fate of our universe. Evidence of Dark Matter and Dark Energy.	**6**

References:

1. Astronomy, A Physical Perspective, Marc Kutner: (Cambridge University Press)
2. The physical universe, An Introduction to astronomy, Frank H. Shu, Uni. Sci. Books
3. An invitation to Astrophysics. T. Padmanabhan. World Scientific
4. Structure of the Universe, J. V. Naralikar
5. An introduction to Modern Astrophysics B. A. Carroll and D. A. Ostlie: (Benjamin Cummings, latest edition, 2017)
6. Astrophysics for physicists, Arnab Rai Choudhuri, Cambridge University Press.
7. An introduction to Cosmology, J. V. Naralikar, Cambridge University Press

Title of the Course and Course Code	ENERGY STUDIES - PHY3606	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the environmental aspects of non-conventional energy resources. In Comparison with various conventional energy systems, their prospects and limitations.	
CO2	Discuss the need of renewable energy resources, historical and latest developments.	
CO3	Illustrate the use of solar energy and the various components used in the energy production with respect to applications like - heating, cooling, desalination, power generation, drying, cooking etc.	
CO4	Explain the need of Wind Energy and classify the various components used in energy generation.	
CO5	Recommend the concept of Biomass energy resources and their classification, types of biogas Plants- applications	
CO6	Write about Solar, Wind and bio energy systems, their prospects, advantages and limitations. Compile the knowledge of fuel cells, wave power, tidal power and geothermal principles and applications.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**An Introduction to Energy Sources:** Classification and study of energy sources: Renewable-solar, wind, tidal, hydro and non-renewable- biomass, fossil fuels, thermal, nuclear sources of energy. Comparison of energy sources. Energy audit, Hybrid Energy Storage, Hybrid Energy Generation System.	**8**
II	**Solar thermal and Photovoltaic Applications:** Sun as a source of energy, Solar Constant, Electromagnetic spectrum, Liquid flat plate collector, construction and working, Concentrating collectors, Solar distillation, Solar drying, Solar cooker (box type), Solar water heating systems. Photovoltaic principle, Power output and conversion efficiency, Limitation to photovoltaic efficiency, Basic photovoltaic system for power Generation, Application of solar photovoltaic systems, Advantages and disadvantages of Solar PV Systems. Configurations of Solar Photovoltaic Systems: Off-grid, Grid-Tied and Grid-Storage Hybrid Solar PV Systems, Net metering and steps in installation of a rooftop solar PV System	**12**
III	**Biomass and wind energy:** Introduction, Bio-mass conversion technologies, Bio-gas generation Factors affecting bio-digestion (list of factors), Working of biogas plant, Advantages and disadvantage of floating and fixed dome type plant, Bio-gas from plant wastes, Methods for obtaining energy from biomass,	**8**

	Thermal gasification of biomass, Working of downdraft gasifier, Advantages and disadvantages of biological conversion of solar energy Introduction to wind energy, Classification and description of wind machines, Wind data.	
IV	**Energy storage devices:** Recent trends in batteries, super capacitors, fuel cells. Lithium-Ion, Sodium-Ion, Solid-state batteries in Batteries Super capacitors, Pseudo capacitors, Hybrid Super capacitors, Applications of storage devices: Electrical Vehicles (EV), Introduction to EV Technology & Motors in EV, charging technologies in EV, Public Charging station, Charging Station Design & Costing, Converter, Inverter, Controls & Controllers in EV, Future Trends in Electric Cars.	**8**

References:

1. Non-conventional Energy sources- G. D. RAI (4th edition), Khanna Publishers, Delhi
2. Solar Energy - S. P. Sukhatme (Second Edition), Tata Mc Graw Hill Ltd., New Delhi.
3. Solar Energy Utilization - G. D. RAI (5th edition), Khanna Publishers, Delhi.
4. Energy Storage Science and Technology by A. R. Pendse, SBS Publishers and Distributors Pvt. Ltd.
5. Textbook On Energy Resources and Management by Dhupper R., CBS PUBLICATION
6. Materials for Super capacitor applications, B. Viswanathan and M. Aulice Scibioh, Elsevier.

