Faculty of Science and Technology

Choice Based Credit System (CBCS)

M. Sc. (Physics)

From Academic Year 2019-2020

Structure of Syllabus

SAVITRIBAI PHULE PUNE UNIVERSITY

GANESHKHIND, PUNE-411007

Proposed Structure of M. Sc. (Physics) Syllabus (C. B. C. S.)

1. Title of the Course: M. Sc. Physics

2. Preamble:

The curriculum for the M. Sc. (Physics) programme is designed to cater to the requirement of Choice Based Credit System following the University Grants Commission (UGC) guidelines. In the proposed structure, due consideration is given to Core and Elective Courses (Discipline specific - Physics), along with Ability Enhancement (Compulsory and Skill based) Courses. Furthermore, continuous assessment is an integral part of the CBCS, which will facilitate systematic and thorough learning towards better understanding of the subject. The systematic and planned curricula divided into two years (comprised of four semesters) shall motivate the student for pursuing higher studies in Physics and inculcate enough skills for becoming an entrepreneur.

Objectives:

- To foster scientific attitude, provide in-depth knowledge of scientific and technological concepts of Physics.
- To enrich knowledge through problem solving, minor/major projects, seminars, tutorials, review of research articles/papers, participation in scientific events, study visits, etc.
- To familiarize with recent scientific and technological developments.
- To create foundation for research and development in Physics.
- To help students to learn various experimental and computational tools thereby developing analytical abilities to address real world problems.
- To train students in skills related to research, education, industry and market.
- To help students to build-up a progressive and successful career in Physics.

3. Introduction: Semester Credit System

4. Eligibility: As per the rules and regulations published by SPPU, Pune.

5. Examination: As per the BOOKLET prepared by SPPU, Pune

A. Pattern of Examination

B. Standard of Passing

C. ATKT Rules

D. Award of Class

E. External Students

F. Setting of Question paper / Pattern of Question paper

G. Verification / Revaluation

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Structure of M. Sc. Physics (Choice Based Credit System)

(Revised)

To be implemented from the Academic Year 2019-20

Subject Name	Year	Semester	Course Type	Course Code	Course Name	Credit
Physics	1	I	Core Compulsory Theory Paper	PHCT-111	Mathematical Methods in Physics	4
				PHCT-112	Classical Mechanics	4
				PHCT-113	Quantum Mechanics	4
			Choice Based Optional Paper	PHOT-114	Electronics	4
			Core Compulsory Practical Paper	PHCP-115	Physics Laboratory – I (Electronics)	4
		II	Core Compulsory Theory Paper	PHCT-121	Electrodynamics	4
				PHCT-122	Solid State Physics	4
				PHCT-123	Statistical Mechanics	4
			Choice Based Optional Paper	PHOT-124	Atoms and Molecules	4
			Core Compulsory Practical Paper	PHCP-125	Physics Laboratory - II	4
	2	III	Core Compulsory Theory Paper	PHCT-231	Physics of Semiconductor Devices	4
				PHCT-232	Laser-Fundamentals and Applications	4
				PHCT-233	Experimental Techniques in Physics - I	4
			Choice Based Optional Paper	PHOP-234	*****Elective - I	4
			Core Compulsory Practical Paper	PHCP-235	Physics Laboratory - III	4
		IV	Core Compulsory Theory Paper	PHCT-241	Nuclear Physics	4
				PHCT-242	Materials Science	4
				PHCT-243	Experimental Techniques in Physics - II	4
			Choice Based Optional Paper	PHOP-244	*****Elective - II	4
			Core Compulsory Practical Paper	PHCP-245	Project	4

Electives:

Semester 3

Sub-code	Elective-I
PHOP234-I	Medical Physics – I
PHOP234-J	Acoustics – I
PHOP234-K	Energy Studies – I
PHOP234-L	Physics of Thin Films
PHOP234-M	Astronomy and Astrophysics – I
PHOP234-N	Electronics Instrumentation – I
PHOP234-O	Communication Electronics
PHOP234-P	Biomedical Instrumentation – I
PHOP234-Q	Atmospheric Physics – I
PHOP234-R	Nuclear Techniques – I
PHOP234-S	Microcontroller Based Instrumentation System – I

Semester 4

Sub-code	Elective-II
PHOP244-I	Medical Physics – II
PHOP244-J	Acoustics – II
PHOP244-K	Energy Studies – II
PHOP244-L	Physics of Nano Materials
PHOP244-M	Astronomy and Astrophysics – II
PHOP244-N	Electronics Instrumentation – II
PHOP244-O	Microwave Physics and Applications
PHOP244-P	Biomedical Instrumentation – II
PHOP244-Q	Atmospheric Physics – II
PHOP244-R	Nuclear Techniques – II
PHOP244-S	Microcontroller Based Instrumentation System – II

Detailed Syllabi:

Course Code and Title: PHCT-111: Mathematical Methods in Physics

Module 1: Complex Analysis **Credit-1**

Complex number, Complex function (polynomial, Exponential, Trigonometric complex function, Logarithm), Limit and Continuity, differentiation, Analytical function, Cauchy-Riemann condition, Line integrals, Cauchy integral formula, Derivative of analytical functions, Power Series, Taylor's theorem, Laurent's theorem, Calculus of residues, Evaluation of real definite integrals (**References: 1-5)**

Module 2: Vector Space and Matrix Algebra **Credit-1**

Revision on Vector space: Vectors (dependent and independent), Vector space, Hilbert space, Dimension of vector space, Matrix representation, Similarity transformation, Eigen values and Eigen vectors, Inner product, Orthogonality, Introduction only to Gramm-Schmidt orthogonalization procedure, Self adjoint and unitary transformation, Eigen values and Eigen vectors of Hermitian and Unitary transformation, Diagonalization (**References: 6, 7)**

Module 3: Special Functions **Credit-1**

Bessel function, Legendre, Hermite, and Laguerre functions – Generating function, Recurrence relations and their differential equations, Orthogonality properties, Bessel's function of first kind, Spherical, Associated Legendre function, Spherical harmonics. (**References: 4, 5, 7)**

