Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Physics

(Faculty of Science & Technology)

T.Y.B.Sc. (Physics)

Choice Based Credit System

To be implemented from Academic Year 2021-2022

Savitribai Phule Pune University, Pune

Revised syllabus for T.Y.B.Sc. (Physics) (CBCS Pattern-2021-22)

To be implemented from Academic Year 2021-22

Salient Features of Revised Syllabi in Physics

As far as possible to promote:

1) Physics Education through Master Texts:
It helps in understanding the theoretical and mathematical development of the subject and to create interest in the subject.

2) Physics Education through Experimentation:
It helps in general to improve scientific attitude. So emphasis is given on the development of experimental skills, data analysis, calculations, and also on the limitations of the experimental method and data and, results obtained.

3) Physics Education through Problem Solving: It helps in understanding the concepts of physics. It underline the strength of equations, formulae, graphs, mathematical tools to tackle the problems. So accordingly, we have introduced compulsory problem part in the question paper.

4) Physics Education through History and Philosophy:
It helps in understanding the conceptual development of the subject and thereby increase the interest in the subject. A topic on this is introduced in the Physics Course.

5) Physics Education through Awareness of Misconceptions:
It improves the scientific awareness among the students. A discussion on different subjects are encouraged.

6) Physics Education through Proto-research:
It creates interest in the subject and improves technological aspect. Accordingly, mini projects, hands-on activities, projects, models and demonstrations etc. is included in the syllabi.

7) Physics Education through Qualitative Overview:
It creates interest in the subject to continue to work in the field of science in general and physics in particular. Accordingly future directions and frontiers of the subject are included in the syllabi.

8) **Structure of Question paper:**
Existing structure shall continue.

9) **ATKT Rules:**
Existing rules shall apply.

10) **Structure of the Course:**

Semester	Course Type	Course Code	Course Name	Credit
V	Discipline Specific Elective Course	PHY-351	Mathematical Methods in Physics-II	2
		PHY-352	Electrodynamics	2
		PHY-353	Classical Mechanics	2
		PHY-354	Atomic and Molecular Physics	2
		PHY-355	Computational Physics	2
		PHY-356: Elective-I (Select any One)		2
		PHY-356**(A)**	Astronomy and Astrophysics-I	
		PHY-356(**B**)	Elements of Materials Science	
		PHY-356(**C**)	Biophysics	
		PHY-356(**D**)	Renewable Energy Sources-I	
		PHY-356(**E**)	Applied Optics	
		PHY-356(**F**)	C# programming	
		PHY-357	Physics Laboratory-3A	2
		PHY-358	Physics Laboratory-3B	2
		PHY-359	Project-I	2
	Skill Enhancement Course	**PHY-3510: Skill Enhancement Course-I (Select any One)**		2
		PHY-3510(**G**)	Python Programming	
		PHY-3510(**H**)	Energy studies	
		PHY-3510(**I**)	Introduction to Arduino	
		PHY-3510(**J**)	Sensors and Transducer	
		PHY- 3511: Skill Enhancement Course-II (Select any One)		2
		PHY-3511(**K**)	Physics Workshop Skill	
		PHY-3511(**L**)	Biomedical Instrumentation	
		PHY-3511(**M**)	Non-destructive Testing Techniques	
		PHY- 3511(**N**)	Acoustics Applications	
VI	Discipline Specific Elective Course	PHY-361	Solid State Physics	2
		PHY-362	Quantum Mechanics	2
		PHY-363	Thermodynamics and Statistical Physics	2
		PHY-364	Nuclear Physics	2
		PHY-365	**(A)** Electronics-II **OR** **(B)** Advanced Electronics	2

		PHY-366: Elective-II (Select any One)		
		PHY-366(**O**)	Medical Electronics	2
		PHY-366(**P**)	Physics of Nanomaterials	
		PHY-366(**Q**)	Microcontrollers	
		PHY-366(**R**)	Lasers	
		PHY-366(**S**)	Astronomy and Astrophysics-II	
		PHY-366(**T**)	Renewable Energy Sources-II	
		PHY-367	Physics Laboratory-4A	2
		PHY-368	Physics Laboratory-4B	2
		PHY-369	Project-II	2
	Skill Enhancement Course	**PHY-3610: Skill Enhancement Course-III (Select any One)**		2
		PHY-3610(**U**)	Scientific Data Analysis using Python	
		PHY-3610(**V**)	Solar PV System: Installation, Repairing and Maintenance	
		PHY-3610(**W**)	Applications of Internet of things (IOT)	
		PHY-3610(**X**)	Calibration Techniques	
		PHY- 3611: Skill Enhancement Course-IV (Select any One)		2
		PHY- 3611(**Y**)	Microcontrollers	
		PHY- 3611(**Z**)	Instrumentation for Agriculture	
		PHY- 3611(**AA**)	Radiation Physics	
		PHY- 3611(**AB**)	Photography	

Semester-V

T.Y.B.Sc. (Physics) (Sem-V)
PHY-351: Mathematical Methods in Physics-II

Lectures: 36 **(Credits-02)**

1: Curvilinear Co-ordinates **(10L)**

Review of Cartesian, spherical and cylindrical co-ordinate, transformation equation, General Curvilinear co-ordinate system: Co-ordinate surface, co-ordinate lines, length, surfaces and volume elements in curvilinear co-ordinate system.

Orthogonal curvilinear co-ordinate system, expressions for gradient, divergence, Laplacian, and curl, special case for gradient, divergence and curl in Cartesian, spherical polar and cylindrical co-ordinate system, Problems.

2: The Special Theory of Relativity **(10L)**

Introduction and applications, Newtonian relativity, Galilean transformation equation, Michelson-Morley experiment, Postulates of special theory of relativity, Lorentz transformations, Kinematic effects of Lorentz transformation, Length contraction, Proper time, Problems.

3: Partial Differential Equations **(8L)**

Introduction and applications of Partial differential equations (PDE), General methods for solving second order PDE, Method of separation of variables in Cartesian, Spherical polar and cylindrical co-ordinate system (two dimensional Laplace's equation, one dimensional Wave equation), Singular points ($x = x_0$), Solution of differential equation-Statement of Fuch's theorem, Frobenius method of series solution.

4: Special Functions **(8L)**

Introduction, generating function for Legendre Polynomials: $P_n(x)$, Properties of Legendre Polynomials, Generating function for Hermite Polynomials: $H_n(x)$, Properties of Hermite Polynomials, Bessel function of first kind: $J_n(x)$, Properties of Bessel function of first kind, Applications of Special Functions in Physics, Problems.

Reference books:

1. Mathematical methods for physicists, Arfken and Weber, Acadmic press Newyork, 7th Edition.
2. Mathematical physics, Rajput, Pragati prakashan-1997.
3. Mathematical methods in the physical sciences – Marry L. Boas, John Willy & Sons publication, 3rd Edition-2005.
4. Introduction to special relativity, Robert Resnick, John Wiley & Sons, Inc.-1968.
5. Mathematical physics, B. D. Gupta, Vikas publishing house Pvt. Ltd., 4th edition-2010.
6. Mathematical physics, H. K. Dass, Dr. Rama Varma, S. Chand & Company Pvt. Ltd.,7th Edition-2014
7. The Special Theory of Relativity: A Mathematical Approach-Farook Rahaman, Springer Publication -2014.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-352: Electrodynamics

Lectures: 36 **(Credits-02)**

1: Electrostatics **(12 L)**

- **a.** Revision of Coulomb's law, Gauss law, Electric field, Electrostatic Potential.
- **b.** Potential energy of system of charges.
- **c.** Statement of Poisson's and Laplace's equation, Boundary Value problems in electrostatics- **S**olution of Laplace equation in Cartesian system, Boundary conditions.
- **d.** Polarization **P**, Electric displacement **D**, Electric susceptibility and dielectric constant, bound volume and surface charge densities.
- **e.** Electric field at an exterior and interior point of dielectric.

2: Magnetostatics **(12 L)**

- a. Concepts of magnetic induction, magnetic flux and magnetic field.
- b. Magnetic induction due to straight current carrying conductor, magnetization of matter, relationship between **B, H** and **M.**
- c. Boundary conditions at the interface of two magnetic media (Normal and tangential components).
- d. Biot-Savart's law, Ampere's force law, Magnetic force between two current carrying loops, Ampere's circuital law.
- e. Equation of continuity, Magnetic vector potential **A,** Magnetic susceptibility and permeability.

3: Electrodynamics **(12 L)**

- **a.** Day to day applications of Electrodynamics.
- **b.** Concept of electromagnetic induction, Faradays law of induction, Lenz's law, displacement current, generalization of Amperes' law.
- **c.** Maxwell's equations (Differential and Integral form) and their physical significance.
- **d.** Polarization, reflection and refraction of electromagnetic waves through media.
- **e.** Wave equation and plane waves in free space.
- **f.** Poynting theorem and Poynting vector.

Reference Books:

1. Introduction to Electrodynamics; D. J. Griffith; Cambridge India; Fourth edition (2020)
2. Classical Electrodynamics; J. D. Jackson; Wiley; Third edition (2007)
3. Introduction to Electrodynamics; A. Z. Capri, Panat P. V.; Alpha science international ltd; Illustrated edition(2002)
4. Foundations of electromagnetic theory; Reitz, Milford and Christy; Pearson education India; Fourth edition (2010)
5. Electrodynamics; Gupta, Kumar, Singh; Pragati Prakashan; Ninteenth edition (2011)
6. Electromagnetic field and waves; Paul-Lorrain, D. R. Corson; W.H. Freeman & co. Ltd; Second edition (1970)
7. Electricity and magnetism; Murugeshan; S. Chand; (2020)
8. Electromagnetic theory and electrodynamics; Satya Prakash; Kedar Nath Ram Nath; (2020)

T.Y.B.Sc. (Physics) (Sem-V)
PHY-353: Classical Mechanics

Lectures: 36 **(Credits-02)**

1: Motion of Particles **(8L)**

a. Charged Particles: Motion of a charged particle in constant electric, magnetic and electromagnetic field,
b. System of particles: Concept of Centre of mass, Conservation of linear momentum, angular momentum, energy of system of particles.(statements only)
c. Day to day applications of Classical mechanics,
d. Problems

2: Central force Field **(8L)**

a. Central force Field: Definition and Properties of central force field. Reduction of two body problem to an equivalent one body problem
b. Motion in central force field,
c. Kepler's laws of planetary motion and their proof
d. Artificial satellite and its orbit
e. Problems.

3: Scattering of particles **(10L)**

a. Elastic and inelastic scattering: Definition and properties,
b. Elastic scattering - Laboratory and center of mass system.
c. Scattering: Scattering angles in laboratory and center of mass system.
d. Differential cross-section, impact Parameter, total cross-section in brief.
e. Problems

4: Langrangian and Hamiltonian formulation **(10L)**

a. Limitations of Newton's Law of Motion,
b. Constraints and Their Classification, Example of Constrains, degrees of freedom, generalized coordinate, configuration space,
c. Principle of Virtual work done,
d. D'Almeberts Principle of virtual work,
e. Langrangian equation from D' Alembert's principle, cyclic coordinates,
f. Phase space, Hamiltonian's equations
g. Problems

Reference books:

1. **Classical Mechanics**, J.C. Upadhyaya, Himalaya publishing Houses, 2nd Edition of 2005.
2. **Introduction to Classical Mechanics,** R. G. Takawale, P. S. Puranik, Tata McGraw Hill publishing Company Ltd., New Delhi.
3. **Classical Mechanics,** NC Rana and PS Joag, Tata McGraw Hill Education Private Limited, New Delhi, 1991.
4. **Classical Mechanics** by P.V.Panat.
5. **Classical Mechanics,** Herbert Goldstein, Narosa Publishing House.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-354: Atomic and Molecular Physics

Lectures: 36 **(Credits-02)**

1: Atomic structure **(6 L)**

1. Revision of various atomic models
2. Vector atom model (Concepts of space quantization and electron spin)
3. Pauli Exclusion Principle and electron configuration, Quantum states, Spectral notations of quantum states.
4. Problems

2: One and Two Valence electron systems **(12 L)**

1. Spin-Orbit Interaction (Single valence electron atom), Energy levels of Na-atom, Selection rules, Spectra of sodium atom, Sodium doublet.
2. Spectral terms of two electron atoms, terms for equivalent electrons, LS and JJ-coupling schemes.
3. Singlet-Triplet separations for interaction energy of LS coupling, Lande's interval rule, Spectra of Helium atom.
4. Problems

3: Zeeman Effect **(4 L)**

1. Zeeman Effect
2. Experimental arrangement
3. Normal and anomalous Zeeman Effect
4. Stark effect (Qualitative discussion)
5. Applications of Zeeman effects
6. Problems

4: Molecular spectroscopy **(8 L)**

1. Introduction of molecular spectra and its types
2. Rotational energy levels, Rotational spectra of rigid diatomic molecule
3. Vibrational energy levels
4. Rotational and Vibrational spectra
5. Electronic spectra of molecules
6. Applications of UV-Vis spectroscopy
7. Problems

5: Raman spectroscopy **(6 L)**

1. History of Raman effect, Molecular polarizability
2. Classical theory and Quantum theory of Raman Effect
3. Characteristics Raman Lines and Applications of Raman spectroscopy
4. Problems

Reference books:

1) R. Murugeshan, Er. K. Sivaprasath, Modern Physics, S. Chand, 2014, Revised edition
2) Robert Eiseberg, Robert Resnik, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, 2016, 2nd edition
3) G. Aruldhas, Molecular structure and Spectroscopy, PHI, 2015, 2nd edition
4) Colin Banwell, Elaine McCash, Fundamentals of Molecular Spectroscopy, TMH, 4th ed
5) Arthur Baiser, Concepts of Modern Physics , McGraw Hill International, 4th edition
6) White H. E, Introduction to Atomic spectra, McGraw Hill International

T.Y.B.Sc. (Physics) (Sem-V)
PHY-355: Computational Physics

Lectures: 36 **(Credits-02)**

1: Concepts of Programming and Introduction to C-programming: (14 L)

a) Definition and Properties of algorithms, Algorithm development, Flow charts- symbols and simple flowcharts.
b) Introduction and Structure of C-program, 'C' Character set, key words, Constants and variables, Variable names, Data types, qualifiers and their declarations, Symbolic Constants.
c) Input/output functions: scanf( ), printf( ), getchar(), putchar(), gets(), puts().
d) Operators and Expressions: Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Conditional Operator.
e) Control statements: if, if else, while, do while, for loop, nested control structures (nested if, nested loops), break, continue, switch- case statement, goto statement.
f) Use of Library functions: e.g. mathematical, trigonometric, graphics.

2: Arrays, Pointers and user defined function in C-Language (8 L)

a) Arrays: 1-D, 2-D: Arranging numbers in descending and ascending order, Sum of matrices, multiplication of matrices.
b) Concept of pointers with suitable illustrative examples.
c) User defined functions: Definitions and declaration of function, function prototype, passing arguments (Call by value, Call by reference). Simple illustrative examples.

3: Graphics in C-Language: (3 L)

Concepts of graphics in C, Some simple graphic commands- Point, Line, Circle, Arc, Ellipse, Bar with suitable illustrative examples.

4: Computational Physics: (11 L)

Numerical Methods to solve the Physics Problems

a) **Iterative methods:** Bisection method and Newton-Raphson Method– Algorithm, Flowchart and writing C- program for finding the roots of the equation, problems
b) **Integration:** Trapezoidal rule, Simpson's $1/3^{rd}$ rule – Algorithm, Flowchart and C-program, problems

Reference Books:

1. Programming in C- (Schaum's series), Gottfreid, TMH
2. Programming in C- Balgurusami, Prentice Hall publications
3. Let us C- Yashwant Kanetkar, BPB publications
4. Programming with C- K.R. Venugopal, S. R. Prasad, TMH.
5. Introductory methods of numerical analysis-S. Sastry, Prentice Hall
6. Computer oriented numerical methods – V. Rajaraman.