Title of the Course and Course Code	**BIOMEDICAL INSTRUMENTATION - PHY3613**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the physiology of biomedical system.	
CO2	Explain the physical and medical principles of biomedical instrumentation and measure biomedical and physiological information.	
CO3	Illustrate the application of Electronics in diagnostics and therapeutic area.	
CO4	Analyze the effect of different methods, danger potential, possibilities and potential developments in biomedical instrumentation.	
CO5	Compare different types of electrical medical equipment, advantages and disadvantages of different methods, sources of error and risks involved in various methods.	
CO6	Specify the required techniques for analyzing effects related to nervous, respiratory and cardiovascular issues.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Bio-Potential and Measurement:** Structure of Cell, Origin of Bio-potential, electrical activity of cell. Cardiovascular Measurement: Blood Pressure- Direct and Indirect types, Blood Flow Electromagnetic and Ultrasonic types, Blood Volume- Types of Plethysmography. (Impedance, Capacitive and Photoelectric), Cardiac Output- Flicks method, Dye-dilution and Thermo-dilution type, Life support Instruments: Pacemaker- Types of Pacemaker, mode of pacing and its application, Defibrillator- AC and DC Defibrillators and their application, Hemodialysis system and the precautions to be taken during dialysis.	12
II	**Physiological Systems and Related Measurement:** Respiratory system- Physiology of respiration and measurements of respiratory related parameters. Cardiovascular system. Structure of Heart, Electrical and Mechanical activity of Heart, ECG measurements and Cardiac arrhythmias. Nervous system- Nerve cell, neuronal communication, nerve-muscle physiology. Generation of EEG and its measurement. Normal and abnormal EEG, evoked potential and epilepsy. Significance of Electrical Safety: Physiological effects of electrical current, Shock Hazards from electrical equipment and methods of accident prevention.	12
III	**Imaging Techniques:** X-Ray- Generation, X-ray tube and its control, X-ray machine and its application, CT Scan- CT Number, Block Diagram, scanning system and application, Ultrasound Imaging- Modes of scanning and their application, MRI- Concepts and image generation, block diagram and its application.	12

References:

1. Biomedical Instrumentation and Measurements - Leslie Cromwell, Pearson Education, 2nd Edition, 1980.
2. Medical Instrumentation - John G. Webster, John Wiley and Sons, 4th Edition, 2010.
3. Biomedical Instrumentation - R. S. Khandpur, Tata McGraw hill, 3rd Edition, 2014.
4. Principles of Biomedical Instrumentation and Measurements - Richard Aston, Prentice Hall of India, 1st edition, 1990.
5. Introduction to Biomedical Equipment Technology - Joseph J. Carr and John M. Brown, Prentice Hall of India, 4th Edition, 2001.
6. Guyton ‘s Medical Physiology - John E Hall, Saunders, 12th Edition, 2011.

Title of the Course and Course Code	PHYSICS OF NANOMATERIALS - PHY3614	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	List different types and forms of nanomaterials.	
CO2	Explain the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale.	
CO3	Outline appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties.	
CO4	Relate properties of nanostructures with their size, shape and surface characteristics.	
CO5	Justify enhanced sensitivity of nanomaterial based sensors and their novel applications in industry	
CO6	Specify applications of novel nanomaterials in medicine, defence, society, etc.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Introduction to nanomaterials:** Introduction to nano-sized materials and structures Brief history of nanomaterials and challenges in nanotechnology, Significance of nano-size and properties, classification of nanostructured materials	**6**
II	**Methods of synthesis of nanomaterials:** Bottom-up and Top-down approaches Physical methods: High energy ball milling, Physical vapour deposition, Chemical methods: colloidal method, co-precipitation and sol-gel method. Hybrid method: Electrochemical and chemical vapour deposition	**8**
III	**Properties of nanomaterials:** Mechanical, Electrical, Thermal, Optical, solubility, melting point and Magnetic properties.	**10**
IV	**Characterization techniques:** UV- visible spectroscopy, X-ray diffraction, Scanning electron microscopy, Transmission electron microscopy	**4**
V	**Special nanomaterials and Applications:** Carbon nanotubes, quantum dots, Nanocrystalline ZnO and TiO_2. Nanoelectronics, Medical, Biological, Automobiles, Space, Defence, Sports, Cosmetics, Cloth industry etc.	**8**