Module 4: Fourier Series and Integral Transforms **Credit-1**

Fourier series: Definition, Dirichlet's Condition, Convergence, Fourier Integral and Fourier transform, convolution theorem, Parseval's identity, Application to the solution of differential equations, Laplace transform and its properties, Fourier transform and Laplace transform of Dirac Delta function. (**References: 3, 4, 7)**

Reference Books:

1. Complex Variables and Application- J. W. Brown, R. V. Churchill - Mc- Graw Hill
2. Complex Variables – Seymour Lipschutz
3. Mathematics for Physical Sciences – Mary Boas, John Wiley and Sons
4. Mathematical methods in Physics- B. D. Gupta
5. Mathematical methods in Physics- Satyaprakash
6. Linear algebra – Seymour Lipschutz, Schaum Outline Series Mc-Graw Hill Edition
7. Mathematical Method for Physicists, Arfken & Weber, 6^{th} Edition, Academic Press, N. Y.

Course Code and Title: PHCT-112: Classical Mechanics

Module 1: Analytical Dynamics (Lagrangian and Hamiltonian Dynamics, Canonical Transformations and Poisson Brackets) Credit-2

Variational principle and its applications to problems like shortest distance, brachistochrone, geodesics etc. Lagrangian and Hamiltonian equations of motion - derivation using Hamilton's principle of least action and their applications to various problems. Hamiltonian for a charged particle. Properties of kinetic energy function. Time-dependence of total energy (theorem on total energy). Symmetry and conservation laws (energy and momentum). Gauge function for Lagrangian. Invariance under Galilean transformation.

Canonical transformations and their applications. Canonical transformations of the free particle Hamiltonian. Liouville's theroem. Area conservation properties of canonical flows. Poisson Brackets. Jacobi-Poisson theorem on Poisson Brackets. Invariance of Poisson brackets under canonical transformations. Dirac's formulation of generalized Hamiltonian.

Module 2: Central Forces and Non-inertial Frames of Reference Credit-1

Lagragian formulation of motion under central forces. Kepler problem. Stability of orbits. Motion of satellites. Rotating frames of reference. Coriolis force, banking of rivers, Foucault's pendulum, and tides.

Module 3 Rigid body dynamics and Small Oscillations Credit-1

Moment of inertia tensor. Euler angles. Euler equation of motion for rigid body motion. Symmetric top. Small oscillations. System of couple oscillators. Normal modes and normal coordinates.

Reference Books:

1. Classical Mechanics by H. Goldstein, C. Poole and J. Safko.
2. Classical Mechanics by N. C. Rana and P. S. Joag.
3. Mechanics by L. D. Landau & E. M. Lifshitz.
4. Classical Mechanics by J. R. Taylor.
5. Classical Mechanics by P. V. Panat
6. Classical Mechanics by Y. R. Waghmare

Course Code and Title: PHCT-113: Quantum Mechanics

Module 1: Revision and General Formalism **Credit-1**

Inadequacy of classical Physics, wave packets and uncertainity relations, Schrodinger wave equation and probability interpretation, Simple one dimensional problems wells, barriers and harmonic oscillator (One dimension)

Postulates of Quantum Mechanics

Representation of states and dynamical variables, observables, self adjoint operators, eigen functions and eigen values, degeneracy, Dirac delta function, Completeness and closure property, Physical interpretation of eigen values, eigen functions and expansion coefficients, eigen values and eigen functions of momentum operator.

Module 2: Representation of States – Dirac Notation **Credit-1**

Hilbert space, Dirac's bra and ket notation, dynamical variables and linear operators, projection operators, unit operator, unitary operator, matrix representation of an operator, change of basis, unitary transformation. Eigen values and eigen functions of simple harmonic oscillator by operator method.

Module 3: Angular Momentum **Credit-1**

Eigen values and eigen functions of L^2 and Lz operators, ladder operators L_+ and L_-, Pauli theory of spins (Pauli's matrices), matrix representation of J in |jm> basis. Addition of angular momenta, Computation of Clebsch-Gordon coefficients in simple cases (J_1=1/2, J_2=1/2)

Module 4: Approximation Methods **Credit-1**

Time-independent Perturbation theory: Non degenerate, Zeeman effect, Time dependent Perturbation theory: Transition amplitude 1st and 2^{nd} order, Fermi's golden rule, Harmonic perturbation, Introduction to WKB approximation, Variational method

Basic principles and applications to particle in box, SHO

Reference Books:

1. A Text-book of Quantum Mechanics by P.M.Mathews and K.Venkatesan.
2. Quantum mechanics by A. Ghatak and S. Lokanathan
3. Quantum Mechanics by L.I. Schiff
4. Modern Quantum mechanics by J. J. Sakurai
5. Quantum Physics by R. Eisberg and R. Resnick
6. Introduction to Quantum Mechanics by by David J. Griffiths
7. Introductory Quantum mechanics by Granier, Springer Publication.
8. Introductory Quantum Mechanics, Li Boff, 4^{th} Edition, Pearson Education Ltd
9. Quntum Mechanics Nouredine Zettili,, A John Wiley and Sons, Ltd., Publication
10. Shankar R. Principles of Quantum Mechanics, II^{nd} Edition (Plenum, 1994)

Course Code and Title: PHCT-114 Electronics

Module 1: Semiconductor Devices and its Applications **Credit-1**

1.1 SCR: Construction, working, Characteristics and applications as half wave and full wave rectifier

1.2 DIAC and TRIAC: Construction, working, characteristics and application as fan regulator

1.3 DC-DC Converter and SMPS: Concept and Applications. (Ref. 1: page nos. 166 to 194 and Ref. 2, 3)

Module 2: Special Function ICs and their Applications **Credit-1**

2.1 Operational Amplifier: Function generator using two OPAMPS with variable controls, Astable and Monostable multivibrators using OPAMPs, Precision rectifiers (Half wave and Full wave), Instrumentation amplifier.