PHY-356: Elective-I

T.Y.B.Sc. (Physics) (Sem-V)
PHY-356 Elective-I (A): Astronomy and Astrophysics-I

Lectures: 36 **(Credits-02)**

1: Fundamentals of Astronomy: **(10 L)**

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, Co-ordinate system, Celestial hemisphere,

2: Astronomical Instruments: **(8 L)**

Optical telescopes, mounts, light gathering power, magnification, Resolution. Spectroscopes, CCD camera, photometer, filters Radio telescopes, Interferometry (only introduction)

3: Star Systems and basic observations: **(10 L)**

Stars life cycle, Stellar processes (Nuclear). Neutron stars, black holes, Chandrasekhar limit. Spectral classification of stars, O, B, A, F, G, K, M. Star Systems: Binaries / Cepheids / RR Lyrae, Observation of Sun: Eclipses, Moon, planets, meteor showers, transits, occultations.

4: Galaxies, Dark Matter and Dark Energy **(8 L)**

A) Galaxies, types, their formation, Hubble's tuning fork diagram, Open and Globular clusters, Dark Matter / Energy (evidence for both), Cosmology: Theories: BBT, Steady State, Oscillating Universe Theory.

B) Observational Astronomy: Concept of time, Magnitudes: apparent and absolute, introduction to Constellations, Star dial.

Reference books:

1. Astronomy structure of the Universe. A.E. Roy and D. Clarke, Adam Hilger Pub.
2. Source Book of Space Sciences, Samuel Galsstone; D.Van Nostrand Co. Inc
3. Astrophysics - Stars and Galaxies, K.D. Abhyankar, Tata McGraw Hill Pub.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Pub.
5. Structure of the Universe, J.V. Narlikar
6. Astrophysics, Baidyanath Basu.
7. Astrophysical Techniques, third Edition, C. R. Kitchin
8. Fundamentals of Astronomy, Michael Seed
9. Telescopes and techniques, C. R. Kitchin (Springer)

List of experiments: (Any 2)

1. Study of Binocular, refracting and reflecting telescopes and their mounts.
2. To determine the diameter of the Moon.
3. Measurement of Solar Constant.
4. Observation of emission, continuous and absorption spectra. (Mercury, sodium or iodine spectra could be obtained.)
5. Study of Construction and working of CCD.
6. Study of Solar Eclipse and Lunar Eclipse.

T.Y.B.Sc. (Physics) (Sem-V)

PHY-356 Elective-I (B): Elements of Material Science

Lectures: 36 **(Credits-02)**

1: Defects in Solids **(7 L)**

1. Material Properties – Mechanical, Electrical, and thermal
2. Impurities in solids.
3. Solid solutions in metals.
4. Rules of solid solubility.
5. Imperfection in crystals.
6. Defects in solids point, line, surface, and volume.
7. Atomic diffusions definition, mechanism, Fick's laws.

2: Single Phase Metals **(6 L)**

1. Single phase alloys
2. Deformation
3. Elastic Deformation and Plastic Deformation
4. Mechanism of plastic Deformation by slip
5. Critical resolved shear stress (CRSS)
6. Plastic deformation in poly crystalline materials

3: Ceramic Materials **(10 L)**

1. Ceramic Phases, Classification of ceramic materials
2. Ceramic crystals (AX)
3. Mechanical behavior of ceramics
4. Electromagnetic behavior of ceramics –
   a) Electric properties dielectrics, semiconductors, piezoelectric
   b) Magnetic Properties Magnetic Ceramics, hard and soft ferrites

4: Phase Diagrams **(9 L)**

1. Basic terms System, Surrounding, Component, Coordinates, Phase, Equilibrium.
2. Phase Diagram definition, importance, and objective
3. Lever rule
4. Gibb's phase rule
5. Phase diagram of a) Sugar water b) NaCl water
6. Types of phase diagrams with construction
   a) Type I Lens type CuNi phase diagram
   b) Type II Only introduction
   c) Type III Eutectic type PbSn phase diagram
7. Isothermal cuts

5: Introduction to smart materials **(4 L)**

1. Definition of smart materials
2. Types and structure of smart materials,
3. Properties of smart materials
4. Applications of smart materials.

Reference books :

1. Elements of Materials Science and Engineering I. H. Vanvlach (4^{th} Edition)
2. Materials Science and Engineering - V. Raghavan

List of experiments : (Any 2)

1. To determine the dipole moment of a given liquid
2. To determine magnetic susceptibility of $FeCl_3$
3. To determine the specific heat of graphite
4. Determination of the yield point and the breaking point of an elastic material
5. Ionic conductivity of NaCl/ NaI
6. Grain size and grain boundary measurement using optical microscope.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-356 Elective-I (C): Biophysics

Lectures: 36 **(Credits-02)**

1: Introduction of Biophysics **(13L)**

1.1 History of Biophysics, Concept of Biophysics and Physical properties applied to biology- Surface tension, Viscosity, adsorption, diffusion, osmosis, Definition for Biostatistics and Biometry

1.2 Cell: Animal and plant cell, types of cell, Functional aspects of cell membrane, cytoplasm, nucleus, mitochondria and chloroplast

1.3 Protein structure (Primary and Secondary), amino acid structure, Genetic code- symmetry, DNA structure

1.4 Photosynthesis process:- electron transport, Gibbs's free energy, Redox couple, Redox potential, Oxidation and reduction, Examples of redox potential in biological system.

2: Bio-potentials **(9L)**

2.1 Bioelectric signals: structure of neuron, resting potential, action Potential, Nernst equation

2.2 Bioelectrodes- Half-cell potential, polarizable and non-polarizable electrodes, Microelectrode- metal and glass electrodes

2.2 Study of Cardiovascular system, Compound action potential of human body-ECG (Electrocardiography), Electrodes for ECG

3: Bio-instruments **(6L)**

3.1 Basic principle, Construction and working of colorimeter, spectrophotometer, PH meter and Centrifuge measurement.

3.2 Electron Microscope: SEM, TEM.

4: Radiation Biophysics **(8L)**

4.1 Definition, Units of Radioactivity and radiation doses, Types of radiation (Ionizing and non- ionizing), radioimmunoassays.

4.2 Applications: PET (Positron Emission Tomography), NMR (Nuclear Magnetic Resonance), MRI (Magnetic Resonance Imaging Techniques), Ultrasonography, CT (Computed Tomography) Scan.

Reference books:

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 Vatsala Piramal, Dominant Publisher and Distributors, New Delhi-110002
5. Textbook of Biophysics - by R.N. Roy
6. Photosynthesis - by Hall and Rao.
7. Introduction to Biomedical Equipment Technology (Fourth Edition) by-Joseph J.Carr
8. Text Book of Bio-medical Electronics-by S.S. Agrawal

List of Experiments : (Any 2)

1. Recording and analysis of ECG signals
2. Verification of Beer's and Lambert's Law
3. Absorption spectrum of Blood/Chlorophyll.
4. pH value of Amino acids.
5. Bimolecular model building using standard kits.
6. Separation of components of Milk/Chlorophyll using centrifuge machine.

T.Y.B.Sc. (Physics) (Sem-V)

PHY-356 Elective-I (D): Renewable Energy Sources-I

Lectures: 36 **(Credits-02)**

1: An Introduction to Energy Sources: **(10L)**

1. Energy: Definition, Classifications of energy sources
2. Conventional and non-conventional energy sources.
3. Sun: The source of energy (Structure, Characteristics and Composition)
4. Solar Constant
5. Electromagnetic Energy Spectrum.
6. Solar radiations outside earth atmosphere.
7. Solar radiation at the earth surface.
8. Problems.

Ref.1- page no. 1 to 11 and 15 to 37

Ref.3- 3.1, 3.2, 3.3, 3.4, 3.5

2: Photothermal Applications: **(10L)**

1. Photothermal devices: Solar Insolation, Selective Coating, Glass Cover, Heat Conductor and Heat Insulation.
2. Solar water heating systems: Types, construction and working of Liquid Flat Plate Collector (FPC) and Evacuated Tube Collector (ETC)
3. Energy Balance Equation (without thermal Analysis).
4. Concentrating collectors: Flat plate collector with plane reflector, Cylindrical parabolic, Compound parabolic, Collector with fixed circular concentrators and moving receiver, paraboloid concentrator.
5. Comparative study between flat plate collector and solar concentrators.
6. Solar distillation, Solar dryer, Solar cooker (box type)

Ref. 1: 3.3, 3.3(A), 3.5, 3.7, 3.8, 5.2, 5.8, 5.11.

Ref. 2: 2.2.6

3: Photovoltaic systems: **(10L)**

1. Introduction to Photovoltaic effect and Photovoltaic Conversion.
2. Basic photovoltaic system for power generation
3. Basics of Solar Cell, PV modules, Arrays,
4. Solar Cell: I-V characteristics, Power output and conversion efficiency.
5. Factors affecting on photovoltaic efficiency. (Change in amount of input light, solar cell area, Change in angle, Change in operating Temperature etc.)
6. Types of solar cells: p-n junction solar cell, p-i-n diode solar cell, cadmium sulphide solar cell, Gallium arsenide solar cell, Indium phosphide solar cell, nano-crystalline solar cell.
7. Application of solar photovoltaic systems.

Ref.3 -15.1, 15.3, 15.4, 15.5, 15.7, 15.8, 15.10.

Ref.8 – 3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5

4: Energy Storage: **(06L)**

1. Importance and Needs of Energy storage in Conventional and Nonconventional Energy Systems.
2. Various forms of Energy Storage
3. Electrical Energy: Super capacitors
4. Electrochemical Energy: Battery
5. Chemical Energy: Hydrogen Production and storage

Ref.4 - Ref.5 - Ref.6 - Ref.7 -

Reference books:

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 Utilizations**,** G. D. RAI (5th edition), Khanna Publishers, Delhi.
4. Energy Storage: Fundamentals, Materials and Applications, by Huggins R. A., Springer
5. Chemical and Electrochemical Energy System by R. Narayan and B. Viswanathan, University Press.
6. Battery Systems Engineering by C. D. Rahn and C. Wang, Wiley Pub.
7. Electrochemical Energy Storage for Renewable sources and grid balancing by P. T. Moseley and J. Garche, Elsevier Science.
8. Solar Photovoltaic Technology and Systems by C S Solanki

List of Experiments: (Any 2)

1. To calculate the thermal efficiency of liquid flat plate collector.
2. To study the box type solar cooker.
3. To determine an instantaneous thermal efficiency of parabolic collector.
4. To calculate an efficiency and fill factor of PN junction solar cell.
5. To study I-V characteristic of various types of solar cells.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-356 Elective-I (E): Applied Optics

Lectures: 36 **(Credits-02)**

1: Fermat's Principle and Matrix Methods in Paraxial Optics: (9L)

1.1 Introduction to Fermat's Principle and its Applications.
1.2 Laws of Reflection and Refraction from Fermat's Principle.
1.3 Ray paths in an Inhomogeneous Medium.
1.4 Introduction to Matrix methods in Paraxial Optics.
1.5 The matrix method, Unit planes and Nodal planes.
1.6 A System of two thin lenses.
1.7 Problems.

2: Multiple-Beam Interferometry and Diffraction: (9L)

2.1 Introduction to Multiple-Beam Interferometry.
2.2 Michelson Interferometer
2.3 The Fabry-Perot Etalon.
2.4 The Fabry-Perot Interferometer.
2.5 Introduction and revision of diffraction.
2.6 Two slit and N-Slit Fraunhofer diffraction pattern.
2.7 Fresnel half period zones, the zone plate and Fresnel Diffraction.
2.8 Problems.

3: Polarization and Holography: (9L)

3.1 Introduction and Revision of Polarization.
3.2 Malus law, Double refraction,
3.3 Phase retarded plate, Quarter wave plate and half wave plate
3.4 Optical activity and Polarimeter
3.5 Introduction and Theory of Holography.
3.6 Importance of coherence and Principle of holography.
3.7 Characteristics, recording and reconstruction of Holography
3.8 Applications of Holography.
3.9 Problems.

4: Fibre Optics: (9L)

4.1 Introduction to Fibre Optics.
4.2 The Optical Fibre: Principle and Structure.
4.3 Fibre Optics: Numerical aperture and Acceptance angle, Pulse dispersion and Calculation of pulse dispersion.
4.4 Types of Optical Fibres: Concept of Mode, Multimode and Single mode fibre.
4.5 Attenuation in optical fibers, single mode and multimode fibers.
4.6 Fibre Optic communication system: Fiber optical telecommunication system.
4.7 Advantages of Fibre Optics.
4.8 Applications of Fibre Optics.
4.9 Problems.

Reference Books:

(1) Ghatak Ajoy, Optics 3rd Edition, The McGraw Hill companies.
(2) N. Subrahmanyam, A textbook of Optics, S. Chand publications.
(3) Optical Fiber and Fiber Optic communication System, S.K Sarkar S. Chand.
(4) Practical Optics, Naftaly Menn, Academic press (2004)
(5) M. Born and E. Wolf, Principles of Optics, Cambridge University Press
(6) F. A. Jenkins, H.E White, Fundamental of Optics, McGraw companies

List of Experiments : (Any 2)

(1) Determination of the numerical aperture of the given optical fibre.
(2) Determination of the optical power loss in attenuators.
(3) Fabry Perot Etalon
(4) To study the nature of polarization of laser light using photo cell and quarter wave plate.
(5)To determine the Brewster's angle for glass using a polarized monochromatic light source.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-356 Elective-I (F): C# Programming

Lectures: 36 **(Credits-02)**

1: MS.NET Framework Introduction **(8L)**

• The .NET Framework - an Overview • Framework Components • Framework Versions • Types of Applications which can be developed using MS.NET • MS.NET Base Class Library • MS.NET Namespaces • The Common Language Runtime (CLR), Common Type System (CTS) • Common Language Specification (CLS) . Installing Required Software – SQL Server and Management studio

2: C # Language Syntax **(8L)**

• Datatypes • Global, Stack and Heap Memory • Common Type System • Reference Type and Value Type • Datatypes and Variables Declaration • Implicit and Explicit Casting • Checked and Unchecked Blocks – Overflow Checks • Casting between other datatypes • Boxing and Unboxing • Enum and Constant • Operators • Control Statements • Working with Arrays • Working with Methods • Pass by value and by reference and out parameters• Writing, testing and execution of program to understand general syntax and functions available in C#.

3: Database Programming Using ADO.NET **(8L)**

• Prerequisite - Knowledge of SQL Queries • Introduction and Evolution of ADO.NET • Understanding the Role of Managed Provider and ADO.NET Objects • connecting to Database and Connection Pooling • Performing Insert, Update and Delete Operations • Fetching Data from database - Executing Select Statements • How to implement Login facility with database

4: Interactive methods **(6L)**

Preparing flowchart, algorithm for interactive methods, Bisection Methods, Newton Rapson Method, Numerical integration by Trapezoidal rule, Simpson 1/3rd rule.

5: Hands on training: **(6L)**

Hands on training to execute numerical problems for interactive methods, Bisection Methods, Newton Rapson Method, Numerical integration by Trapezoidal rule, Simpson 1/3rd rule.