References:

1. Nanotechnology: Principles and Practices by Sulabha Kulkarni, Capital Publishing Co. New Delhi.
2. Introduction to nanotechnology, by C. P. Poole Jr. and F. J. Ownes, Willey Publications.
3. Origin and development of nanotechnology by P. K. Sharma, Vista International publishing house.
4. Nanostructure and nanomaterials synthesis, Properties and applications, by G. Cao, Imperials College Press, London.

Title of the Course and Course Code	**Physics Practical Paper –IV - PHY3607**	**Number of Credits :2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe different experimental techniques to determine values of various constants, coefficients, parameters.	
CO2	Arrange the apparatus as per the requirements of the aims and objectives of the experiment.	
CO3	Demonstrate the procedure to perform the experiments and the skills required for the particular experiment.	
CO4	Explain the theory behind the formulae used and Validate the hypotheses.	
CO5	Standardize the entire procedure to obtain reliable, repeatable results.	
CO6	Perform the experiment, tabulate the data, identify the sources of errors, and show how to minimize the errors.	

Sr. No.	**Experiment Title**
1	Solar Constant
2	Temperature of Sun
3	Calorific value of wood and efficiency of domestic water heater
4	Solar cell panels efficiency and fill factor, solar cooker
5	Study of Electricity generation using Windmill
6	RS and JK Flip – Flops
7	Four - Bit shift Register using IC 7495
8	Study of Multiplexer
9	Legendre Polynomial / Bessel Recurrence Relation
10	Simpsons 1/3 Rule / Trapezoidal Rule
11	Newton – Raphson Method
12	Simple Harmonic Oscillator

Title of the Course and Course Code	Physics Practical Paper – V - PHY3608	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe different experimental techniques to determine values of various constants, coefficients, parameters.	
CO2	Arrange the apparatus as per the requirements of the aims and objectives of the experiment.	
CO3	Demonstrate the procedure to perform the experiments and the skills required for the particular experiment.	
CO4	Explain the theory behind the formulae used and validate the hypotheses.	
CO5	Standardize the entire procedure to obtain reliable, repeatable results.	
CO6	Perform the experiment, tabulate the data, identify the sources of errors, and show how to minimize the errors.	

Sr. No.	Experiment Title
1	G.M. Tube Characteristics
2	Mechanical Equivalent of Heat – Calendar – Barne's Method
3	Y by Koenig's Method
4	Optical Fibre – Measurement of Numerical Aperture
5	Stefan's Constant
6	Frequency Response of Speaker
7	Constant Deviation Spectrometer
8	Determination of Rydberg Constant
9	Distance measurement by LVDT
10	Study of Zeeman Effect
11	Decade Counter using IC 7490
12	Digital to Analog conversion using R – 2R Ladder Network and 8 – Bit ADC using IC 0809

Title of the Course and Course Code	Physics Practical Paper – VI - PHY3609(Project)	Number of Credits :2
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe the necessity, need, relevance and importance of the project undertaken.	
CO2	Outline the work into small tasks like reference work, collection of equipment and materials, the apparatus as per the requirements of the aims and objectives of the project, actual performance of experiment, data collection etc.	
CO3	Carry out the experiments as per the designed procedure to achieve the goals	
CO4	Explain the theory behind the formulae used, collect and analyze the data and validate the hypotheses.	
CO5	Standardize the entire procedure to obtain reliable, repeatable results. Compare and Contrast if necessary, with the published data to Justify the results obtained.	
CO6	Prepare a project report, compile and quote the references properly. Develop an ability to communicate effectively and present project work to a panel of experts.	