2.2 Timer IC 555: Applications as PAM, PWM, FM and FSK generator.

2.3 Voltage Controlled Oscillator (IC566): Block diagram and working.

2.4 Phase Locked Loop (IC565): Block diagram and working and applications as FM detector, FSK detector, Frequency multiplier and Frequency Translator .(Ref. 4, 5, and 6)

Module 3: Digital Logic Circuits I: Combinational Logic **Credit-1**

Review of Boolean identities and its use to minimize Boolean expressions. Use of Karanaugh Map to design 4-variable logic circuits like BCD to 7-segment decoder, Binary-to-Gray and Gray-to-Binary code converter.

Digital Logic Circuits II: Sequential Logic

4-bit serial, parallel and combinational counter. Study of IC 7490 with applications as MOD counters (01 to 99)Study of IC 7495 and its use as SISO, SIPO, PIPO and PISO.UP-DOWN counters, Ring counter and their applications. (Ref.: 7, 8, and 9)

Module 4: Data Converters **Credit-1**

4.1 Digital to Analog converters: Binary weighted and R-2R ladder type with practical circuit (Using Input switches, Level amplifiers, Control gates and Buffer amplifier)

4.2 Analog to Digital converters: Single slope, Dual slope, Flash (Simultaneous) type, Counter ramp type, Continuous type and Successive approximation type. (Ref.: 7, 8, and 9)

Reference Books:

1. Power Electronics Circuits, Devices and Applications, 3rd Edition by *Muhammad H. Rashid*, Pearsons Publications
2. Electronic Devices and Circuits: An Introduction by *Allen Mottershed.*
3. Solid State Electronic Devices, 6th Edition, by *Ben G. Streetman.*
4. Operational Amplifiers, 5th Edition by *G.B. Clayton.*
5. Linear Integrated Circuits, 4th edition by *Roy Choudhari*
6. Design with OPAMPS and Analog Integrated Circuits by *Sergio Franco*
7. Digital Electronics by *R.P. Jain*
8. Digital Principles and Applications by *Leach and Malvino*
9. Digital Electronics: An Introduction to Theory and Practice by *W.H. Gothmann*

Course Code and Title: PHCP-115 Physics Laboratory-I (Electronics)

Student has to perform any **12 Experiments** **Credits-4**

1. Diode Pump Staircase generator using UJT
2. Foldback Power Supply
3. Crystal Oscillator & Digital Clock
4. Voltage Control Oscillator using IC-566
5. Function generator using IC -8038
6. Optocoupler using OPAMPs and IC MCT-2E
7. Constant current Source using OP-AMP
8. DAC (Digital to Analogue Converter) using R-2R and Binary ladder
9. Active filters using OP-AMP / IC- 8038(L-P, H-P. Notch type)
10. Study of Multiplexer & Demultiplexer
11. Precision rectifier
12. Design, built and test oscillator – LC oscillator
13. 8-bit ADC
14. PLL application using IC565
15. OPAMP : logarithmic amplifier
16. Voltage to Frequency / Frequency to voltage converter using OP-AMP
17. Study of errors in electrical measurement and results due to loading
18. To determine the transition capacitance of a varactor diode and use it as a variablecapacitor.(Pg. 28, Experiments in Electronics, S.V. Subramanian, McMillan India Limited, 1982)
19. Measurement of efficiency of a power amplifier.(IC 810)and study of its frequency response.(Pg. 118, Experiments in Electronics, S.V. Subramanian, McMillan India Limited, 1982)
20. Study of noise performance of an amplifier. (Pg. 449, Art of Electronics, Horowitzand Hill, Cambridge, University Press, Low Price Edition, 1995.)
21. Fourier analysis (Pg. 18, Experiments in Electronics, S.V. Subramanian, McMillan India Limited, 1982)

Reference Books:

1. Signetic Manual.
2. Power supplies: B.S. Sonde.
3. Digital Principles: Malvino (6^{th} Edition, Tata McGraw Hill Publication Co. Ltd. Delhi)
4. Operational Amplifier: G.B. Clayton.
5. OP-AMPS and Linear Integrated Circuits: Ramakant Gaikwad.
6. Data Converters: B.S. Sonde, Tata Mc-Graw Hill Pub. Co. Ltd. (1974).
7. Pulse, Digital and Switching Circuits: Miliman and Taub.
8. Electronic Integrated Circuits & Systems: Franklin, C. Fitchen (Van No strand Reinhold Co.
9. Digital Principles & Applications: Leach and Malvino, (5^{th} Edition, 2002)

Course Code and Title: PHCT-121, Electrodynamics

Module 1: Multipole expansions and time varying fields **Credit-1**

Multipole expansions for a localized charge distribution in free space, linear quadrapole potential and field, static electric and magnetic fields in material media, boundary conditions, Time dependent fields, Faraday's law for stationary and moving media, Maxwell's displacement current, differential and integral forms of Maxwell's equations, Maxwell's equations for moving medium. (Ref: 1- 4, 10)

Module 2: Energy, Force, Momentum relations and Electromagnetic wave equations **Credit-1**

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy, Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth. (Ref: 1- 6, 8, 10).

Module 3: Inhomogeneous Wave Equations **Credit-1**

Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Hertz potential and its use in computation of radiation fields. Ref: 1- 5, 8, 10

Module 4: Relativistic Mechanics and Covariance **Credit-1**

Experimental basis for special theory of relativity (Michelson – Morley experiment), Lorentz transformations, Relativistic velocity addition, Minkowski's spacetime diagram, Four vector potential, electromagnetic field tensor, Lorentz force on a charged particle (Ref: 1-3, 6, 9, 10).

Reference Books:

1. Introduction to Electrodynamics, (3rd Edition) by David J. Griffith, Publication: Prentice-Hall of India, New Delhi.
2. Introduction to Electrodynamics, by A.Z. Capri & P.V. Panat, Narosa Publishing House.
3. Classical electricity & Magnetism, by Panofsky and Phillips, Addison Wesley.
4. Foundations of Electromagnetic theory by Reitz & Milford, World student series Edition.
5. Classical Electrodynamics, by J.D. Jackson, 3rd Edition John Wiley.
6. Electromagnetic Theory and Electrodynamics, by Satya Prakash, Kedar Nath and Co., Meerut.
7. Special theory of Relativity, by Robert Resnick.
8. Electromagnetics by B.B. Laud, Willey Eastern.
9. Matrices and Tensors in Physics, A. W. Joshi, 3rd Edition, New Age International.
10. Electrodynamics by Kumar Gupta and Singh.