Reference Books:

1. C# 8.0 Pocket Reference: Instant Help for C# 8.0 Programmers
2. Programming in C# by E Balagurusamy
3. Beginning C# Object-Oriented Programming (English, Paperback, Clark Dan)
4. Pro C# 9 with .NET 5: Foundational Principles and Practices in Programming by Troelsen, Andrew, Japikse, Philip

Web References:

1. https://dotnet.microsoft.com/learn/csharp
2. https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/
3. https://www.pragimtech.com/courses/c-sharp-tutorial-for-beginners/
4. https://www.tutorialspoint.com/csharp/csharp_tutorial.pdf

List of Experiments: (Any 2)

1. Write a program that converts 1 lower case letter ("a" - "z") to its corresponding upper case letter ("A" - "Z"). For example if the user enters "c" then the program will show "C" on the screen.
2. Write a program using a switch statement that takes one value from the user and asks about the type of conversion and then performs a conversion depending on the type of conversion. If user enters:
3. Write a program using conditional operators to determine whether a year entered through the keyboard is a leap year or not.
4. Write a program using a for loop that prints the following output (you need to find a pattern to print letters in this order): A B D H P
5. Write a program using a loop that prints the following output. 1 2 2 3 3 3 4 4 4 4 5 5 5 5 5 6 6 6 6 6 6 . . . nth iteration.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-357: Physics Laboratory-3A

Lectures: 36 **(Credits-02)**

(General Laboratory, Electromagnetism, Atomic and Molecular Physics, and Optics)

(Any Eight)

GROUP-I: GENERAL PHYSICS (any FOUR)

1. Kater's pendulum
2. Moment of Inertia by Bifilar suspension
3. Young's modulus by Koeing method
4. Surface tension of mercury by ripple method
5. Surface tension liquid by Fergusson method
6. Surface tension of mercury by Quincke's method
7. 'Y' by vibration of wooden scale
8. Young's modulus by Newton's rings
9. Determination of wavelength of light by Michelson's interferometer
10. Study of damped oscillations of physical pendulum and finding log decrement

GROUP-II: ELECTROMAGNETISM (any TWO)

1. Study of forced oscillations by electromagnetically driven simple pendulum
2. Self-Inductance by Anderson's bridge
3. Core losses in transformers
4. Electromagnetic pendulum
5. Self-Inductance by Maxwell's bridge

GROUP-III: ATOMIC AND MOLECULAR PHYSICS AND OPTICS (any TWO)

1. Determination of Rydberg's constant
2. Zeeman Effect
3. Llyod's mirror
4. Determination of Resolving Power of grating
5. Determination of wavelength by Constant deviation spectrometer

Additional Activities (Any ONE)

- Demonstrations: Any 2 demonstrations equivalent to 2 experiments
- Study tour with report equivalent to 2 experiments
- Mini project equivalent to 2 experiments
- Computer aided demonstrations (simulations or animations)
  (Any 2 demonstrations equivalent to 2 experiments)

Note: *Students have to perform* ***ten*** *experiments or* ***one*** *additional activities in addition to* ***eight*** *experiments mentioned above. Total laboratory work with additional activities should be equivalent to* ***ten*** *experiments.*

T.Y.B.Sc. (Physics) (Sem-V)
PHY-358: Physics Laboratory-3B

Lectures: 36 **(Credits-02)**

GROUP-I: EXPERIMENTS USING CRO/INSTRUMENTATION (any TWO)

1. Charging and discharging of capacitor and RC time constant
2. Measurement of g using simple pendulum
3. Velocity of sound
4. Radiation detection
5. IV Characteristics of diode
6. Measuring a value of a capacitor using CRO.
7. Temperature controller using AD590
8. Study of IC 7490 as mod 2, mod 5, mod 7 and mod 10 counter.

GROUP-II: C-PROGRAMMING (any TWO)

1. Factorial of a number by simple and recursive method.
2. To find out the first 100 prime numbers
3. Matrix multiplication
4. Position time data using kinematic equations
5. Finding pressure using Van-der-Waals' equation of state

GROUP-III: COMPUTATIONAL PHYSICS (NUMERICAL BASED) (any TWO)

1. Roots of an algebraic equation (Bisection)
2. Roots of polynomial (Newton Raphson)
3. Numerical Integration by Trapezoidal rule
4. Numerical Integration by Simpson's 1/3 rule

GROUP-IV: PRACTICAL FROM OPTIONAL COURSE (Any TWO)

Additional Activities (Any ONE)

- Demonstrations: Any 2 demonstrations equivalent to 2 experiments
- Study tour with report equivalent to 2 experiments
- Mini project equivalent to 2 experiments
- Computer aided demonstrations (simulations or animations)
  (Any 2 demonstrations equivalent to 2 experiments)

Note: *Students have to perform* ***ten*** *experiments or* ***one*** *additional activities in addition to* ***eight*** *experiments mentioned above. Total laboratory work with additional activities should be equivalent to* ***ten*** *experiments.*

T.Y.B.Sc. (Physics) (Sem-V)
PHY-359: Physics Project-I

Lectures: 36 **(Credits-02)**

Guidelines:

It is expected that,

1. The student does work equivalent to about ten (10) laboratory experiments throughout the semester in the third year.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic physics and/or their applications.
4. The theme chosen should be such that it promotes better understanding of physics concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the physics concepts involved and the final presentation at the time of viva voce.
6. It is also recommended that a teacher will look after Four (4) projects at one time.
7. Practical examination will be conducted semester wise.
8. The student can perform an Experimental/Theoretical/Computational Project in Physics or interdisciplinary areas under the supervision of one or more guides.
9. The student can learn the basics of the topic chosen for project, to learn how to do literature survey and set up the basic experimental/theoretical and computational techniques needed for the project.
10. The department encourage to students for projects both in experimental and theoretical areas of Physics in collaboration with other institutes and industry.

The Project work shall consist of the following Criterions.

1. Project work is mandatory for all the T. Y .B. Sc. students.
2. All the T. Y. B. Sc. students will be have to complete the Project work prescribed by the Board of Studies in Physics of Savitribai Phule Pune University during the V^{th} Semester.
3. The Project work shall consist of the following Criterions.
    - It is expected that students must finalize the Title of Project, Aim and objective, Significance, Literature survey, Materials required, Method and Application etc.
    - Introduction to foundations of Project Work.
    - Introduction of Project Research Methodology.
    - Study of Data Collection Methods.
    - Project Problem Writing and Presentation Skills.

Evaluation weightage:

- Project-I: Semester End University Examination : 35 Marks
- Internal Examination: 15 Marks

Skill Enhancement Courses

Skill Enhancement Courses (SEC)

a) Selection of Skill enhancement courses

There are two skill enhancement courses (SEC) in 5th semester (PHY-3510 and PHY-3511). For 5th semester, there are four options available. The college has to select any one from the given four options. It is advised that college should not offer elective and skill enhancement course of same theme.

b) Teaching Learning process for Skill Enhancement Courses

Skill base courses are intended to explore the applications of physics knowledge. Learning in skill enhancement courses is largely experience based. The skill enhancement courses may be categorized as knowledge skill or technical skill. For knowledge skill courses one can use the conventional method for teaching along with problem solving, assignments seminars etc. For acquiring the technical skill, the students will get adequate 'hands-on' experience. The teachers may use demonstrations and activity-based learning techniques. On field visits, study tour and mini projects will enrich the learning experience of the students.

c) Assessment methods for skill enhancement courses

Continuous evaluation will be the best method for assessment of skill enhancement courses.

One can use tools like assignments, mini projects or activities, problems, etc and grade the students according to their performance. The internal assessment should have 50 % weightage.

The University examination may be conducted for the remaining 50%.

The University examination question paper should have adequate proportion of objective and subjective question.

d) List of Skill Enhancement Courses:

Semester-Vth	**Semester-Vth**
PHY-3510	**PHY-3511**
PHY-3510(G): Python Programming	PHY-3511(K): Physics Workshop Skill
PHY-3510(H): Energy studies	PHY-3511(L): Biomedical Instrumentation
PHY-3510(I): Introduction to Arduino	PHY-3511(M): Non-destructive Testing Techniques
PHY-3510(J): Sensors and Transducer	PHY-3511(N): Acoustics Applications

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3510 SEC (G): Python Programming

Lectures: 36 **(Credits-02)**

Pre-requisite	: Basic mathematics (XII-Science)
Version of python	: 3.4
Proposed IDE	: Spider, Py Charm or Jupyter

Python Programming:

Python is one of the top ten popular programming languages. Python is a general purpose and high level programming language. You can use Python for developing desktop GUI applications, websites and web applications. Also, Python, as a high level programming language, allows you to focus on core functionality of the application by taking care of common programming tasks. The simple syntax rules of the programming language further makes it easier for you to keep the code base readable and application maintainable. There are also a number of reasons why you should prefer Python to other programming languages.

Advantages of Python Programming

i.) Readable and Maintainable Code
ii.) Multiple Programming Paradigms
iii.) Compatible with Major Platforms and Systems
iv.) Robust Standard Library
v.) Many Open Source Frameworks and Tools
vi.) Simplify Complex Software Development
vii.) Adopt Test Driven Development

Objectives:

i.) To build foundation for understanding Python environment to enhance computational skills.
ii.) Understand variables, input and output functions in python and To Apply computational skill in problem solving approach of Physics
iii.) Get exposure to arithmetic, assignment, relational, logical and Boolean operators.
iv.) Be familiar with Python modules and Libraries

Course outcomes:

After completion of this course student will be able

i.) To write code for complex scientific computational requirement.
ii.) Use Libraries like NumPy for numeric computation
iii.) Use Library SciPy for scientific and technological calculations
iv.) Use Library Matplotlib for plotting of graph and its visualization.
v.) Develop own functions for Physics or mathematics.

Syllabus

a) Python Programming:

Unit No.	Topic	Lectures
1	**Introduction to Python Programming Language**: Introduction to Python Language, • Strengths and Weaknesses, • IDLE, Dynamic Types, • Naming Conventions, • String Values, • String Operations, • String Slices, • String Operators, • Numeric Data Types, • Conversions, • Built In Functions	03
2	**Data Collections and Language Component:** • Introduction, • Control Flow and Syntax, • Indenting, • The if Statement, • Relational Operators, • Logical, • Operators, • True or False, • Bit Wise Operators, • The while Loop, break and continue, • The for Loop, Lists, • Tuples, • Sets, • Dictionaries, • Sorting Dictionaries, • Copying Collections.	05
3	**Functions and Modules :** • Introduction • Defining Your Own Functions Parameters • Function Keyword and Optional Parameters • Passing Collections to a Function • Variable Number of Arguments Scope • Functions Passing Functions to a Function • Mapping Functions in a Dictionary	05

	• Modules • Standard Modules – sys • Standard Modules – math • Standard Modules – time • The dir Function	
4	**Modules and packages in Python :** • NumPy, SciPy • MathPlot etc	**05**

Activity: **any- 6** **[18L]**

Sr. No.	Practical/Demonstration to Communicate Concepts and Application in Physics, Electronics, Statistics and Mathematics
1	Write python program to use basic math and string operations.
2	Write python program to find roots of quadratic equation, prime numbers etc
3	Write python program to store data in list and perform matrix operation
4	Write python program to do numerical methods
5	Write python program involving tuples, dictionaries in problems related to physics or mathematical concepts
6	Write python program to use random number generator as probability density to show expected value is 0.5 to explain quantum mechanical behaviour of particle in one dimensional well.
7	Write python program to use NumPy library for more complex arithmetic operations
8	Write python program to use complex numbers and complex algebra
9	Write python program to use bitwise operation
10	Write python program to plot graphs using mathplotlib or similar library

Reference books:

- Python Programming: Using Problem Solving Approach. By Reema Thareja.
- Think Python By Allen Downey
- Problem Solving and Python Programming By Balguruswami McGrow Hill
- Let Us Python By Aditya Kanetkar
- Learning with Python By Allen Downey
- Data Analytics By Bharti Motwani

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3510 SEC (H): Energy Studies

Lectures: 36 **(Credits-02)**

Objectives:

1. Students understand the comparative aspects, advantages and disadvantages of various sources of energy. They understand the facts and myths regarding the energy sources.
2. Students learn the basic principles involved and technologies developed in the uses of solar energy, biomass energy, wind energy, fuel cells.
3. Students understand the challenges and opportunities in conversion of energy from one form to another, generation of electricity and mechanical work using different energy sources.
4. Students get acquainted with challenges and recent trends in energy storage devices and they learn more about super-capacitors and batteries, electrical vehicles. They can imagine about future road maps in the fields of energy conversion and storage technologies.

Course Outcomes:

1. Students become capable of conducting energy audits and give consultancy in that field.
2. Students can design different types of solar heaters for small domestic as well as large scale community level applications.
3. Students acquire skills to implement solar P-V systems at domestic levels as well as for office premises and educational institutions. Students become able to start their own enterprise in net metering.
4. Students get ideas and hence become self-employed in the field of design , production, commissioning and implementation of bio-mass energy sources , bio-gas plants, gasifiers, wind mills, hybrid systems etc.
5. Students can go for research in the fields of super-capacitors, battery technologies, fuel cells and material synthesis for implementation of these technologies.
6. Students become successful entrepreneurs in the energy field.

Students strive to make the regions where they live and work self-sufficient in generating and fulfilling their own energy needs using different energy solutions.

Syllabus:

Unit No.	Topic	Lectures
1	**An Introduction to Energy Sources:** Classification and comparison of energy sources (hydro, thermal, nuclear, solar, wind, biomass, and fossil fuels) considering environmental, safety, economy, production and distribution aspects. Facts and Myths about various sources of energy, thermal, nuclear sources of energy, Hybrid sources. Energy audit.	3
2	**Solar thermal Applications:** Sun as a source of energy, Solar Constant, Liquid flat plate collector, construction and working, Concentrating collectors, Solar drying, Solar water heating systems.	3
3	**Solar Photovoltaic systems Applications:** Photovoltaic principle, Power output and conversion efficiency, Limitation to photovoltaic efficiency, Basic photovoltaic system for power Generation,	4

	Application of solar photovoltaic systems, Advantages and disadvantages of Solar PV Systems. Configurations of Solar Photovoltaic Systems: Off-grid, Grid-Tied and Grid-Storage, Net metering and steps in installation of a rooftop solar PV System design.	
4	**Biomass and wind energy:** Bio-mass conversion technologies, Bio-gas generation, Working of biogas plant, Bio-gas from plant wastes, Methods for obtaining energy from biomass, Thermal gasification of biomass, Introduction to wind energy, Classification and description of wind machines, Wind energy, Wind data.	4
5	**Energy storage devices and electrical Vehicles :** Recent trends in batteries, super-capacitors, fuel cells. Applications of storage devices: Electrical Vehicles (EV), Converter, Inverter, Controls & Controllers in EV, Future Trends in Electric Cars.	4

Activity: any-6 (At least one activity from each unit) **[18L]**

Unit-I:

1. Energy audit of college campus/public campus/home/building.
2. Comparison of energy sources.
3. Visits to energy generation/distribution sites.

Unit-II:

4. Study of solar water heaters.
5. Study of large scale solar heaters for industrial/cooking/water heating applications.
6. Study of flat plate, parabolic solar concentrators.

Unit-III:

7. Efficiency measurement of PV systems using I-V characteristics of Amorphous Si, Mono-crystalline Si, Polycrystalline Si in individual, series and parallel combinations.
8. Effect of intensity of incident light, incident angle and shading on Solar PV Module on Output power.
9. Study of design of solar lanterns, street lights using solar systems.
10. Study of Installation and commissioning of roof top solar PV systems.
11. Study of net metering systems.

Unit-IV:

12. Visit to bio gas plant
13. Visit to bio diesel plants
14. Study of modified bio mass plants
15. Design and implementation of domestic/small scale biogas plants.
16. Study of different types of gasifiers
17. Study of wind mill / visit to wind mill

Unit-V:

18. Preparation and testing of fuel cell on Laboratory scale
19. Preparation and testing of super capacitors on Laboratory scale
20. Preparation and testing of paper batteries and other types of batteries on Laboratory scale.
21. Design and implementation of battery-operated toys using green technology

Reference books:

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 Utilisation - G. D. RAI (5th edition), Khanna Publishers, Delhi.
4. Renewable Energy Technology: A practical guides of beginners, Chetan Singh Solanki, PHI Learning Private-Ltd., New Delhi.
5. Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Learning Private-Ltd., New Delhi

Note :

1. It is expected that students should undertake at least 1 activity from each unit and total 6 activities amounting to 18 lectures time.
2. Out of the total time allotted to each unit, half the time should be utilized for classroom teaching and remaining half for the activity.
3. Students should be encouraged to study this course by using Case–Study approach.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3510 SEC (I): Introduction to Arduino

Lectures: 36 **(Credits-02)**

Introduction:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino board designs use a variety of microcontrollers. Boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various circuits. It has USB that is used for loading programs. Microcontrollers can be programmed using C / Python programming languages. This course will focus on creative thinking and on hands-on project development using Arduino Boards.

Objectives:

- To create general awareness and interest in Arduino Boards.
- To provide knowledge of different Arduino boards and various sensors and actuators.
- The course enables student to understand the basics of interfacing with Arduino Boards.
- To familiarize students with Arduino as IDE, programming language & platform and to Program basic Arduino examples.
- To provide knowledge of different Smart System applications.
- Develop skills to design and implement various smart system application.

Course Outcomes: After successful completion of this course, student will be able to

- Students will be able to understand and use various Arduino Boards, and its various components, Input / Output Pins, Input / Output Devices.
- Understand general concepts of Programming Arduino Boards.
- Apply the knowledge gain to design applications using Arduino in different domains.
- To analyze and evaluate the performance of various Arduino based devices.
- Learn and understand about any new IDE, compiler, and MCU chip in Arduino compatible boards or similar types.