Title of the Course and Course Code	DIGITAL ELECTRONICS - PHY3611	Number of Credits :2
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Recall the basic digital gates, binary arithmetic, and principles of Boolean algebra.	
CO2	Explain internal block and detailed diagrams and working of the Digital Integrated circuits.	
CO3	Illustrate use of encoders, decoders, multiplexers in various circuits.	
CO4	Explain working of flip flops, counters, and registers.	
CO5	Compare ADC and DAC techniques.	
CO6	Design digital circuits for dedicated applications.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Number systems, Logic Gates, Boolean Algebra and Combinational Circuits:** Binary, Octal and Hexadecimal number systems and interconversions, Logic gates, Boolean algebra and axioms, De Morgan's Theorems, Karnaugh's maps up to 4 variables for simplification of Boolean expressions. Half, full and parallel adder. Worst case input, output voltages and currents. Noise Margin, Fan –In, Fan-Out, compatibility. Combinational circuit design. Encoders, Decoders, Multiplexers and Demultiplexers.	9
II	**Sequential Circuits:** R-S, J-K, D and T flip-flops. Counters (Synchronous and asynchronous). Up-down counter. Study of IC 7490. Digital Clock, Shift registers. SISO, SIPO, PISO and PIPO operations of shift registers. Shift left, shift right registers. Ring Counter. Study of IC 7495.	9
III	**Data Converters:** Introduction to Analog and Digital Systems. Digital to Analog Converters – Weighted resistor method, Binary Ladder method, 4 – bit D/A converter. D/A accuracy and resolution, Analog to Digital Converters – Simultaneous conversion, counter method, continuous conversion, successive approximation method, single slope and dual slope techniques for A/D conversion. Accuracy and resolution of A/D converters.	9
IV	**Semiconductor Memories:** Use of a simple switch, a capacitor and a flip-flop as a memory element, Study of diode matrix as a ROM. Study of PROM, EPROM and EEPROM. RAMs, Static and Dynamic RAMs, Memory cells, organization and addressing of memory cells. Study of ICs 2114.	9

References:

1. Digital Principles and Applications – Leach, Malvino, Saha - Mc Graw Hill
2. Digital Integrated Electronics – Taub, Schilling – Mc Graw Hill.

Title of the Course and Course Code	C-PROGRAMMING - PHY3612	Number of Credits :2
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the basic structure of C language, concept of Flowchart and Algorithm and define functions and pointers.	
CO2	Discuss the structure of C language, keywords, operators, constants and variables, control statements, standard I/P functions etc.	
CO3	Implement C programming to solve the basic problems in Physics and objective oriented tasks.	
CO4	Explain the basic of graphics in C programming.	
CO5	Review the use of Arrays.	
CO6	Write the programs using C language.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Introduction to Programming**: What is programming, how to convert given problem into a pseudo code, writing algorithm, efficiency of algorithms, loops and repetitions, writing algorithms for simple problems, writing flowcharts, flowchart symbols.	**8**
II	**Data types and structures:** Integers, float, real, characters, logical Declaration of variables, Input and Output of data: printf, scanf reading and writing data from files, formatting input and output, operators, writing simple programs using data types, Arrays and pointers: uses, simple programs using arrays	**12**
III	**Basics of C-Programming**: Control statements: if, if-else, nested if, for loop, do while loops, go to statement, continue statement, jump statement, exit and break statement, Functions and Subroutines	**10**
IV	**Using graphics in C** Concept of graphics, simple graphics statements, Programming using graphics libraries in C, Applications of graphics	**6**

References:

1. C-Programming for Physicists, by W. H. Bell.
2. Computer Basics and C-Programming, by Y. Rajaraman (PHY Learning Publications).
3. Let us C, by Yashwant Kanetkar. 16th Edition, BPB publication
4. Programming in C (Schaum's series) Gottfreid THM