Course Code and Title: PHCT-122 Solid State Physics

Module-1: Crystal Structure of Solids **Credit-1**

Revision of crystal structures, Reciprocal Lattice, Brillion zone, Ewald's spherical construction, structure of atomic form factor, X-Ray diffraction and Neutron diffraction.

Module-2: Electronic Structure of Solids **Credit-1**

Revision of free electron theory, Mathesien value of resistivity, Bloch theorem, KronigPenney Model, nearly free electron model, Fermi sphere, Tight binding approximation, Band structure (in R space) of semiconductor crystal.

Module -3: Magnetism and Superconductivity **Credit-1**

Dia-magnetism, Para-magnetism, (Classical and quantum theory), Ferromagnetism (Weiss theory and quantum theory), Anti-ferromagnetism and Ferrimagnetisms, Superconductivity: Meissner effect, Type I and II superconductor, Josephson Superconductor junction

Module-4: Dielectric Properties of Solids **Credit-1**

Macroscopic and local electric field, Polarizability, Dielectric constant, Clausius–Mossotti relation, Piezoelectricity, Dielectric behavior in $BaTiO_3$

Reference Books:

1. Solid State Physics, N. W. Ashcroft and N. D. Mermin, (CBS Publishing Asia Ltd.).

2. Introduction to Solid State Physics, C. Kittel, (John Wiley and Sons.).

3. Introductory Solid State Physics, H. P. Myers, (Viva Books Pvt. Ltd.)

4. Solid State Physics, H. Ibach and H. Luth, (Springer-Verlag).

5. Fundamentals of Solid State Physics, J. R. Christman, (John Wiley and Sons).

6. Solid State Physics, A. J. Dekkar, (Prentice Hall).

7. Solid State Physics, J. J. Quinn and K-Soo Yi (Springer).

Course Code and Title: PHCT-123 Statistical Mechanics

Module1: Probability theory, Statistical Description of thermodynamic system Credit-1

Brief discussion on probability distributions (F. Reif Chap-1), Thermodynamical laws and basic thermodynamic relations including Maxwell's equations.

Specification of state of a system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Probability calculations, Behaviour of density of states, Liouville's theorem (Classical). Distribution of energy between systems in equilibrium, Sharpness of the probability distribution, Equilibrium between interacting systems.

Module 2: Classical Statistical Mechanics Credit-1

Micro-canonical ensemble, Canonical ensemble, Partition function, Applications of canonical ensembles to Paramagnetism, Molecule in an ideal gas, Law of atmosphere. System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble in terms of energy, enthalpy and pressure. Connection with thermodynamics and Calculations of thermodynamic quantities, Ideal monoatomic gas.

Gibbs paradox, Equipartition theorem and its applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid (Einstein and Debye Specific heat) v) Maxwell velocity distribution, related distributions and mean values

Module 3: Applications of Statistical Mechanics and Quantum Distribution Functions Credit-1

Grand-canonical ensemble, Physical interpretation of Chemical potential (μ) in the equilibrium state. Mean values and fluctuations in grand canonical ensemble. Thermodynamic functions in terms of the Grand partition function. Application: adsorption of gas molecule on surface using grand partition function.

Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermion gases, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, quantum mechanical paramagnetic susceptibility

Module 4: Ideal Bose and Fermi Systems (1 Credit)

Bose-Einstein statistics: Partition function, thermodynamic behavior, Ideal Bose gas: Photon gas -i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity; Einstein derivation of Planck's law, Specific heat of on gas and Bose Einstein Condensation.

Fermi-Dirac distribution function: Ideal Fermi system. Fermi energy, Mean energy of fermions at absolute zero, Fermi energy as a function of temperature, Electronic specific heat, White – Dwarfs (without derivation)

Reference Books

1. Fundamentals of Statistical and Thermal Physics, - F. Reif, McGraw Hill International Edition (1985).
2. Statistical and Thermal Physics: With Computer Applications- Harvey Gould and Jan Tobochnik (Princeton University Press; 6.1.2010 edition (July 21, 2010).
3. Statistical Physics, Berkeley Physics Course, F. Reif, (Tata McGraw-Hill, 2008).

4. Fundamentals of Statistical Mechanics- B.B. Laud, New Age International Publication (2003).
5. Statistical Mechanics by R.K. Pathria, Bufferworgh Heinemann (2^{nd} Edition).
6. Statistical Mechanics by K. Huang, John Willey and Sons (2^{nd} Edition).
7. Statistical Mechanics by Satya Prakash and Kedar Nath Ram, Nath Publication (2008)
8. Statistical Mechanics by Loknathan and Gambhir

Course Code and Title: PHCT-124 Atoms and Molecules

Module 1: Atoms **Credit-1**

(a) Revision of Atomic models, Revision of Hydrogen atom, Revision of quantum numbers, exclusion principle, electron configuration, Hund's rule

(b) origin of spectral lines, selection rules, One electron spectra, Coupling schemes, two electron spectra, fine structure and hyperfine structure, The Hartree Theory, Results of Hartree theory, X-ray line

(c) Atoms in Electromagnetic field: Zeeman effect- Normal and Anomalous, Paschen- Back effect, Stark effect (weak field)

Module 2: Molecules **Credit-1**

Bonding mechanism in molecules, Molecular orbital methods, Valence band method, Molecular Spectra – Rotational and vibrational spectra for diatomic molecules, Electronics spectra of diatomic molecules, vibration course structure, vibrational analysis of band system, Frank – Condon principle, Dissociation energy and dissociation products, rotational fine structure of electronic vibration transitions, electronic angular momentum in diatomic molecules.