Instructions: This course consists of two parts

- Part I: Theory and Part II: Practical / Project.
- Out of which 1 Credit is for Theory and 1 credit is for Practical work.
- Part II has two sub parts:
- Part II(A) : Practical / Demonstration & Part II(B) : Project. The A or B parts are optional, students can opt any one for 1 credit

Part I: Theory

Unit	Topics	Lectures
I : Introduction to Microcontrollers	• Introduction to Embedded Systems, Block Diagram, Single Board Computers (SBC) and System on Chip (SoC), Single Board Microcontroller (SBM), microprocessor vs microcontrollers, Basic system with microcontroller such as Arduino (SBM), Raspberry Pi (SoC) etc.	04

II : Introduction to Arduino and Arduino Programming	• **Arduino Basics:** What is Arduino, Advantages of Arduino, Arduino Types, Arduino Components, Arduino Uno Architecture • **Arduino Hardware:** Types of Arduino boards, Various components on Arduino Board, Various sensors and actuators: Overview of Sensors working, Analog and Digital Sensors	**06**
III : Introduction to Programming for Arduino	• **Arduino Software:** Integrated Simulation Environment (IDE), Setup the IDE, Arduino Libraries, What is Sketch, Writing Arduino Sketches, Serial Monitor, **Introduction to programming:** Fuctions, Variables & Basic Structure of Arduino (C++) Code, Basics Programs (Hello Word, Blinking of LED), Loading program through USB and Test performance of the System, Integration of Sensors and Actuators with Arduino	08

Part II (A): Arduino Programming (Practical / Demonstration) : **any-6 [18 L]**

Simple Practical using Arduino Uno Board (Software + Hardware): Choose any-3 Practical from group-1 and any-3 practical from group-2. (Total = 6 practical)

Sr No	List of Practical's
	Group 1 : Any-3
1	Demonstration of Arduino Uno Board, Its Various Components, Pins
2	Installation Arduino Software (IDE) on computer, Introduction to Sketch, Loading of Program from computer, Simple programs: Hello Word, Blinking of LED on Arduino board etc.
3	Interfacing external LED (ON & OFF); Fading of LED
4	Analog Read Serial: 1. Read a potentiometer, print its state out to the Arduino Serial Monitor. 2. Read an analog input and prints the voltage to the Serial Monitor.
5	Digital Read Serial: Interfacing a switch, Read a switch, print the state out to the Arduino Serial Monitor.
6	Digital: Interfacing push Button: Use a push button to control an LED or Buzzer
7	Digital : State Change Detection: Count the number of button pushes.
8	Analog In Out Serial: Read an analog input pin, map the result, and then use that data to dim or brighten an LED.
	Group 2 : Any 3
9	Knock: Detect knocks with a piezo element.
10	Interfacing of Ultrasonic Sensor, Detect objects with an ultrasonic range finder.
11	Interfacing of Proximity Sensor

12	Interfacing of Temperature & Humidity Sensor : To interface DHT11 sensor for recording temperature and humidity readings with Arduino.
13	Interfacing LCD display with Arduino
14	Interfacing of Relay Switch and Servo Motor with Arduino
15	Interfacing Bluetooth Module to Arduino
16	Interfacing of Motion (PIR Sensor) or Light Sensor using (LDR & LED) or Gas Sensor (MQ-2) with Arduino

OR

Part II (B): Arduino Programming (Practical / Demonstration)

Project : any-1 (Simple Projects Using Arduino Uno Board) [18 L]

Sr No	List of Simple Projects
1	Line Following Robot with Arduino
2	Obstacle Avoiding Robot with Arduino
3	Weather Station using Arduino
4	Home Automation using Arduino
5	Android Based Air quality Monitor
6	Intelligent automatic irrigation system

References:

1. www.arduino.cc
2. https://www.arduino.cc/en/Tutorial/BuiltInExamples
3. https://create.arduino.cc/projecthub

T.Y.B.Sc. (Physics) (Sem-V)

PHY-3510 SEC (J): Smart Sensors and Transducer Technology

Lectures: 36 **(Credits-02)**

Course Objectives:

- To make students familiar with the constructions and working principle of different types of sensors and transducers.
- To make students aware about the measuring instruments and the methods of measurement and the use of different transducers.

Course Outcomes: At the end of the course, a student will be able to:

- Use concepts in common methods for converting a physical parameter into an electrical quantity
- Classify and explain with examples of transducers, including those for measurement of temperature, strain, motion, position and light
- Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc
- Predict correctly the expected performance of various sensors
- Locate different type of sensors used in real life applications and paraphrase their importance
- Set up testing strategies to evaluate performance characteristics of different types of sensors and transducers and develop professional skills in acquiring and applying the knowledge outside the classroom through design of a real-life instrumentation system.

Syllabus: **[18 L]**

Unit-I: Mechanical and Electromechanical sensor:

Definition, principle of sensing & transduction, classification. Resistive (potentiometric type): Forms, material, resolution, accuracy, sensitivity. Strain gauge: Theory, type, materials, design consideration, sensitivity, gauge factor, variation with temperature, adhesive, rosettes. LVDT: Construction, material, output input relationship, I/O curve, discussion.

Unit-II: Capacitive sensors:

Variable distance-parallel plate type, variable area- parallel plate, serrated plate/teeth type and cylindrical type, variable dielectric constant type, calculation of sensitivity. Stretched diaphragm type: microphone, response characteristics..

Unit-III: Thermal sensors:

Material expansion type: solid, liquid, gas & vapor Resistance change type: RTD materials, tip sensitive & stem sensitive type. Thermo emf sensor: types, thermoelectric power, general consideration, Junction semiconductor type IC and PTAT type.

Unit-IV: Magnetic sensors:

Sensor based on Villari effect for assessment of force, torque, proximity, Wiedemann effect for yoke coil sensors, Thomson effect, Hall effect, and Hall drive, performance characteristics. Radiation sensors: LDR.

Activity: any-6 (At least one activity from each unit) **[18 L]**

Unit-I:

1) Linear displacement measurement using potentiometric sensor.
2) Displacement/pressure measurement using strain gauge sensor.
3) Linear displacement measurement using LVDT.

Unit-II:

1) Capacitive type transducer measure small displacement/force varying plate area/distance of plate/dielectric constant.
2) Displacement/pressure measurement using microphone.
3) Liquid pressure measurement using pressure sensor

Unit-III:

1) Measurement of temperature using RTD .
2) Measurement of temperature using Thermocouple transducer.
3) Silicon diode as temperature sensor

Unit-IV:

1) Magnetic sensor/Hall effect/proximity sensor based measurement magnetic susceptibility magnetisation
2) LDR based measurement light intensity etc.

Reference books:

1) R Sensor & transducers, D. Patranabis, 2nd edition, PHI
2) Instrument transducers, H.K.P. Neubert, Oxford University press.
3) Measurement systems: application & design, E.A.Doebelin, Mc Graw Hill
4) Sensor & transducers, D. Patranabis, 2nd edition, PHI
5) Instrument transducers, H.K.P. Neubert, Oxford University press.
6) Measurement systems: application & design, E.A.Doebelin, Mc Graw Hill

T.Y.B.Sc. (Physics) (Sem-V)

PHY-3511 SEC (K): Physics Workshop Skill

Lectures: 36 **(Credits-02)**

Objectives:

This course is to get exposure with various aspects of instruments and their usage through hands-on mode.

Course outcomes:-

After completion of this course students will able to handle and test various instruments.

Syllabus:

Unit-1. Basic of Measurement: 4L

- Accuracy, precision, sensitivity, resolution, range etc.
- Errors in measurements and loading effects.
- Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter.

Multimeter:

- Block diagram and working of a digital multimeter.
- Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance.
- Specifications of a multimeter and their significance.

Unit-2. Electronic Voltmeter: 4L

- Principles of voltmeter, Construction (block diagram only).
- Specifications of an electronic Voltmeter and their significance.
- AC Milli Voltmeter: Type of AC Milli Voltmeters
- Block diagram ac Milli Voltmeter,
- Specifications and their significance.

Unit-3. Cathode Ray Oscilloscope: 5L

- Block diagram of basic CRO.
- Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only-no mathematical treatment),
- Brief discussion on screen phosphor, visual persistence & chemical composition.
- Time base operation, synchronization. Front panel controls.
- Specifications of a CRO and their significance.
- Use of CRO for the measurement of voltage (dc and ac frequency, time period.
- Special featuresof dual trace oscilloscope.
- Introduction to digital oscilloscope, Block diagram and principle and working.

Unit-4. Signal Generators and Analysis Instruments: 2L

- Block diagram, explanation and specificationsof low frequency signal generators.
- Pulse generator, and function generator.

- Brief idea for testing, specifications. Distortion factor meter, wave analysis.

Unit-5. Impedance Bridges and Q-Meters: 3L

- Block diagram of bridge.
- Working principles of basic (balancing type) RLC bridge.
- Specifications of RLC bridge. Block diagram & working principles of a Q- Meter.
- Digital LCR bridges.

Activity: any-6 (18 L)

1. Use of Digital multimeter. (3L)
2. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance. (3L)
3. To observe the limitations of a multimeter for measuring high frequency voltage and currents. (3L)
4. Measurement of voltage, frequency, time period and phase angle using CRO. (3L)
5. Measurement of rise, fall and delay times using a CRO. (3L)
6. To measure Q of a coil and its dependence on frequency, using a Q- meter. (3L)
7. Measurement of distortion of a RF signal generator using distortion factor meter. (3L)
8. Measurement of R, L and C using a LCR bridge/ universal bridge. (3L)

Reference Books:

1) A text book in Electrical Technology - B L Theraja - S Chand and Co.
2) Performance and design of AC machines - M G Say ELBS Edn.
3) Digital Circuits and systems, Venugopal, 2011, Tata Mc Graw Hill. Logic circuit design, Shimon P. Vingron, 2012, Springer.
4) Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3, 2012, Tata Mc-Graw Hill
5) Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

T.Y.B.Sc. (Physics) (Sem-V)

PHY-3511 SEC (L): Biomedical Instruments

Lectures: 36 **(Credits-02)**

Objectives

- Introduction to various bio-signals and their origin
- Understanding of electrode theory
- Use of transducers in biomedical instrumentation
- Patient safety while using biomedical instrumentation
- Instruments handling and analysis of the recorded data

Course Outcomes

- Students will acquire basic knowledge of biomedical instrumentation.
- Students can handle and operate different equipment's like ECG, Oxymeter, and Glucometer.
- Students will be able to record the different health parameters using it.
- Student will also able to analyze and interpret the recorded data.

Syllabus:

Unit-I: Physiological transducers **(7L)**

- Introduction to physiological transducers
- Classification of Transducer
- Performance characteristic of transducer.
- Displacement, position and motion transducer.
- Pressure transducer for blood pressure measurement
- Transducer for Body temperature measurement
- Biosensors

Unit-II: Bioelectric signals and cardiovascular system: **(7L)**

- Basics of signal measuring system
- Basic and essentials of biomedical instrumentation system.
- Heart and Cardiovascular system
- Resting and action potential, propagation of action potential, Passive and active conduction.
- Electro-conduction system of heart
- Blood Pressure measurement
- Heart Sounds, Phonocardiography
- Pulse oximetry

Unit-III: Electrocardiography: **(4L)**

- Introduction and Principle
- Interpretation of Electrocardiogram
- Block diagram of electrocardiograph, ECG machine maintenance and trouble shooting
- The ECG leads
- Effect of artifacts on ECG recording

- Types of ECG recorders

Activities: any-6 (3 Lecture hours each) (18L)

1. Study of ECG machine(Voltage gain , chart speed etc) and EEG placement of electrodes
2. ECG recording and analysis (Calculation of heart rate, measurement of peak amplitude and period of waves)
3. Study of anolog sphygmomanometer and digital BP monitor – Measurement of SBP, DBP and pulse rate
4. Measurement of pulse parameter using pulse oxymetry /pulse measuring instrument
5. Use of biosensor (sugar level measurement / skin resistance).
6. To study Infrared sensor/ temperature gun and measuring values
7. Study of BMI/ body composition monitor and measurement of physiological parameters (BMI, % Body fat,
8. First aid for heart patient – study and practice
9. Study of Spirometer and practice for increasing lung capacity
10. Visit to established hospital

Reference Books:

1. Biomedical Instrumentation and Measurements (Second edition) - Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer Pearson education.
2. Handbook of Biomedical Instrumentation (Second Edition) - R. S. Khandpur (Tata McGraw Hill).
3. Biomedical Instrumentation and Measurement by Carr and Brown-Pearson.
4. Biomedical instruments and measurements (Second edition) - R. Ananda Natarajan Eastern economy edition
5. A textbook of Biomedical engineering edited - R.M. Kenedi, blackie (Glasgow & London)
6. Medical instrumentation: Application and design (Third edition)- John G. Webster, Willey India Education

Required Equipment with Probable cost:

1. Electro Cardiogram- ECG machine- analog- Rs. 30000/-
2. SPO_2 meter- Analog- Rs. 3000/-
3. Fat Meter- Digital- Rs. 4000/-
4. Sphygmomanometer – Digital and analog: Rs. 3000/- each
5. Glucometer- Digital: Rs.2000 each.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3511 SEC (M): Nondestructive Testing Techniques

Lectures: 36 **(Credits-02)**

Objective:

- To study and understand the various non-destructive testing (NDT) methods, and their industrial and scientific applications.

Outcomes:

- After completion of this course the students will be able to use NDT methods for defects and characterization of industrial components.

Syllabus:

Unit No.	Topics	Lectures
I	Definition and objectives of NDT, introduction to materials testing, purpose of testing and properties of materials, classification of material testing, destructive testing and its examples only, Definition, Characteristics detected, principle, advantages, limitation and applications of various methods like Visual inspection, liquid penetrant testing, magnetic particle testing, thermography testing, eddy current testing, ultrasonic testing, acoustic emission testing, radiography testing,	6
II	What are the discontinuities, Types of discontinuities in materials? Processing the discontinuity, service induced discontinuity, factors for selection of NDT method in different cases of discontinuity, brief description of equipment used in visual testing method, Principles of liquid penetrant method, stages of liquid penetrant process, liquid penetrant process flow chart, chemical and solvent cleaning methods of surface preparation, how to apply and removal of excess penetrant?, application of developer, and observation of defects, penetrant, their types and properties, role of developer, their types, Magnetic particle testing method, procedure of Magnetic particle testing methods, portable magnetization equipment and stationary magnetization equipment, dry and wet particle inspection techniques and stages involved in it and its applications	6
III	Thermography testing, basics of infrared theory, range characteristics, wavelength, frequency, emission, convection, conduction, reflection, transmission, emissivity of infrared, basic principles of thermography testing, elements of infrared detection system, thermography testing active and passive approach, basics of eddy current testing, working principles of eddy current testing, stages in eddy current testing, factors influencing in eddy current testing, Ultrasonic testing and its methods (transmission and pulse echo method), Acoustic emission testing, factors influencing acoustic wave propagation and data acquisition, instrumentation of acoustic	6

	emission testing, Radiography testing, principle, various stages in testing, gamma ray radiography testing, SWSI and DWSI techniques in X ray testing, Fluoroscopy testing arrangement and working principle, Computed tomography in NDT	

Activity: any-6 (each activity will be equivalent to 3-hrs) **[18L]**

1. Video demonstration of any two NDT techniques
2. Study of different X ray photograph and MRI scan photographs in medicine
3. Study of NDT by acoustic method
4. Surface visual study of defects of various objects provided
5. Study of surface defects by liquid penetration method
6. Study of surface defects by liquid leak method
7. Study of surface defects by liquid spray method
8. Study of surface defects by using UV light and fluorescent liquid method
9. Visit to any industry and observing NDT method live (equivalent to two demonstrations)
10. Audio visual expert lecture of industrialist who is using NDT method for quality control.

Reference Books:

1. Non- destructive testing of materials, Dr V. Jaykumar, Dr. K. Elangovan, Lakshmi Publications, Tamilnadu, India.
2. Practical non-destructive testings, Baldev Raj, T. Jaykumar, M. Thavasimuthu, Narosa Publications
3. Basics of non-destructive testings, Lari and Kumar, S.K. Kataria& Sons publications
4. Non-destructive testing techniques, Ravi Prakash, New Age International Private Limited
5. Non-destructive test and evaluation of materials, J. Prasad, C.G.K. Nair, McGraw Hill Education

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3511 SEC (N): Acoustics Applications

Lectures: 36 **(Credits-02)**

Objective:

To study and understand about sound physics, properties and their applications.

Outcomes:

After completion of this course the students will be able to use sound detection and characterization of sounds.

Syllabus:

Unit-1: Environmental Acoustics (3 L)

1.1 Environmental Noise: sonic boom, aircraft flyover, foot-fall noise, slammed door
1.2 Weighted sound levels: Sound level meters, A-weighted & C-weighted sound level, Phon, Sone,
1.3 Noise rating: Community noise: Highway noise, Aircraft noise
1.4 Noise induced hearing loss: Chronic, Trauma.
1.5 Mufflers: Automobile, Silencers, Transmission loss,

Unit-2: Sound Reinforcement Systems (5 L)

2.1 Microphones- Types, selection criteria, Professional grade, sensitivity, FM microphones
2.2 Loudspeakers- Direct Radiator type, Horn- Folded and Flared horn, Woofer, Squawker, Tweeter, Loudspeaker Cabinets- Enclosed cabinet, Open Cabinet, Bass Reflex Cabinet,
2.3 Amplifiers: Public Address systems, Gain and Bandwidth
2.4 Headphones- Noise cancellation features
2.5 Acoustic Delays
2.6 Synthesizers, Graphic equalizers, mixers
2.8 Basics of Audio Signal Processing
2.9 Monophonic and Stereophonic Systems

Unit-3: Musical Acoustics **(**4 L)

3.1 Pitch, timbre, rhythm, intensity, loudness, consonance, dissonance, Bass, Treble, Harmonics and Overtones
3.2 Standing waves, interference, beats, harmony, melody
3.3 Octave: Musical Scales
3.4 Types of Musial Instruments: String - violin, guitar, Wind - Brass, Reed instruments, organ, Percussion - Drums, Tabla
3.5 MIDI - Musical Instruments Digital Interface
3.6 Audio file formats: MP 3 and MP 4 systems

Unit-4: Room Acoustics (2 L)

4.1 Growth and decay of sound in live rooms
4.2 Sabine Equation, Reverberation time measurement methods
4.3 Room modes, Sound absorption materials
4.2 Speech Intelligibility: Articulation Test, Articulation Score

Unit-5: Acoustics in Medicine and Ultrasound (2 L)

5.1 Audiometry and Hearing loss

5.2 Ultrasonography

5.3 Ultrasonic Transducers

5.4 Ultrasonic cleaning, Non Destructive Testing (NDT)

Unit-6. Underwater Acoustics (2 L)

6.1 Speed of sound in sea water, Transmission loss

6.2 Sonar: Active and Passive Sonar

Activities: Any-6 **[18L]**

1. Frequency response of loudspeaker
2. Polar characteristics of a microphone
3. Study of Graphic Equalizer
4. Estimation and measurement of reverberation time
5. Online calculators for Room Modes
6. Speaker response of a direct radiator loudspeaker
7. Transmission loss (TL) of an expansion chamber muffler.
8. Acoustic power output of direct radiator loudspeakers
9. Verification using an online mode calculator

Reference Books:

1. Fundamentals of Acoustics, L.E. Kinsler and A. R. Frey, Wiley Eastern
2. Audio and Video Systems, R. G. Gupta, Tata McGraw Hill, 2010
3. Acoustics, W.W. Seto, Schaum's Outline
4. Handbook of Sound Engineers, G.M. Ballou, Academic Press
5. Basic Acoustics, D.E. Hall, Oxford University Press
6. Design for good Acoustics and Noise Control, J.E. Moore, University Press

Semester-VI

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-361: Solid State Physics

Lectures: 36 **(Credits-02)**

1: The Crystalline Structures **(10 L)**

Lattice, Basis, Translational Vectors, Primitive Unit Cell, Symmetry Operations, Different types of lattices: 2D and 3D (Bravais lattices) Miller indices, Inter Planer Distances, SC, BCC and FCC structures, Packing Fraction, Crystal structures NaCl, diamond, CsCl, ZnS, HCP, Concept of Reciprocal Lattice and its properties, Problems

2: X ray Diffraction and Experimental Methods **(9 L)**

Bragg's Diffraction, Bragg's Law, Experimental X-ray diffraction Methods: The Laue Method, Bragg's Spectrometer, The Powder Crystal Method, Analysis of cubic structure by Powder Method, Ewald's Construction, Bragg's Diffraction condition in direct and reciprocal lattice, Problems

3: Free Electron and Band Theory of Metals **(9L)**

Assumptions of Classical and Somerfield Free Electron model, Energy levels and Density of States (One and Three Dimensions), Nearly free electron model, Fermi energy, Fermi level, Hall Effect, Mobility, Hall Angle

Band Theory of Solids: Origin of energy gap, Energy bands in Solids, Distinction between metal, semiconductor and insulator, Problems

4: Magnetism **(8L)**

Diamagnetism, Langevin theory of Diamagnetism, Paramagnetism, Langevin theory of Paramagnetism, Ferromagnetism, Antiferromagnetism, Ferromagnetic Domains, Hysteresis, Curie temperature, Neel temperature, **Superconductivity**, Day to day applications of Magnetism, Problems

Reference books:

1. Solid State Physics S.O.Pillai, 6th Edition, New Age International (P) Ltd, Publisher, (2010).
2. Solid State Physics – Kakani S.L. and Hemrajani C, 4th Edition, S. Chand Publication (2005).
3. Fundamentals of Solid State Physics – B.S.Saxena, R.C.Gupta and P.N.Saxena, Pragati Prakashan, Meerut , Uttar Pradesh
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. Elementary Solid State Physics Principles and Applications, M Ali Omar, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.(2006)
8. Problems and Solution in Solid State Physics-S.O. Pillai, New Age International (P) Ltd.
9. Solid State Physics, P.K. Palanisamy, Scitech Publications(India) Pvt Ltd, Chennei, 1st Edition (2004)
10. Solid State Physics: Essential Concepts, David W. Snoke, 2nd Edition, Cambridge University Press

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-362: Quantum Mechanics

Lectures: 36 **(Credits-02)**

1: Origin of Quantum Mechanics (08 L)

1. Historical Background: Black body radiation, photoelectric effects.
2. Matter waves - De Broglie hypothesis. Davisson and Germer experiment.
3. Wave particle duality
4. Concept of wave function, wave packet, phase velocity, group velocity and relation between them
5. Heisenberg's uncertainty principle with Electron diffraction experiment, different forms of uncertainty.
6. Different fields of applications of quantum mechanics
7. Problems

2: The Schrodinger equation (10 L)

1. Physical interpretation of wave function
2. Schrodinger time dependent equation.
3. Schrodinger time independent equation.(Steady state equation).
4. Requirements of wave function.
5. Probability current density, equation of continuity, and its physical significance.
6. An operator in Quantum mechanics, Eigen function and Eigen values.
7. Expectation value, Ehrenfest's theorem (Only statements)
8. Problems

3: Applications of Schrodinger Steady state equation (14 L)

1. Free particle.
2. Step potential.
3. Potential barrier. (Qualitative discussion). Barrier penetration and tunnelling effect.
4. Particle in infinitely deep potential well (one - dimension).
5. Schrodinger's equation in spherical polar co-ordinate system.
6. Rigid rotator (free axis).
7. Problems

4: Operators in Quantum Mechanics (4 L)

1. Hermitian operator.
2. Position, Momentum operator, angular momentum operator, and total energy operator (Hamiltonian).
3. Commutator brackets- Simultaneous Eigen functions.
4. Commutator Algebra
5. Commutator bracket using position, momentum and angular momentum operator
6. Concept of parity according to quantum mechanics, parity operator and its Eigen values.
7. Applications of Operators in Quantum Mechanics
8. Problems

Reference books:

1. Eisberg, Robert M., and Robert Resnick. *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles*. Wiley, 1985. ISBN: 9780471873730.
2. Liboff, Richard L. *Introductory Quantum Mechanics*. Addison Wesley, 2002. ISBN: 9780805387148.
3. Griffiths, David J. *Introduction to Quantum Mechanics*. Upper Saddle River, Pearson Prentice Hall, 2005. ISBN: 9780131118928
4. Feynman, Richard P., Robert B. Leighton, and Matthew L. Sands. *The Feynman Lectures on Physics*. Addison Wesley, 1989. ISBN: 9780201500646.
5. P M Mathews and K Venkatesan, *A Textbook of Quantum Mechanics*, Tata McGraw Hill publication, *ISBN*. : 9780070146174
6. N. Zettili, *Quantum Mechanics- Concepts and applications*, Wiley publication, *ISBN*: 978-0-470-02679-3
7. Ajoy Ghatak, S. Lokanathan, *Quantum Mechanics: Theory and Applications*, Springer Publication, *ISBN* 978-1-4020-2130-5
8. G Aruldhas, *Quantum Mechanics*, Phi Learning Private Ltd., *ISBN* : 97881203363
9. Shankar, Ramamurti. *Principles of Quantum Mechanics*. Springer, 2008. ISBN: 9780306447907.
10. Gupta, Kumar & Sharma, *Quantum Mechanics*, Jai Prakash Nath Publications.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-363: Thermodynamics and Statistical Physics

Lectures: 36 **(Credits-02)**

1: **Transport phenomenon and Maxwell's relations:** **(9L)**

Mean free path, Transport phenomenon, Viscosity, Thermal conductivity and diffusion.
Thermodynamic functions: Internal Energy, Enthalpy, Helmholtz function, Gibb's function,
Derivation of Maxwell Relations, Specific heat and latent heat equations, Joule Thomson effect (Throttling Process), Problems

2: Elementary Concepts of Statistics: **(9L)**

Probability, distribution functions, Random Walk and Binomial distribution, Simple random walk problem, Calculation of mean values, Probability distribution for large-scale N, Gaussian probability distributions, Problems

3: Statistical Distribution of System of Particles and Ensembles: **(12L)**

Specification of state of system, Statistical ensembles, Basic Postulates, Probability calculations, Behaviors of density of states, Thermal, Mechanical and general interactions
Micro canonical Ensemble (Isolated System), Canonical ensembles, simple application of canonical ensemble, Molecules in Ideal gas, Calculation of mean values in canonical ensemble.
Problems.

4: **Introduction to Quantum Statistics**: **(6L)**

Quantum distribution function, Maxwell-Boltzmann's statistics, Bose-Einstein Statistics, Fermi-Dirac Statistics, Comparison of the distributions. Applications of Quantum Statistics, Problems.

Reference books:

1) Lokanathan, R.S. Gambhir, Statistical and Thermal physics
2) F. Reif, Fundamentals of statistical and thermal physics
3) A. Beiser, Perspectives of modern physics
4) B.B. Laud, Fundamental of Statistical Mechanics
5) R.B. Singh, A primer of Statistical Mechanics
6) Gupta, Kumar, Statistical Mechanics

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-364: Nuclear Physics

Lectures: 36 **(Credits-02)**

1: Nuclear Structure, Properties and Radioactivity: (12 L)

a) Basic Concept of Nucleus:

- Composition, charge, size, density of nucleus(Revision)
- Nuclear Angular momentum,
- Nuclear magnetic dipole moment
- Electric quadrupole moment, Parity & symmetry,
- Mass defect and Binding energy, packing fraction,
- Classification of nuclei,
- Stability of nuclei (N Vs Z Curve)
- Day to day applications of Nuclear Physics
- Problems.

b) Radioactivity:

- Radioactivity disintegration (concept of natural and artificial radioactivity, Properties of α, β, γ-rays, Laws of radioactive decay, half-life, mean life, Specific activity and its units (Revision)
- Successive disintegration and equilibriums and radioisotopes.
- Radiocarbon dating
- Application of radioactivity (Agricultural, Medical, Industrial, Archaeological).
- Problems

Ref.(1) Ch.(2,3), Ref.(3) Ch.(3, 6)

2: Particle Accelerator and Radiation Detectors: (06 L)

a) Particle Accelerators:

- Introduction and Classification
- Linear Accelerator (electron/proton LINAC)
- Cyclic Accelerator (Cyclotron)
- Particle Accelerators In India (Discussion only)

Ref.(1) Ch.(12)

b) Nuclear Detector:

- Classification of Nuclear Detectors
- Gas filled Detectors (G. M. counter)
- Solid state detectors (scintillation counter)
- Problems:

Ref.(2) Ch.(4), Ref.(3) Ch.(7, 15)

3: Nuclear forces and Nuclear Models: (09 L)

a) Nuclear Forces:

- Classification of Nuclear Forces

- Meson theory of nuclear forces,
- Properties Of nuclear forces, properties of deuteron system,
- Elementary particles,

b) Nuclear Models:

- Quarks model for elementary particles
- Shell Model: Assumptions, Evidences, and Spin and Parity limitations.
- Liquid drop model: Assumptions
- Semi-empirical B.E. formula
- Problems:

Ref.(1) Ch.(9, 17, 18), Ref.(3) Ch.(18)

4: Nuclear Reactions and Reactor Theory: (09 L)

a) Introduction to Nuclear reactions:

- Nuclear Reaction, Conservation laws (Revision)
- The Q-value equation, Exothermic and Endothermic reaction
- Compound nucleus
- Threshold energy
- Nuclear cross-section
- Nuclear fission , nuclear fusion stellar energy, chain reaction and critical mass,

b) Reactor Theory:

- Nuclear reactor and its basic components, homogeneous and heterogeneous reactors, power reactor, fast breeders
- Nuclear Reactors In India (Discussion only)
- Problems.

Ref.(1) Ch.(14, 15), Ref.(3) Ch.(11, 13, 14)

Reference books:

1. Dr. S. N. Ghoshal, Nuclear Physics, Revised Edition, S. Chand Publication, 2014
2. D. C. Tayal, Nuclear Physics, Revised Enlarged Edition, Himalaya Publishing House.
3. K.S. Krane, Introductory Nuclear Physics, Wiley, India, 1988
4. B. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill
5. I. Kaplan, Nuclear Physics, 2nd Edition, Narosa, New Delhi, 1989
6. S.B. Patel, Nuclear Physics: An Introduction, New Age International, 1991

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-365 (A): Electronics-II

Lectures: 36 **(Credits-02)**

1: Semiconductor Devices: **(9L)**

a. LED and Photodiode, Optocoupler. (Working Principles) Problems. Ref. 1.
b. BJT: Transistor amplifier classifications - Class A, B, C and AB (working only), Differential amplifier (transistorized), Problems. Ref. 1.
c. Field Effect Transistor: JFET (Introduction, classification, principle, working and IV characteristics) MOSFETs (DE-MOSFET and E only MOSFET). Problems. Ref. 1

2: Applications of Semiconductor Devices: **(9L)**

a. Three Pin Regulators: Block diagram of 3-pin IC regulator, study of IC-78XX, 79XX. Dual Power Supply using IC-78XX, 79XX. Ref. 1
b. Switching Regulators (SMPS): Introduction, Block diagram, Advantages and Disadvantages. Ref. 4
c. Modulation and Demodulation : Concept of Carrier Wave, Need of Modulation and Demodulation, Methods of Modulation like AM, FM, PM (Concepts Only),
d. Concept of Modulation Index, Upper and Lower Side Band Frequencies in AM. Problems, Ref.3

3: Integrated Circuits: **(9L)**

a. Integrated Circuits: Introduction, Scale of Integration, Advantages and drawbacks of IC Ref.4
b. OP-AMP Applications as Integrator, Differentiator, Comparator. Ref. 1
c. Timer IC-555: Block diagram, Astable, monostable multivibrator (working and design). Problems, Ref. 1

4: Combinational and Sequential Circuits: **(9L)**

a. Combinational Circuits: Introduction to SOP and POS equation. Concept of Standard SOP and POS equation. Concept of K-map and their use in reduction of Boolean expressions, design of half adder, full adder, half subtract, Study of binary to gray and gray to binary code conversion. Problems. Ref. 2
b. Sequential Circuits: RS flip flop using NAND/NOR, clocked RS, D, JK and T-flip flops. Application of flip flops in Sequential Circuits as Counters and Registers. Asynchronous and Synchronous Counters. (3-bit Counter), Shift Registers and their types of operation -SISO, SIPO, PISO, PIPO (Concepts only). Ref. 2

Reference books:

1. Malvino, Electronic Principles (6th Ed.), Tata McGraw Hill, New Delhi
2. R. P. Jain, Modern Digital Electronics (3rd Ed.), Tata McGraw Hill, New Delhi
3. B. L. Theraja, Basic Electronics - Solid State, S. Chand and Company, New Delhi
4. K. R. Botkar, Integrated Circuits, Khanna Publishers, Delhi

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-365 (B): Advanced Electronics

Lectures: 36 **(Credits-02)**

(Important Note: This course is designed for the student who has offered Electronics as one of the subjects at S.Y.B.Sc. level**)**

1: Sensors: **(9L)**

Introduction to Sensors: Revision of temperature measurement and Pressure Measurement.