Module 3: Spectroscopic Techniques **Credit-1**

(a) Microwave Spectroscopy: microwave spectrometer, information derived from rotational spectra and analysis of microwave absorption by H2O

(b) Infrared spectroscopy: IR spectrophotometer and instrumentation, sample handling techniques, FTIR spectroscopy and analysis of HCl spectrum, Applications

(c) Raman spectroscopy: Theory of Raman scattering, Rotational Raman spectra, Mutual exclusion, Raman spectrometer, sample handling techniques, Fourier transform Raman spectrometer, Structure determination using IR and Raman spectroscopy (diamond), Applications

Module 4: Resonance spectroscopy **Credit-1**

(a) ESR- Principles of ESR, ESR spectrometer, total Hamiltonian, hyperfine structure.

(b) NMR-Magnetic properties of nucleus, resonance condition, NMR instrumentation, relaxation process, chemical shift, applications of NMR.

Reference Books:

1. Fundamentals of Molecular spectroscopy. Collin N. Banwell and Elaine M. McCASH

2. Molecular structure and Spectroscopy G. Aruldhas

3. Quantum Physics – Robert Eiesberg and Robert Resnik

Course Code and Title: PHCP-125 Physics Laboratory-II (General Lab)

Student has to perform any **12 Experiments** **(Credit-4)**

1. **Photoconductivity:**
a) To plot the current voltage characteristics of a CdS photoresistor at constant irradiance.
b) To measure the photocurrent as a function of irradiance at constant voltage.

2. **Speed of Light** :
To determine the speed of light using transit time of light pulse as a function of a reflecting mirror.

3. **Faraday Effect**: Rotation of The Polarization Plane Φ As A Function of The Magnetic Field and Rotation of The Polarization Plane 2Φ As A Function Of The Magnetic Field

4. **Dielectric constant**:
a) To Measure the charge Q on a plate capacitor as a function of the applied voltage E.
b) To determine the capacitance C as a function of areas A of plates.
c) To determine the capacitance C with different dielectrics between the plates.
d) To determine the capacitance C as a function of the distance d between the plates

5. **Millikan Oil Drop Apparatus:** To measure the rise and fall times of the oil droplets at different voltages having different charges.
a) To determine the radii of droplets. b) To determine the charge '**e**' on the droplets

6. **Michelson's Interferometer:**
To determine the wavelength of He-Ne LASER by using Michelson's Interferometer apparatus.

7. **Specific Heat of Solids**:
To determine the specific heat of copper, lead and glass at three different temperatures.

8. **Electron Spin Resonance**:
To study the Electron Spin Resonance and to determine Lande's g-factor

9. **Frank-Hertz experiment**: To study the discrete energy levels using Frank-Hertz experiment

10. **G.M. counter:** Counting statistics, Characteristics of GM tube and determination of end point energy of β-ray source

11. **G.M. counter:** Determination of dead time of GM tube by Double source method

12. **Skin depth :** Skin depth in Al using electromagnetic radiation

13. **Gouy's Method:** Measurement of magnetic susceptibility of MnSO4

14. **Thermionic emission:** To determine work function of Tungsten filament

15. **Hall effect:** To determine charge concentration, conductivity of Ge-semiconductor

16. **Four Probe method:** Temperature variation and Band gap of Ge-semiconductor

17. Ionic Conductivity of NaCl

18. Fabry-Parot Etalon

19. Zeeman Effect

20. Stefan's constant – Black Body Radiation

21. To study absorption spectra of Iodine molecule and to determine its dissociation Energy using spectrometer

Reference Books:

1. Solid State Laboratory Manual in Physics, Dept. of Physics, University of Pune, (1977).

2. Experimental Physics, Wersnop and Flint.

3. Molecular structure and Spectroscopy, G.Aruldas Prentice-hall of India Pvt. Ltd. New Delhi.

4. Practical Physics, D.R. Behekar, Dr.S. T. Seman, V.M.Gokhale,P.G.Kale (KitabMahal Publication)

5. Introduction to experimental Nuclear Physics, R.M. Singru, Wiley Eastern privateLtd. New Delhi.

Course Code and Title: PHCT-231 Physics of Semiconductor Devices

Module 1: Properties of semiconductor **Credit-1**

Band structure of semiconductors, carrier concentration at thermal equilibrium for intrinsic and doped semiconductors and calculation of Fermi level, Current density equations, carrier transport phenomenon- Mobility, resistivity and Hall effect, Excess carrier generation and recombination, Excess carrier lifetime, basic equation for semiconductor device operation

Module 2: p-n Junction **Credit-1**

Types of semiconductor, direct and indirect band gap semiconductors, Basic device technology, Depletion region and depletion layer capacitance, current voltage characteristics- ideal case- Shockley equation, generation-recombination process, high injection condition, diffusion capacitance, junction breakdown.

Module 3: Junction Transistor and Field Effect Devices **Credit-1**

Formation of transistor, basic current voltage relationship, mathematical derivations current gain factors- injection efficiency, base transport factor and recombination factor, static characteristics common base and common emitter configurations, power transistors-general consideration, Static and dynamic characteristics of switching transistor (second breakdown), unijunction transistor, silicon controlled rectifier, junction field effect transistor and their energy band diagrams.

Module 4: Metal and Metal Insulator semiconductor devices **Credit-1**

Energy band relation at metal semiconductor contacts - ideal condition and surface states, depletion layer, Schottky effects, Current transport processes- thermionic emission theory, Diffusion theory and Thermionic emission-Diffusion theory, general expression for barrier height, Schottky Barrier diode - current voltage measurement, metal semiconductor IMPATT diode, Ideal MIS diode - surface space-charge regions and effect of metal work function.

Reference Books:

1. Physics of Semiconductor Devices – S.M. Sze.
2. An introduction to Semiconductor Devices—Donald A. Neaman (McGraw-Hill 2006).
3. Solid State Electronic Devices – B.G. Streetman and S.K. Banerjee (Pearson Education).
4. Fundamentals of Semiconductor Devices – J. Lindmayer and C.Y. Wrigley.
5. Physics of Semiconductor Devices – Micheal Shur.

Course Code and Title: PHCT-232 Laser Fundamentals and Applications

Module 1 **Credit-1**

Interaction of radiation with matter: Absorption, spontaneous and stimulated emission, population inversion, properties of laser, metastable state, gain, absorption coefficient, Einstein's coefficient, stimulated emission cross section, threshold condition. (Ref. 1, 2)

Module 2 **Credit-1**

Three and four level system and rate equations, pumping mechanisms (electron beam impact, optical, and current injection type), threshold pump power, relative merits and demerits of three and four level system. g-parameters of laser cavity, stability curve, Gaussian beam and their properties (TEM modes 00, 01, 10, 11). Line broadening (homogeneous and non-homogeneous) mechanisms. Measurements of laser power, energy, wavelength, frequency, line width.

(Ref. 1-4, 10)

Module 3 **Credit-1**

Principle, Construction, Energy level diagram and working of following lasers:
Solid state lasers (Ruby laser, and Nd:YAG laser), Semiconductor lasers (homo junction), Gas lasers (He-Ne laser, Nitrogen laser, CO_2 laser, and Excimer lasers), Liquid lasers (Dye laser).
(Ref. 1, 2, 7)

Module 4 **Credit-1**

Industrial applications: Cutting, melting, welding, drilling, surface hardening
Medical applications: Skin therapy, laser eye surgery, laser surgery, tumor ablation
Military applications: Range finders, laser radar, laser gyro
Scientific applications: In spectroscopy, laser deposition, optical fiber communication
` (Ref.1, 2, 7, 8)

Reference Books:

1. Solid State Engineering Vol-I – W. Koechner Springer Verlag (1976).
2. Lasers Fundamentals – W.T. Silfvast.
3. Principles of Lasers – O. Svelto – Plenum, 1982.
4. Laser Parameters – Heard.
5. Laser and Non-Linear Optics – B.B. Laud (2^{nd} Edition).
6. Lasers : Principles, Types and Applications -- K.R. Nambiar.
7. Introduction to Fiber Optics – A.Ghatak, K.Thyagarajan- Cambridge University Press.
8. Principles of Laser And Their Applications – Callen O'Shea, Rhodes.
9. An Introduction to Laser Theory and Application – M. N. Avdhanulu, S. Chand Publications.
10. Experiments with Laser – Sirohi.

Course Code and Title: PHCT-233: Experimental Techniques in Physics-I

Module 1: Signal, Signal Analysis and Sensors **Credit-1**

Signals, Signal analysis (Time and Frequency Domain), Signal to noise ratio. Measurement, result of a measurement, sources of uncertainty and experimental error, Systematic error, random error, Reliability-chi square test, Analysis of repeated measurement, Precision and accuracy, Elementary data fitting.

Sensors: Sensor's characteristics, Classification of sensors, Operation principles of sensors such as electric, thermal, mechanical, pressure, gas and humidity with examples.

Module 2: Vacuum Physics **Credit-1**

Importance and fields applications of vacuum, kinetic theory of gases, impingement rate of molecules on a surface, average velocity of gas and mean free path, gas transport properties (thermal conductivity, viscosity and diffusion), various ranges of vacuum, gas conductance of a vacuum line, gas impedance of a vacuum line, pumping speed, flow of gases through apertures, elbows, tubes etc. for viscous and molecular flow regimes, pump down time, Numerical

Module 3: Vacuum Techniques **Credit-1**

Principles of Pumping concept, Types of Vacuum pumps: Rotary, Molecular drag, Oil diffusion, Cryogenic getter ion, Titanium sublimation, Sputter ion, Orbitron

Module 4: Vacuum Measurement and Low Temperature Techniques **Credit-1**

Vacuum gauges: Mc Leod, Thermocouple (Pirani), Penning gauges. Hot cathode ionization (triod type), Bayard-Alpart. Leak detection in vacuum pump. Low Temperature Techniques: Refrigeration principle (including thermodynamical aspects) and low temperature production techniques (Throttling process).

References:

1. Instrumentation: Devices and Systems, C.S. Rangan, G.R. Sarma and V.S.V. Mani, Tata Mc Graw Hill Publishing Co. Ltd.
2. Vacuum Physics and Techniques, T. A. Delchar, Chapman and Hall.
3. Vacuum Technology, A. Roth, (North Holland, Elsevier Science B.V. 1990).
4. High vacuum techniques, J. Yarwood (Chapman and Hall, London, 1967).
5. Experimental principles and methods below 1 K, O. U. Lounasmaa, (Academic Press, London and, New York, 1974).

Course Code and Title: PHY234 (Elective-I)

PHOP234-I: Medical Physics-I

Module 1: Forces acting on body and Physics of the skeleton **Credit-1**

Statics, Frictional forces, Dynamics, Conservation of Energy in the body, Heat losses from body, Pressure in the body. Physical properties of bone, Mechanics of joints.

Module 2: Electricity within the body **Credit-1**

Nervous system and neuron, Electric properties of Nerve, Electrical potential of nerve, Nernst Equation, Bio potentials EMG, ECG, EEG, EOG, ERG, Magnetic signals from heart and Brain

Module 3: Physics of hearing **Credit-1**

Basic definition of Audibility, Physics of ear, Human Audibility Curve, Sensitivity of ear, Testing of hearing. Deafness and hearing aids, Sound in medicine, Sound pollution, Effects of sound pollution on living body, Methods to minimize sound pollution

Module 4: Physics of vision **Credit-1**

Optics of eye, Diffraction effects of eye, Refractive effect in eye and its correction, Contact Lenses, Color vision and chromatic aberration, Instruments used in Ophthalmology.