Motion sensors: Types of motions, Accelerometers' principles, Types of accelerometers, applications.

Optical sensors:

Photo detectors, Photo detector characteristics, photoconductive detectors, photo voltaic detectors, Photodiode detectors, photo emissive detectors.

Pyrometry: Thermal radiation, Broadband pyrometers, Narrowband pyrometers.

Optical sources: Conventional light sources, Laser light sources and principles.

Applications: Label inspection, Turbidity, Ranging.

2: Analog Signal Conditioning: **(11L)**

Introduction to analog and digital signals: Analog Multiplexer and De-Multiplexer using Ic-4051, Ideal & Practical characteristics of Low Pass, High Pass, band pass and band reject filters. 2nd order active low pass and high pass filter using op-amp. Instrumentation amplifier using 3-OP-AMP, Application of Instrumentation Amplifier as thermocouple signal conditioning. Interpretation of integrator and differentiator as low pass and high pass filters respectively.

3: Digital signal conditioning: **(10L)**

Digital Multiplexer and De-Multiplexer using NAND gate, Priority encoder using Ic-74148, Decoders: 2 to 4 decoder and 3 to 8 Decoder.

Signal Converters:

DAC: R-2R ladder type DAC, Binary weighted DAC.

ADC: Single slope ADC, Successive Approximation ADC, Flash ADC.

Data Acquisition System using 3-channels

4: Introduction to Process Control: **(6L)**

Block diagram of Process control, Process control using ON-OFF controller, Op-amp and temperature sensor, Process control using Proportional Control Logic, Definition of Process LAG, and Problems.

Reference books:

1. C.D. Johnson, Process Control Instrumentation Technology, Pearson Education, 8th edition.
2. Krishna Kant, Computer Based Industrial Control, Eastern Economic Edition
3. Rangan, Mani, Sharma, Instrument of Device System
4. B. C. Nakra, K. K. Chaudhari, Instrument measurement and analysis

PHY-356: Elective-II

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-366 Elective-II (O): Medical Electronics

Lectures: 36 **(Credits-02)**

1: Introduction: **(9L)**

1. 1 Terminology of medical instrumentation,
1.2 Physiological system of body
1.3 Sources of bioelectric signals,
1. 4 Origin of bioelectric signals,
1.5 Analysis of ECG pattern
1.6 Nernst equation
1.7 Various types of bioelectric signals,
1.8 Basic medical instrumentation system,
Problems
Ref: 1

2: Bio potential Electrodes and sensors: **(9L)**

2.1 Electrode-electrolyte interface,
2.2 Polarizable and non-polarizable electrodes,
2.3 Electrodes for ECG, EEG, EMG,
2.4 Resistive sensor
2.5 Capacitive sensor
2.6 Inductive sensor
2.7 Piezoelectric sensor
2.8 Temperature sensor
Problems
Ref: 2

3: Amplifiers and Signal Processing: **(9L)**

3.1 Introduction
3.2 Basic amplifier requirements
3.3 The Differential amplifier
3.4 Common mode rejection
3.5 Instrumentation amplifier
3.6 Isolation amplifier
3.7 Pateint safety
3.8 Cardiac monitor
Problems
Ref: 2

4: Measurements of Pressure and Volume Flow of Blood: **(9L)**

4.1 Direct measurements of blood pressure,
4.2 Indirect measurements of BP.
4.3 Heart sounds,

4.4 Phonocardiography,

5.4 Ultrasonic blood flow meter

5.5 Laser Doppler blood flow meter

Ref: 1

Reference books :

1. Handbook of Biomedical Instrumentation, R.S. Khandpur
2. Medical Instrumentation application design, John G Webster, Houghon Mifflin Co.
3. Clinical Biophysics, P. Narayanan
4. Introduction to biomedical equipment technology J. Carr and John M. Brown
5. Introduction to Biomedical Electronics, Joseph DfuBovy, Mc Graw Hill.

List of Experiments: (Any Two)

1. Measurement of BP using Mercury sphygmomanometer and digital BP monitor
2. Study of ECG machine. Gain, chart speed arrangements and positioning electrodes
3. Recording of ECG and its analysis.
4. Absorbance using calorimeter/ Absorption spectra using Spectrophotometer.
5. Pulse oximetry. Measurement of SpO2
6. Use of thermal scanner/Thermal gun
7. Study of glucometer as a sensor and measurement of BSL

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-366 Elective-II (P): Physics of Nanomaterials

Lectures: 36 **(Credits-02)**

1: Introduction to nanomaterials: **(10 L)**

- Introduction to Nano-sized materials and Structures
- Significance of Nano-size
- Properties of Nanomaterials: Mechanical, Electrical, Thermal and Optical properties
- Classification of nanostructured materials

2: Methods for Synthesis of Nanomaterials: **(08 L)**

- Bottom-up and Top-down approaches
- Classification of Synthesis Techniques: Vapour phase and Liquid phase approach.
- Synthesis Methods: Thermal Evaporation, Sputter deposition, Colloidal method, Sol-gel Method, Chemical Vapour deposition and Electrochemical Deposition.

3: Characterization techniques: **(08 L)**

- Over view of structural characterization of nanomaterials by XRD
- Microstructural characterization and elemental analysis of nanomaterials using Scanning electron microscopy (SEM)and Energy Dispersive Spectroscopy (EDS)
- Structural characterization of nanomaterials using Transmission electron microscopy (TEM)
- Optical characterization of nanomaterials using UV- visible spectroscopy

4: Special nanomaterials: **(04 L)**

- Carbon nanotubes, their types and properties
- Quantum dots and their properties

5: Applications: **(06L)**

- Nanomaterials for application in Nano-electronics, Cosmetics, Medical, Biosensors Automobiles, Space, Sports, Cloth industry etc.
- Nanomaterials for environmental pollution monitoring and reduction etc.
- Nanomaterials for energy generation and storage

Reference books :

1. Nanotechnology: Principles and Practices by Sulbha 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.
5. The chemistry of nanomaterials: Synthesis, properties and applications, C. N. R. Rao, A. Muller, A. K. Cheetham (Eds) Wiley VCH Verlag Gmbh& Co, Weinheim, 2004.

List of experiments: (Any Two)

1. Synthesis of metallic nanoparticles by wet chemical method.
2. Synthesis of Metal Oxide Nanoparticle using different techniques.
3. Synthesis of silver nanoparticles from silver nitrate by colloidal solution method.
4. Study of optical absorption of nanoparticles.
5. Determination of crystallite size from X-ray diffraction spectra.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-366 Elective-II (Q): Microcontrollers

Lectures: 36 **(Credits-02)**

1: 8051-Architecture: **[10L]**

1.1 Comparison of Microprocessor and Microcontroller,

1.2 Intel 8051 Microcontroller: Block Diagram and Functions of each block, Pinout details, A and B CPU registers, Program status word (PSW) register, Program Counter, Data Pointer, Stack and Stack Pointer.

1.3 Memory Organization of 8051, Internal RAM, Register Banks, Special function registers, Internal ROM, I/O Ports and their functions, Oscillator and Clock.

2: 8051-Assembly Language Programming: **[16L]**

2.1 Introduction to 8051 Assembly programming, 8051 data types and assembler directives, Different Addressing modes, Concept of Unsigned and Signed numbers.

2.2 Instruction Set of 8051 microcontroller: Data Transfer instructions, Arithmetic Instructions, Logic and compare instructions, rotate instructions, Branch (Jump, Call RET) instructions.

2.3 Use of Instruction Set in Assembly Language Programming.

3: 8051-Interrupts, Timers/Counters and Serial Communication: **[10L]**

3.1 Interrupts and their vector structure, IE register, Interrupt priority in the 8051

3.2 Timers and Counters: Use of Basic Registers in Programming 8051 timers, Timer/ Counter Operation modes. Problems on Timer clock frequency and its Period.

3.3 Basics of Serial Data Communication, Types of Serial Data Communication, Concept of Baud Rate, RS 232 Standards, 8051 connection to RS 232, Functions of SBUF and SCON Registers.

Reference Books:

1. 8051 Microcontroller by Kenneth J. Ayala.
2. 8051 Microcontroller and Embedded Systems using Assembly and C by Mazidi and D Mac Kinlay, 2006 Pearson Education Low Price Edition.
3. 8051 Microcontroller – Hardware, Software and Applications by V Udayashankara, M S Mallikarjunaswamy, McGraw Hill Education (India) Pvt.Ltd, New Delhi.
4. Microprocessor and Microcontroller by R. Theagarajan, Sci Tech Publication, Chennai
5. Programming customizing the 8051 Microcontroller by Myke Predko, Tata McGraw Hill

List of Experiments: (Any Two)

Use Keil / Pinacle software for:

1. Addition of two 16 bit numbers
2. Multiplication of two 8 bit numbers.
3. Write a program to find largest/smallest number of N numbers in given block.
4. Memory block transfer from one location to another.
5. Find one's and two's complement of given number.
6. Subtraction two 8 bit numbers using two's complement method.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-366 Elective-II (R): Lasers

Lectures: 36 **(Credits-02)**

1: Introduction to Lasers: **(8 L)**

Brief history of Lasers, Interaction of radiation with matter, Energy levels, Population density, Boltzmann distribution, Stimulated Absorption, Spontaneous Emission and Stimulated Emission, Einstein's Coefficients, Einstein's relations.

Characteristics of Laser: Directionality, Mono-chromaticity, Coherence,

2: Laser Action: **(6 L)**

Population inversion, Condition for light amplification, Gain coefficient, Active medium, metastable states.

Pumping schemes: three level and four level

3: Laser Oscillator: **(6 L)**

Optical feedback, round trip gain, critical population inversion, Optical resonator, condition for steady state oscillations, cavity resonance frequencies.

4: Laser Output: **(3 L)**

Line-shape broadening: Lifetime broadening, Collision broadening

5: Types of Lasers: **(7 L)**

Solid State Lasers – Ruby Laser, Diode Laser, Gas Lasers – HeNe Laser, CO_2 Laser

6: Applications of Lasers: **(6 L)**

Industrial: welding, cutting, drilling

Nuclear Science: laser isotope separation, laser fusion,

Medical: eye surgery

Reference books:

1. An introduction to Lasers - Theory and applications, M.N. Avadhanulu, S. Chand and Co. New Delhi
2. Experiments with He-Ne Laser by Sirohi
3. Optical fibre and Laser - Principle and applications, Anuradha De, New Age International Publishers,

List of Experiments: (Any Two)

1. Determination of wavelength of He-Ne Laser by transmission grating
2. Determination of Angle of prism (Pin and drawing paper)
3. Study of Lissajous figures using diode Laser and mirrors
4. Beam divergence of a Diode Laser.
5. Determination of the diameter of a thin wire using a laser.
6. Measurement of wavelength of Laser beam using Michelson Interferometer.
7. To study the interference of light using optical fibers
8. Measurement of the focal length of a given convex lens using a laser.

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-366 Elective-II (S): Astronomy and Astrophysics-II

Lectures: 36 **(Credits-02)**

1: Astronomical Scales: **(10 L)**

Measurement of Astronomical Quantities, Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Astronomical Coordinate system (only introduction)

2: The Milky Way and Universe: **(8 L)**

Basic Structure and Properties of the Milky Way, Active Galaxies, Quasars and Radio Galaxies, Hubble's law with equation, its significance, Concept of space time, fate of our universe, Multiverse (only introduction)

3: The Stellar Phenomenon: **(10 L)**

Basic Composition of Interstellar Medium, Sun: Solar Cycle, Activity, Butterfly diagram, Photospheric phenomenon, Stars as distance estimators, Hydrostatic Equilibrium of a Star, Stellar models (only introduction).

4: Non-optical Astronomy: **(8 L)**

Basic parameters of an antenna, various types of antennas. UV, IR, X-ray and Gamma ray Telescopes, Detectors for optical and infrared regions. Orbiting space based telescopes: HST, Chandra.

List of Reference Books:

1. Astronomy structure of the Universe, A. E. Roy and D. Clarke, Adam Hilger Pub.
2. Source Book of Space Sciences, Samuel Galsstone; D.Van Nostrand Co. Inc
3. Astrophysics - Stars and Galaxies, K.D. Abhyankar, Tata McGraw Hill Pub.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Pub.
5. Structure of the Universe, J.V. Narlikar
6. Astrophysics, Baidyanath Basu.
7. Astrophysical Techniques, third Edition, C. R. Kitchin
8. Fundamentals of Astronomy, Michael Seed
9. Telescopes and techniques, C. R. Kitchin (Springer)

List of experiments: (Any Two)

1. To determine the temperature of an artificial star.
2. To observe the Fraunhofer lines in sunlight and determine the elements present.
3. To obtain the solar image on the screen and trace out the existing sunspots.
4. To locate and observe the various stars, constellation, planets. (At least 2 observation of each)
5. To polar Align an astronomical telescope.
6. To study the solar limb darkening effect.

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-366 Elective-II (T): Renewable Energy Sources-II

Lectures: 36 **(Credits-02)**

1: Bioenergy and Biofuels: **(10L)**

Bioenergy:

1. Introduction to Bioenergy
2. Basic Routs: Biochemical, Thermochemical, Transesterification
3. Biochemical- Biogas generation/methanation
4. Biogas plant: Floating gas holder and fixed dome type biogas plant, construction and working
5. Factors affecting on bio-digestion (list of factors).
6. Thermochemical: Pyrolysis, Gasification, Carbonization
7. Transesterification:
8. Comparative study of floating gas holder and fixed dome type biogas plant.
9. Working of downdraft gasifier.
10. Various methods to obtain energy from biomass.

Biofuel:

1. Introduction to Biofuels
2. Production of Biofuels (Jatropa and Sugar cane bagasse)

Ref 1: 7.1, 7.2, 7.2.1, 7.2.2, 7.4, 7.5, 7.6, 7.7, 7.8, 7.11, 7.23, 7.24.1

Ref 2: 10.3 (page no 374 to 380)

2: Wind Energy **(08L)**

1. Introduction to wind energy.
2. Principles and components of wind energy conversion system.
3. Classification of wind machines: Horizontal axial machine and vertical axial machine.
4. Advantages and disadvantages of wind energy.
5. Wind data

Ref -1: 6.1, 6.2, 6.3, 6.5, 6.7, 6.8

3: Other Energy Sources: **(08L)**

1. Introduction to tidal and geothermal energy.
2. Tidal energy: methods of utilization of tidal energy.
3. Advantages and disadvantages of tidal power generation.
4. Geothermal energy: Geothermal sources and energy conversion.
5. Advantages and disadvantages of geothermal energy.
6. Introduction to Thermocell

Ref -1 (9.3), pages from 510-532),

Ref -1 (8), pages from 443, 470-476, 477) Ref -1 (11), pages from 609-657)

4: Energy Management: **(10L)**

1. Introduction to Energy Management (Definition, Principles etc)
2. Need of Energy Saving and Management
3. Different strategies of Energy Management
4. Role of Energy Managers and Auditors,

5. Energy Audit Measurements and Instruments, and Preparation of Energy Audit Report (in brief).
6. Case studies of Energy Audit & Management (e.g. Industries & Green Buildings, Boilers, Furnaces, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery, Electric motors, Pumping systems, Fans and blowers, Cooling Towers,
   Industrial/Commercial Lighting system, BEE Star rated equipment) any one.