Reference Books:

1. Medical Physics by John R. Cameron, J. G. Skofronick, John Wiley and Sons, International Publications
2. Essential of Biophysics by Narayanan, New age Publication
3. Radiation Biophysics by Edward Alphan, prentice Hall Advance Refers
4. T.B. of Biophysics by R.N. Roy, Central Publication
5. Medical Informatics by Smita Mishra and K. C. Mishra, ICFAI University
6. Fundamental of Bioinformatics by S. Harisha
7. Biomedical Engineering by S.N. Sarbadhikari, University Press
8. Principles of Medical Electronics and Biomedical Instrumentation by C. Raja Rao, S. K. Guha, University Press
9. Electronics in Medicine and Biomedical Instrumentation by Nandini Jog

PHOP234-J: Acoustics-I

Module 1: Measurement and Perception of Sound **Credit-1**

Velocity of sound in fluids; Energy density of a plane wave; Acoustic intensity; Acoustic standards and reference conditions; Specific acoustic impedance; Decibel Scales: Intensity level (IL), Sound pressure Level (SPL), Sound Power Level (PWL), Loudness Level (LL)

Module 2: Transmission Phenomenon, Resonators and Filters **Credit-1**

Transmission from one fluid medium to another: Reflection at the surface of a solid, Significance of standing wave ratios; Helmholtz resonator; acoustic, electrical and mechanical analogues; Expansion chamber muffler

Module 3: Speech Hearing and Community Noise Criteria **Credit-1**

Equivalent continuous sound pressure level (L_{Aeq}); Perceived noise level (L_{EPN}) Human voice and hearing mechanism, thresholds of the ear; Audiometry; Haas effect and delay

Module 4: Architectural Acoustics **Credit-1**

Growth and decay of sound in live rooms; Sabine equation; Decay of sound in dead rooms: Eyring approach, Millington and Sette approach; Optimum reverberation time; Methods of measuring reverberation time; Sound absorption coefficients; Room modes; Room acoustics: Sound transmission class, High-loss frame walls, Floor and ceiling systems

Reference Books:

1. Fundamentals of Acoustics, II or Ill Edn., L. E. Kinsler and A. R. Frey, Wiley Eastern, 1982
2. Acoustics, W.W. Seto, Schaum's Outline, 1978
3. Basic Acoustics, D. E. Hall, Oxford University Press
4. Technical Aspects of Sound, Richardson, Prentice Hall: 1962
5. Noise Reduction, L. L. Baranek, MIT Press, 1970
6. Handbook of Sound Engineers (The New Audio Cyclopedia), G. M. Ballou, Academic Press, 1998
7. Design for good Acoustics and Noise Control, J. E. Moore, University Press, 1998
8. Acoustics Sourcebook, S. Parker, McGraw Hill, 1996

PHOP234-K: Energy Studies-I

Module 1: Energy Sources **Credit-1**

Energy, Work and Power, Energy units and inter-conversion, Various types of energy sources, Non Renewable Energy sources (Coal, Oil, Natural gas, Nuclear power, Hydroelectricity, and their potentials), Renewable Energy sources (Solar, Wind, Biomass, Tidal, Ocean wave, Ocean thermal, Geothermal and their potentials)

Energy crisis: Energy consumption and its impact on environment, Climate Change, Global Warming.

Future Energy Option: Sustainable development, Energy for security and security of energy, Transition to carbon free technologies, Carbon credits

Module 2: Solar Radiation and Its Measurements C**redit-1**

Importance of Solar Energy: Nature of solar radiation, Sun as a fusion rector, spectral distribution of terrestrial and extraterrestrial radiation, Estimation of extraterrestrial solar radiation, Radiation on horizontal and titled surfaces.

Nature of Solar Radiations - beam, diffuse, global radiation and their measurement by Pyranomater, Pyrhelimeter, Sunshine recorder (Ref. 8)

Module 3: Basics of Heat transfer **Credit-1**

Heat and Thermodynamics: Basic units, dimensions, Concept of heat, 1st and 2nd law of thermodynamics, Types of heat transfer. Conductive heat transfer: Fourier's law. Stefans-Boltzman relation and IR heat transfer between gray surfaces. Radiative heat transfer: sky radiation, radiation heat transfer coefficient

Convective heat transfer: Natural and forced convection, natural convection between parallel plates, Non-dimensional numbers, conductive heat transfer coefficient, Heat transfer due to wind (Ref. 9)

Module 4: Energy Storage **Credit-1**

Types of energy storage systems: sensible and latent heat storage systems, Electric energy storage systems, Chemical energy storage systems, Heat exchanges, Hydrostorage, solar pond as a energy storage, Green house (Ref. 11)

Reference Books:

1. TEDDY Year Book (Tata Energy Research Institute (TERI) Publication, New Delhi)
2. World Energy Resources, Charles E.Brown (Springer Publication) 2002
3. Energy Policy for India, B.V. Desai (Welley Eastern Publication)
4. Handbooks of Solar Radiation, A. Mani (Allied Publishers) 1980.
5. Solar Energy Fundamentals and Applications, H.P. Garg and Satya Prakash, (Tata McGraw Hill) 1977
6. Treatise on Solar Energy, H.P. Garg, Volume 1, 2, and 3 (John Wiley and Sons) 1982
7. Principles of Solar Engineering, F. Kreith and J.F. Kreider, McGraw Hill, 1978
8. Solar Energy Thermal Processes, J.A. Duffie and W.A. Beckman, (John Wiley & Sons) 1980.

9. Heat and Thermodynamics, M.W. Zemansky (McGraw Hill Publication).

10. Principles of Solar Energy Conversion, A.W. Culp (McGraw Hill Publication).

11. Solar Energy Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Edition (Tata McGraw Hill Publication Co. Ltd.) 1976.

12. Solar Energy Utilization, G.D.Rai (Khanna Publishers) 1996.

13. Solar Thermal Engineering, J.A. Duffie (Academic Press).

14. Renewable Energy Sources and Conversion Technology, N.K. Basal, M. Kleeman and S.N. Srinivas, (Tata Energy Reserch Institute, New Delhi) 1996.

PHOP234-L: Physics of Thin Films

Module 1: Introduction to Thin Films **Credit-1**

Overview of vacuum techniques, Comparison of thin and thick films, Theory of growth of thin films: Nucleation, condensation, Capillarity model, Atomistic model, comparison of models, various stages of film growth.