Ref- 4 to 12 - Use any book for reference

Reference books:

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 Utilisation**,** G. D. RAI (5th edition), Khanna Publishers, Delhi.
4. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
5. Energy Management Principles: C.B.Smith (Pergamon Press).
6. Efficient Use of Energy: I.G.C.Dryden (Butterworth Scientific)
7. Energy Economics -A.V.Desai (Wieley Eastern)
8. Industrial Energy Conservation: D.A. Reay (Pergammon Press)
9. Energy Management Handbook – W.C. Turner (John Wiley and Sons, A Wiley Inter science publication)
10. Industrial Energy Management and Utilisation –L.C. Witte, P.S. Schmidt, D.R. Brown (Hemisphere Publication, Washington)
11. Hand book of Energy Audit by Sonal Desai (Publisher Tata McGraw Hill.)
12. Energy Management and Conservation Handbook, Frank Kreith and Yogi Goswami, (CRC Press)

List of Experiments: (Any Two)

1. Fuel value of wood/charcoal.
2. Study of sensible heat storage using liquid.
3. Selective and Non-selective coatings – Determination of Selectivity ratio.
4. To do energy audit of home/society/college/industry and prepare a detail audit report.
5. Study and analysis of home Electricity Bill
6. Study of Power consumption of conventional tube light vs LED fitting

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-367: Physics Laboratory-4A

Lectures: 36 **(Credits-02)**

(General Physics, Thermodynamics and Statistical Physics, Nuclear Physics and Quantum Mechanics)

(Any Eight)

GROUP-I: GENERAL PHYSICS (any FOUR)

1. Surface Tension of Mercury by method of Ripples.
2. Viscosity of Liquid by rotating cylinder method.
3. Coefficient of sound absorption
4. 'Y' by Cornu's Method
5. Hall Effect: To measure the Hall coefficient
6. Energy gap of a semiconductor
7. Study of XRD spectrum of any material.
8. Resistivity by Four probe method
9. Platinum resistance thermometer

GROUP-II: THERMODYNAMICS AND STATISTICAL PHYSICS (any TWO)

1. Determination of pressure coefficient of air by constant volume thermometer.
2. Verification of Stefan's fourth power law by bulb filament
3. Thermal conductivity by Forbes Method.
4. Thermal conductivity of rubber tube.
5. Thermal diffusivity of Brass.
6. Thermal and Electrical conductivity of Cu.

GROUP-III: NUCLEAR PHYSICS AND QUANTUM MECHANICS (any TWO)

1. Characteristics of G.M. tube
2. Inverse square law (γ-rays)
3. e/m by Thomson method
4. Determination of Planck's constant
5. Study of Gaussian distribution by G. M. tube.

Additional Activities (Any ONE)

- Demonstrations: Any 2 demonstrations equivalent to 2 experiments
- Study tour with report equivalent to 2 experiments
- Mini project equivalent to 2 experiments
- Computer aided demonstrations (simulations or animations)
  (Any 2 demonstrations equivalent to 2 experiments)

Note: *Students have to perform* ***ten*** *experiments or* ***one*** *additional activities in addition to* ***eight*** *experiments mentioned above. Total laboratory work with additional activities should be equivalent to* ***ten*** *experiments.*

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-368: Physics Laboratory-4B

Lectures: 36 **(Credits-02)**

(Electronics (Essential) or Advanced Electronics, acoustics and Lasers, Optional Courses)

(Any Eight)

GROUP-I: ELECTRONICS (ESSENTIAL) (any TWO)

(For the students not offering advance electronics in theory courses)

1. Characteristics of JFET
2. Design and built astable multivibrator using IC 555/IC 741
3. Half adder /Full adder
4. Integrator and differentiator using IC 741
5. IC 723 as regulated power supply

GROUP-I: ADVANCED ELECTRONICS (any TWO)

(For the students offering advance electronics in theory courses)

1. Instrumental amplifier using three op-amps
2. Temperature controller using PT 100 / thermocouple /thermistor temperature sensors
3. Object counter (two digit)
4. Schmitt trigger
5. Study of LVDT

GROUP-II: ACOUSTICS AND LASERS (any FOUR)

1. Frequency response of loudspeaker (twitter, woofer, mid-range)
2. Study of interference by Quinck's method
3. Use of Ultrasonic interferometer to measure velocity of sound in liquids
4. Transmission loss using expansion chamber muffler.
5. Study of diffraction using a transmission/reflection grating (metal ruler)
6. Study of the characteristics of a laser beam.
7. Determination of the diameter of a thin wire using a laser beam.
8. 'μ' By total internal reflection of light

GROUP-III: PRACTICAL FROM OPTIONAL COURSE (Any-2)

Additional Activities (Any ONE)

- Demonstrations: Any 2 demonstrations equivalent to 2 experiments
- Study tour with report equivalent to 2 experiments
- Mini project equivalent to 2 experiments
- Computer aided demonstrations (simulations or animations)
  (Any 2 demonstrations equivalent to 2 experiments)

Note: *Students have to perform* ***ten*** *experiments or* ***one*** *additional activities in addition to* ***eight*** *experiments mentioned above. Total laboratory work with additional activities should be equivalent to* ***ten*** *experiments.*

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-369: Physics Project-II

Lectures: 36 **(Credits-02)**

Guidelines:

It is expected that,

1. The student does work equivalent to about 10 laboratory experiments throughout the semesters in the third year.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic physics and/or their applications.
4. The theme chosen should be such that it promotes better understanding of physics concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the physics concepts involved and the presentation of the final report at the time of viva voce.
6. The viva voce should be conducted at the time of evaluation of project work at least for twenty minutes per student. Extra care must be taken in the evaluation of projects done in a pair or group. Delegation of the work done by individuals must be sought from the students in such cases.
7. Any ready-made material used in the report (such as downloaded pages from the web) must be clearly referred to and acknowledged.
8. It is also recommended that a teacher will look after 4 projects at one time.
9. Any non-adherence to this norm should attract a penalty by way of deduction in the marks awarded to a student. It is recommended that the College will provide consumables/contingencies for every project, to the tune of Rs. 750 /- each. (*If the students paid extra fee other than laboratory fee then college will provide financial assistance for the Project work.)

The Project work shall consist of the following Criterions.

1) Working model (Experimental or Concept based simulation/Demonstration Related to Physics).
2) Understanding of the project.
3) Experimental Details.
4) Data collection and Data Analysis.
5) Innovation.
6) Outcomes/Result.
7) Conclusion.

Note: At the time of project practical examination, the candidate must submit the certified project report by the project in-charge and HOD. A candidate will be allowed to appear for the Project practical examination only if the candidate submits a project completion report duly certified by the project in-charge and Head of the department.

The Project work shall include:

Models based / Demonstrated Applications / Review articles / Simulation on PC on any concept in Physics / Comparative & differentiative study / Improvement in the existing experiment (Design and fabrication concept) / Extension of any regular experiments / Attempt to make experiment open-ended / Thorough survey of existing active components / devices, ICs, methods, means, technologies, generations, applications etc. / any innovative projects using the concept of Physics / Interdisciplinary areas.

Evaluation weightage:

- Semester End University Examination : 35 Marks
- Internal Examination: 15 Marks

Skill Enhancement Courses

Skill Enhancement Courses (SEC)

a) Selection of Skill enhancement courses

There are two skill enhancement courses (SEC) in 6th semester (PHY-3610 and PHY-3611). For 6th semester, there are four options available. The college has to select any one from the given four options. It is advised that college should not offer elective and skill enhancement course of same theme.

b) Teaching Learning process for Skill Enhancement Courses

Skill base courses are intended to explore the applications of physics knowledge. Learning in skill enhancement courses is largely experience based. The skill enhancement courses may be categorized as knowledge skill or technical skill. For knowledge skill courses one can use the conventional method for teaching along with problem solving, assignments seminars etc. For acquiring the technical skill, the students will get adequate 'hands-on' experience. The teachers may use demonstrations and activity-based learning techniques. On field visits, study tour and mini projects will enrich the learning experience of the students.

c) Assessment methods for skill enhancement courses

Continuous evaluation will be the best method for assessment of skill enhancement courses.

One can use tools like assignments, mini projects or activities, problems, etc and grade the students according to their performance. The internal assessment should have 50 % weightage.

The University examination may be conducted for the remaining 50%.

The University examination question paper should have adequate proportion of objective and subjective question.

d) List of Skill Enhancement Courses:

Semester-VIth	**Semester-VIth**
PHY-3610	**PHY-3611**
PHY-3610(U): Scientific Data Analysis using Python	PHY-3611(Y): Microcontrollers
PHY-3610(V): Solar PV System: Installation, Repairing and Maintenance	PHY-3611(Z): Instrumentation for Agriculture
PHY-3610(W): Applications of Internet of things (IOT)	PHY-3611(AA): Radiation Physics
PHY-3610(X): Calibration Techniques	PHY-3611(AB): Photography

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-3610 SEC (U): Scientific Data Analysis using Python

Lectures: 36 **(Credits-02)**

Pre-requisite	: Basic knowledge of computer programming (Python/c)
Mode of internal Assessment	: A small project analysing scientific data for visualization
Data sets may include	: Pollution Data, Rain data, Astronomical data, any scientific data Related to Physics or science in general
Sources of Data sets	: MERI, Nashik, AIUCAA Pune, NASA or similar 1. Website for competition: https://www.kaggle.com/ 2. Google dataset: https://datasetsearch.research.google.com/ 3. Data for visualization and dataset resources: https://dev.to/aspittel/my-favorite-data-visualization-and-dataset-resources-35kp Other potentially useful searches: 1. https://bigdata-madesimple.com/70-amazing-and-free-data-sources-for-data-visualization/ 2. https://eduinpro.com/blog/data-sets-for-data-visualization-projects-datascience/

Learn how to analyses data using Python. This course will take you from the basics of Python to exploring many different types of data. You will learn how to prepare data for analysis, perform simple statistical analyses, create meaningful data visualizations, predict future trends from data, and more

Student will learn how to:

- Import data sets, access different elements of data frames.
- Understand the functions available in existing Python modules.
- Understand the utility of functions available in NumPy and Pandas library.
- Clean and prepare data for analysis
- Manipulate pandas Data Frame
- Understand awareness with different types of basic charts and functions in matplotlib library
- Get exposure to visualization techniques from seaborn library
- Build data pipelines

  Data Analysis with Python is delivered through lecture, hands-on labs, and assignments. It includes following parts:
- Data Analysis libraries: will learn to use Pandas Data Frames, Numpy multi-dimensional arrays, and SciPy libraries to work with a various datasets. We will introduce you to pandas, an open-source library, and we will use it to load, manipulate, analyze, and visualize cool datasets. Then we will introduce you to another open-source library, scikit-learn, and we will use some of its machine learning algorithms to build smart models and make cool predictions.

Outcome of the course

- Know basic notions and definitions in data analysis.
- Know standard methods of data analysis and information retrieval.
- Be able to formulate the problem of knowledge extraction as combinations of data filtration, analysis and exploration methods.
- Be able to translate a real-world problem into mathematical terms.

Syllabus:

Unit No.	Topics	Lectures
I	**Data Structures, modules and Importing Datasets** Lists: Creating list, accessing list elements, functions for lists, programming with lists Tuples: Creating Tuples, accessing list elements, functions for Tuples, programming with Tuples Dictionary: Creating Dictionary, accessing list elements, functions for Dictionary, programming with Dictionary. In Built modules : Math module, random Module, Array module, string Module etc	6
II	**Core libraries in Python** NumPy Library for Arrays Pandas Library for Data Processing Basics of data frames, create, adding/ deleting of rows, columns to data frames Import of data, functions of data frames Data Normalization Sets, data extraction using relational, logical operators. Group by functionality, missing values	6
III	**Summarizing the Data Frame and visualization** Matplotlib Library for visualization: Pie chart, violin plot, scatter plot, histogram, bar chart, area plot. Seaborn Library for Visualization: Box plot, point plot, line plot, count plot, bar plot, strip plot, scatter plot and Regression Plot	6

Activity: Hands on data Analysis and Visualization with Pandas [18L]

Note: For Internal assessment students will either do **any-6 activities** related to data analysis and visualization on particular dataset or will carry out small project on analysis or visualization using science (preferably physics) related dataset.

Reference Books:

- Python Programming: Using Problem Solving Approach - Reema Thareja.
- Let us Python - Aditya Kanetkar
- Learning with Pythob - Allen Downey
- Data Analytics - Bharti Motwani

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-3610 SEC (V): Solar PV System: Installation, Repairing and Maintenance

Lectures: 36 **(Credits-02)**

Objectives:

1. In this skill oriented course, student will study basics of solar photovoltaic (PV) cells, modules, and system components.
2. Design and sizing of off-grid PV system for homes, apartments as well as commercial offices.
3. Understanding energy conversion from sunlight to electricity, and working with solar conversion equipment.
4. This Course will hands on experience needed to become self-employed.

Outcomes:

1. Learn basics of light conversion in electricity.
2. Hands on training will motivate to use Solar PV system.
3. Become entrepreneur / self-employed.
4. Analyzed of MSEB electricity bill and design and sizing of off-grid PV system
5. Participants will learn about solar PV module and batteries used in solar PV plant.

Syllabus:

Unit-1: Introduction **(6L)**

The Sun, Earth, and Renewable Energy, Photovoltaic Effect, Working of Solar cell, Types of solar cell, PV Modules and Arrays, Module Parameters, Sunshine and Shadow, tracking mechanism, aligning the Array.

Unit-2: Solar Radiations and Measurement **(6L)**

Introduction, Solar constant, Solar radiation at the earth surface, Need of solar radiation measurement, Instruments for the measurement of solar Radiation, Pyrheliometer, Pyranometer, Sunshine Recorder, Sun Meter or Lux Meter

Unit-3: Basics Solar PV Systems **(6L)**

Basics types of PV Systems on grid and off grid, DC to AC conversion, Building-integrated Photovoltaics, Engineering and Architecture, Balancing of PV system. System Components, Batteries, Charge controllers, Inverters, Hybrid systems, System sizing, Applications of off grid PV System.

Activity: any-6 **(18L)**

1. Estimate the value of the Solar Constant.
2. Study of intensity variation on the performance of PV module.
3. Study of series and parallel combination of the PV modules.
4. Measurement of Solar radiation measurement using Sunmeter and Pyranometer.
5. Analysis of MSEB electricity bill.
6. Energy Farm/PV Plant visit report.
7. Study of intensity variation using Sun Meter or Lux Meter.
8. Study of I-V characteristics and working of solar cell.
9. Study of different types of solar cell.
10. Study of Hybrid systems.

Reference books:

1. Solar Energy, S.P. Sukhatme (second edition), Tata Mc.Graw Hill Ltd, New Delhi.
2. Solar Energy Utilisation, G. D. RAI (5th edition), Khanna Publishers,Delhi.
3. Electricity from Sunlight, An Introduction to Photovoltaics, Paul A. Lynn, John Wiley & Sons, Ltd.
4. Solar Electricity, 2nd edition, T. Markvart, John Wiley & Sons, Ltd.
5. Solar Photovoltaic Basics, White Sean, Taylor & Francis Ltd.

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-3610 SEC (W): Applications of Internet of Things (IOT)

Lectures: 36 **(Credits-02)**

Objectives:

- To introduce the terminology, technology and its applications
- To introduce the concept of M2M (machine to machine) with necessary protocols
- To introduce the C# Language which is used in many IoT devices
- To introduce the Raspberry PI platform, that is widely used in IoT applications
- To introduce the implementation of web based services on IoT devices

Learning Outcomes :

a) IOT concepts
b) IOT Standards
c) Components of IOT System.
d) Relevance of IOT for the future.
e) IOT Applications.
f) IOT for smart cities (Case study Smart city Barcelona)
g) IOT in Indian Scenario
h) Challenges in IOT implementation.

This subject does not have the intention of being a comprehensive course about the technologies involved in IOT. The focus will be more on the possibilities offered by the different technologies, and on the creative thinking techniques to find innovative applications of combinations of such technologies in real-life scenarios. Some presentations will also be scheduled in which people from industry will make presentations about selected topics related to the IoT. The Internet of Things (IoT) is a course about the new paradigm of objects interacting with people, with information systems, and with other objects. The course will focus on creative thinking and on hands-on project development. The duration of the course is 30 hours. Will be a mix of 75 minutes session and 2 hours session. Lab will be for 5 hours.

Future Scope:

It is a system of interrelated computing devices, digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Internet of Things

What Internet of Things can do?

3. Medical Check-up Health Devices Operational Efficiency Medical Report Health Sector
4. Advanced Kitchen Automatic Parking Remote Home Control Security System Smart Home
5. Wi-Fi Connectivity Traffic Control Security System Advanced Parking System Smart City
6. Advanced Power Supply Manufacturing Bill Payment Planning Industrial Automation
7. Let's Take an Example of Internet of Things

● Renewal Energy Source. ● Automatic wearing suit. ● Next Gen way to fly. ● Speech Recognition. ● Perfect example of AI. ● Advanced GPS.

Syllabus:

Unit-1: Introduction to Internet of Things **[4L]**

Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, IoT Communication APIs IoT enabled Technologies – Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols,

Unit-2: IOT Concepts and introduction **[5L]**

Technologies that led to evolution of IOT, IOT and SCADA, IOT and M2M, IOT and Big Data Requirement of international standard (case study), IOT standards in practice, Operating platforms /systems

Unit-3: IOT Applications (case study)**.** **[4L]**

Lighting as a service, Intelligent Traffic systems, Smart Parking, Smart water management, IOT in Indian Scenario

Unit-4: Introduction to C# **[5L]**

Language features, commands, functions of C#, Data types, data structures, Control of flow, functions, modules, Packaging, file handling, data/time operations, classes, Exception handling.

Activity: Any -6 (each case study will be 3-hrs) **[18 L]**

1) Lighting as a service (case study)
2) Intelligent Traffic systems (case study)
3) Smart Parking (case study)
4) Smart water management (case study)
5) IoT for smart cities (Case study-Smart city Barcelona)
6) Requirement of international standard (case study)
7) Study different functions of C#
8) Study how to control of flow of C# program
9) Study different data types of C#
10) Study various commands used in C#

Reference books:

1. Internet of Things – A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759
3. The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World Paperback – 26 March 2015 by Michael Miller.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3610 SEC (X): Calibration Techniques

Lectures: 36 **(Credits-02)**

Objective:

- To make students familiar with the constructions and working principle of different types of Instruments
- To make students aware about the measuring instruments and Calibration of Instrument

Course Outcomes: At the end of the course, a student will be able to:

- Calibrate hydraulic, pneumatic and mechanical measuring and control equipment: setting, adjustment, validation or verification of mechanical, pneumatic, hydraulic, measuring and control instruments using reference standards in accordance with predetermined procedures.
- Calibrate electrical and electronic measuring and control equipment: setting, adjustment, validation or verification of electrical, electronic measuring and control instruments using reference standards in accordance with predetermined procedures.
- Carryout maintenance activities on instrumentation and control panel.

Syllabus:

Unit-1: Principles of Calibration [4 L]

1. Introduction and Importance of Calibration
2. Traceability in Calibration
3. Calibration Uncertainty
4. Various Calibration Methods
5. Factors Affect Calibration
6. Instrument Classification and Instrument Identification

Unit-2: Pressure Calibration [6L]

1. Introduction to pressure calibration
2. Pressure unit conversion standards
3. Types of Pressure Gauges
4. Calibration of Pressure Gauges
   a. Accuracy
   b. Pressure Media
   c. Contamination
   d. Height Difference
   e. Leak test of Piping
   f. Adiabatic Effect
   g. Torque Force
   h. Calibration Position
   i. Generating Pressure
   j. Pressurizing the Gauge
   k. Reading the Pressure Value
   l. Number of Calibration Points
   m. Hysteresis (deviation of calibration points)
   n. Number of Calibration cycles
5. Instruments required for calibration:
   a. Pressure comparator
   b. Master Gauge
6. Pressure Calibration with Example

Unit-3: Calibration of Electronic Instruments [4L]

1. Identification of Components
2. Equipment required for calibration
3. Procedure of Calibration
   a. Read operational Specifications
   b. Sequence of events
   c. Identification of common Faults
4. Electronic Calibration with Examples (Oscilloscopes, Multimeters, Function Generators, Signal Generators)

Unit-4: Temperature Calibration [4L]

1. Temperature units and Conversions
2. Temperature Sensors
3. Calibration of temperature sensors
   a. Handling temperature sensor
   b. Preparations
   c. Temperature sources
   d. Reference Temperature Sensor
   e. Immersion Depth
   f. Stabilization
   g. Temperature sensor handle
   h. Calibrated temperature range
   i. Calibration Points
   j. Adjusting/trimming a temperature sensor
4. Examples:

Activity: any-6 **[18L]**

Calibration of a dial thermometer

1) RTD calibration check
2) Temperature controller loop
3) Calibration of pressure Transmitters
4) Calibration of pressure switch
5) Level calibration Instrument
6) Liquid head measurement
7) Calibrating a differential pressure level transmitter
8) Calibration of top pan balance
9) Calibration of digital balance
10) Calibration of PH/Conductivity meter
11) Calibration of Volt meter
12) Calibration of Current meter
13) Calibration of Oscilloscopes
14) Calibration of Function Generators

Reference Books :

1) **Calibration:** A Technician's Guide - Mike Cable
2) Measurement and Control Basics -Thomas A. Hughes
3) Measurement and Control of Liquid Level - Chun H. Cho
4) A Practical Book On Calibration Of Analytical Instruments - Dr S Jain ,
5) Calibration Handbook of Measuring Instruments - Alessandro Brunelli

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3611 SEC (Y): Microcontroller

Lectures: 36 **(Credits-02)**

Objective:

- To make students familiar with the constructions and working principle of microprocessor
- To make students aware about microprocessor

Outcome: After successful completion of this course students are supposed to develop their own applications/ mini/ tiny projects using microcontroller.

Syllabus:

Unit-1. ARCHITECTURE OF 8051: **[05]**

Microprocessor and Microcontrollers a short comparison, Overview of the 8051 family, Block diagram of Microcontroller, Functions of each block, Pin details of 8051, A and B CPU registers, Flags and Program status word (PSW), Program Counter (PC) and Data Pointer register (DPTR), Internal RAM, Stack and Stack Pointer, Special function registers, Memory Organization of 8051, Internal ROM, I/O Ports, Oscillator and Clock

Unit-2. 8051 ASSEMBLY LANGUAGE PROGRAMMING: **[05]**

Introduction to 8051 Assembly programming, Assembling and running an 8051 program, 8051 data types and directives, Jump, loop, and call instructions, 8051 I/O programming, Addressing modes, arithmetic and logical instructions and programs, Signed number concepts and arithmetic operations, Logic and compare instructions, Rotate instructions, BCD, ASCII, and other application programs.

Unit-3. TIMERS/ COUNTERS AND INTERRUPT PROGRAMMING: **[04]**

Timers of 8051, TMOD and TCON registers, Programming timers 0 and 1 in 8051, counter programming**,** 8051 interrupts, Interrupt priority in the 8051, and Application programs using interrupts.

Unit-4. INTERFACING TECHNIQUES **[04]**

Key/ keyboard (push button) interfacing, interfacing a LCD display, interfacing an ADC and LM35 temperature sensor.

Activity: any-6 **[18L]**

1. Addition of two 16 bit numbers using of Kiel/ Pinnacle
2. Multiplication of two 8 bit numbers using of Kiel/ Pinnacle
3. Write a program to find largest/smallest number of N numbers in given block using of Kiel/ Pinnacle
4. Memory block transfer from one location to another using of Kiel/ Pinnacle
5. Find one's and two's complement of given number using of Kiel/ Pinnacle
6. Subtraction two 8 bit numbers using two's complement method using of Kiel/ Pinnacle
7. To run basic programs using IDE/Software
8. Single key / Keyboard Interfacing.
9. ADC/DAC Interfacing.
10. Mini Project (Water level controller, Electronic Thermometer etc.)

Reference Books:

1. 8051 Microcontroller by Kenneth J. Ayala.
2. 8051 Microcontroller and Embedded Systems using Assembly and C - Mazidi, Mazidi and D MacKinlay, 2006 Pearson Education Low Price Edition.
3. Microprocessor and Microcontroller by R.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3611 SEC (Z): Instrumentation for Agriculture

Lectures: 36 **(Credits-02)**

Objectives:

After completion of this course students can

1. Get knowledge of sensors used in agriculture field
2. Learn continuous and batch process
3. Learn greenhouse automation schemes
4. Learn Instrumentation in Irrigation

Course Outcomes:

After completion of this course student will

1. Able to test soil and water parameters.
2. Able to develop their own juice extract plant.
3. Able to developed their own green house

Syllabus:

Unit-1: Introduction **[02L]**

Necessity of instrumentation and control for agriculture, sensor requirement, remote sensing, bio sensors in agriculture.

Unit-2: Soil Properties & Sensing **[04L]**

Properties of soil: fundamentals definitions and relationship, index properties of soil, permeability & seepage analysis, shear strength, Mohr's circle of stress, active & passive earth pressures, stability & slopes,

Sensors: introduction to sonic anemometers, hygrometers, fine wire thermocouples, open & close path gas analyzers

Unit-3: Instrumentation in Continuous & Batch process **[04L]**

Flow diagram of sugar plant, sensors & instrumentation setup, Flow diagram of fermenter & control (batch process), flow diagram of dairy industry & instrumentation setup for it, Juice extraction control process & instrumentation setup.

Unit-4: Instrumentation in Irrigation **[04L]**

Water distribution and management control, Auto drip and sprinkler irrigation system, upstream & downstream control concept, SCADA for DAM parameters &control.

Unit-5: Greenhouse Parameters & Instrumentation **[04L]**

Greenhouse effect, Concept and construction of greenhouse, merits & demerits, ventilation, cooling & heating, wind speed, temperature & humidity, soil moisture, rain gauge, carbon dioxide enrichment measurement & control, Leaf area length *evapotranspiration*, temperature, wetness & respiration measurement & data logging, electromagnetic radiations photosynthesis.

Activity : any-6 **[18L]**

1) Measurement of water holding capacity of soil.
2) Measurement of soil texture.
3) Measurement of moisture contain in soil.
4) Micronutrients analysis of soil.
5) Measurement of physical properties of soil. (Color, odder, texture etc.)

6) Measurement of Chemical properties of soil (pH, chloride, Oxygen, Sulphur etc. contain in soil)
7) Measurement of Biological properties of soil (Fungi, Bacteria)
8) Air quality measurement.
9) Analysis of Residues in fruits.
10) Visit to green house.
11) Visit to Sugar industry/Juice extract plant/ dairy industry

Reference books:

1. Industrial instrumentation, "Patranabis", TMH.
2. Instrumentation handbook-process control, "B.G. Liptak", Chilton.
3. Process control and instrumentation technology, "C.D. Johnson", PHI
4. Wills B.A., " Mineral Processing Technology", 4th Ed., Pergamon Press
5. Principle of Farm Machinery, R.A Kepner, Roy Bainer;: CBS Publication
6. Agricultural Engineering; Radhey Lal: Saroj Publication
7. Environmental Engineering, Peary. II. S. and others

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3611 SEC (AA): Radiation Physics

Lectures: 36 **(Credits-02)**

Course Objectives:

1. Students should understand the mechanism of interaction of various types of radiations with matter.
2. Students should get acquainted with principles of Measurement radiation levels, design principles and and actual implementation of variety of radiation detectors.
3. Students should learn about standards regarding safety levels laid down by National and International agencies, methods adapted to maintain safety standards in various places and methods of shielding.
4. Students should study the applications of radiations in various fields.

Course outcomes:

1. Students can use the knowledge in the applications of Radiation Physics in the fields like radio carbon dating, medical diagnostic tools.
2. Students acquire skill in operating different types of radiation detectors to detect and measure radiation levels in different places.
3. Students can work as advisers in maintenance of radiation safety standards and following of strict protocols at various places like Hospitals, Industry, and Laboratories etc.
4. Students become able to employ their skills to develop applications of radio activity in the fields like agriculture, industry, hospitals etc.

Syllabus:

Unit No.	Title and Contents	Lectures
I	**Interaction of Radiation with Matter** Interaction of different types of radiation with matter-Ionizing & Nonionizing radiations, excitation, ionization, radioactive losses-Energy loss by collision, range energy relation, Bethe-Bloch formula collision stopping power, radiation stopping power, Straggling.	3
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.	3
III	**Radiation units and Measurement of radiation exposure** Units for radiation exposure- Roentgen, Becquerel, Gray, Sievert, RAD, REM, KERMA. Radiation exposure, Absorbed Dose, Equivalent Dose, Effective Dose, Ambient and directional equivalent dose, Relative biological effective dose, Quality factor, Personal dosimeters, Film badge dosimeters, Thermo luminescent dosimeter.	3
IV	**Radiation Sources and Radiation Shielding** Natural & Artificial radioactive sources, Alpha, Beta, Gamma Sources, Basic concept of radiation shielding, linear and mass absorption coefficient, stopping power, materials for shielding of gamma and neutron, shielding interaction cross section.	3

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.	3
VI	**Radiation Applications:** 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.	3

Activity: any-6 [18L]

1. Study the different types of radio isotopes and their applications in medical field.
2. Study use of isotopes in radiocarbon dating.
3. Study of working of G. M. Counter.
4. Study of G. M. Counter characteristics – Dead Time and End point energy.
5. Study of commercially available portable, handy radiation detectors.
6. Survey of various places to measure radiation levels
7. Visit to hospitals and other such locations for measuring radiation exposure.
8. Visit to industrial areas to measure radiation exposure levels
9. Study of various shielding materials and their stopping power.
10. Study of dependence of radiation stopping power of materials on physical properties of materials
11. Study of protocols followed by various units to follow safety measures
12. Visit to food industry using preservation techniques using nuclear radiations.
13. Visit to pharmacy industry producing radioactive compounds.
14. Visit to diagnostic centres which employ radiation sources

Reference books:

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.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3611 SEC (AB): Photography

Lectures: 36 **(Credits-02)**

Objectives:

- To create general awareness and interest in photography process.
- To make students familiar with the Photographic equipment and handling techniques.
- To help students to learn basic photographic and image processing skills.

Course Outcomes: After successful completion of this course, student will be able to

- Understand the basic principle, structure and handling techniques in digital photography.
- Students will be able to develop and apply photographic skills using digital photography tools including digital editing, saving, sizing, and posting of the images
- Student gets proficient at the technical aspect of photographing with a digital camera.
- Students can identify and apply appropriate business practices specific to the self-employed professional photographer

Syllabus:

Unit No.	Topics	Lectures
I	**Introduction of Photography:** **Introduction:** History & Development of photography, Principles, functions and structure of camera, Indoor and outdoor lighting techniques; Background selection; Flash and its features. Black & White v/s Digital camera (Limitation & advantages) **Types of Camera:** Pinhole camera, Box camera, SLR camera, Studio camera, Digital camera.	6
II	**Camera Control and Exposure:** **Camera Controls:** Need for camera controls. Apertures, Depth of field and depth of focus. Shutters (Ideal, leaf and focal plane shutter). Shutter speed (slow and fast). Auto focus, Manual focus and Image stabilization **Camera lenses & Exposure:** Normal, Wide angle, Telephoto and Zoom range, Incident and reflected light, Exposure triangle, Exposure and equivalent exposures, Brief idea of exposure meter (TTL and Flash meter).	6
III	**Colour Theory & Digital Camera:** **Colour Theory:** Classification and use of colours in photography, Construction of colour enlarger, Colour Head, sources of light and filters used in a colour enlarger **Digital Camera:** Types of Digital Camera and its features, Memory Chip card, Creative shots, Settings in the Digital Camera - Handling methods; White balance, Maintenance of camera. Digital camera sensors and its types.	6

Activity: any-6 (Practical/Demonstration) **[18L]**

Sr No	List of Practical's
1	To study the effect of aperture on depth of field
2	To study and recognize the use of slow and fast shutter speed
3	To study the effect of Exposure for different colour temperatures
4	To identify and determine the focal length of the different types of lenses
5	To study the Image Mixing, Image Cutting and Text Building Effect
6	To study Blurr Effect and Transformation Tools
7	To understand the effect of clip mask, photo filter and stamping Tool
8	To study the effect of natural light, tungsten light and fluorescent light on Photograph.
9	Lighting for still life (Earthen ware, Metal ware, Glass ware, Fruits, Crockery, Jewelry, Flowers, Food etc.)
10	Indoor shooting using three point lighting set up
11	Image processing 1: (Lightroom techniques 1): Brightness, saturation etc
12	Image processing 2: (Lightroom techniques 2): Exporting, contact sheet, print
13	Nature photography
14	Wild life photography
15	Night photography
16	Event Photography
17	News photography and preparing a photo story
18	Cover page design for a magazine

Reference books:

1. Basic Photography- M.J. Langford, Focal Press.
2. The basic book of Photography – Fifth edition – by Tom Gri
3. Beginner's guide to photographic lighting: Techniques studio or on Location-Dom Marr
4. Photography its principles & practice: A manual of the photography – Carroll.
5. Photography for the 21st century by Katic Millar
6. Advanced Photography (Vol.-I & Vol.-II) - M.J. Langford, Focal Press.
7. Applied Photographic Optics- Sidney F. Ray; Focal Press
8. The Practical Guide to Photographic Lighting, John Tarrant, Focal Press