Module 2: Deposition Techniques and Measurement of Thickness **Credit-1**

Physical Vapour Deposition, Chemical Vapour Deposition, Molecular Beam Epitaxy, Sputtering, Spray pyrolysis, Dip coating and Spin coating, photolithography, Electron –beam deposition, Pulsed Laser Ablation. Tolansky technique, Talystep (styles) method, Quartz crystal microbalance, Stress measurement by optical method, Gravimetric method

Module 3: Properties of Thin Films **Credit-1**

Electrical Properties: Source of Resistivity in Metallic conductors, Influence of thickness on the resistivity of thin films, Hall Effect & Magneto-resistance in thin films, Fuch-Sondhemir theory, TCR and its effects. Mechanical properties: Adhesion and its measurement with mechanical and nucleation methods, stress measurement by using optical method. Optical properties: Absorption and transmission.

Module 4: Applications of Thin Films **Credit-1**

Resistors, capacitors, Junction devices (Metal semiconductor junction) Solar cells, ICs, Optical coating, Thin film sensors (gas and humidity), Thin films for information storage, electro acoustics and telecommunication

Reference Books:

1. Hand book of Thin Film Technology: Maissel and Glang, (Mc Graw Hill).
2. Thin Film Phenomena: K. L. Chopra (Mc Graw Hill).
3. Material Science of Thin Films: M. Ohring (Academic Press).
4. Thin Film Process: J. L. Vossen and Kern (Academic Press).
5. Vacuum Technology by A. Roth (2^{nd} Revised Edition) (North Holland).

PHOP234-M: Astronomy and Astrophysics-I

Module 1: Astronomical Scales & Basic Concepts of Positional Astronomy Credit-1

Astronomical Distance, Mass and Time Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities, Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature, Celestial Sphere Geometry of a Sphere Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinates Horizon System, Equatorial System Diurnal Motion of the Stars Conversion of Coordinates, Measurement of Time Sidereal Time Apparent Solar Time Mean Solar Time Equation of Time, Calendar

Module 2: Astronomical Techniques and Physical Principles Credit-1

A. Basic Optical Definitions for Astronomy Magnification Light Gathering Power Resolving Power and Diffraction Limit Atmospheric Windows Optical Telescopes Types of Reflecting Telescopes Telescope Mountings Space Telescopes Detectors and Their Use with Telescopes Types of Detectors Detection Limits with Telescopes, Sky charts and their importance

B. Gravitation in Astrophysics Virial Theorem, Newton versus Einstein, Keplar's laws, Systems in Thermodynamic Equilibrium, Theory of Radiative Transfer, Radiation Field Radiative Transfer Equation, Optical Depth; Solution of Radiative Transfer Equation, Local Thermodynamic Equilibrium

Module 3: The Sun and Stellar Structure Credit-1

A. Solar photosphere Solar Atmosphere, Chromosphere, Corona, Solar Activity,Basics of Solar Magneto, hydrodynamics Helioseismology. Solar System: Facts andFigures Origin of the Solar System: The Nebular Model Tidal Forces and Planetary rings.

B. Hydrostatic Equilibrium of a Star, Some Insight into a Star: Virial Theorem Sources of Stellar Energy, Modes of Energy Transport, Simple Stellar Model Polytropic Stellar Model. Stellar Spectra and classification: Atomic Spectra Review, Stellar Spectra, Spectral Types and their Temperature Dependence, Black Body Approximation, H-R Diagram, Luminosity Classification

Module 4: Star Formation, Nucleo-synthesis and Stellar Evolution Credit-1

Basic Composition of Interstellar Medium, Interstellar Gas, Interstellar Dust Formation of Protostar, Jeans Criterion Fragmentation of Collapsing Clouds from Protostar to Pre-Main Sequence Hayashi Line, Cosmic Abundances, Stellar Nucleo-synthesis, Evolution of Stars, Evolution on the Main Sequence, Evolution beyond the Main Sequence, Supernovae. Basic Familiarity with Compact Stars, Equation of State and Degenerate Gas of Fermions, Theory of White Dwarf, Chandrasekhar Limit, Neutron Star, Gravitational Red-shift of Neutron Star, Detection of Neutrons

Reference Books:

1. Structure of the Universe, J.V. Narlikar.
2. Astronomy- Fundamentals and Frontiers, Robert Jastraw, H.Thomson (John Wiley and Sons).
3. Astrophysics by Bowers and Deeming Vols.1 and 2.
4. Cox and Guili: Principles of Stellar Interiors - Vol. I and II.

5. Mihalas: Stellar Atmospheres.
6. C.R. Miczaika and W.M.Sinton: Tools of the Astronomers.
7. Baidyanath Basu: Introduction to Astrophysics.
8. W.A. Hiltner (Ed): Astronomical Techniques.
9. A. Unsold: The New Cosmos (3rd Edition). Springer-Verlag 1983.
10. M. Schwarzschild: Stellar Evolution.
11. S. Chandrasekhar: Stellar Structure.
12. Menzel, Bhatnagar and Sen: Stellar Interiors.
13. J. Greenstein (Ed): Stellar Atmospheres.
14. The Physical Universe, F. Shu (University Science Books).
15. Bowuwer and Clemence: Methods of Celestial Mechanics.

PHOP234-N: Electronic Instrumentation- I

Module 1: General Background and Measurements **Credit-1**

1.1 General configuration and functional description of measuring instruments, few examples of instruments and their functional description. (Ref.1: #2.1 to 2.4). Input output configuration of measuring instruments, methods of correction of unwanted inputs. (Ref.1: #2.5)

1.2 Qualities of measurements (Ref. 9 Ch#1) Static characteristics, Errors in measurement, Types of errors, sources of errors (Ref. 9 Ch#1) Dynamic characteristics: Generalized mathematical model of measurement System, order of instruments: zero, first and second order. Step, ramp and frequency response of first order instruments (Ref.1: # 3.3 pp 94 to 115 & 123 to 131) References: 1, 3, and 9

Module 2: Transducers **Credit-1**

2.1 Electrical transducers, resistive, strain gauge, thermistor, inductive transducers, variable reluctance, LVDT, pressure inductive, capacitive transducers, piezoelectric transducer, photoelectric, magneto resistive sensors. Transducers for displacement, velocity, acceleration.

2.2 Fluid flow, fluid rate and velocity. Various temperature transducers: Acoustic temperature sensor, high temperature measurement using a cooled thermocouple (Ref.1), Humidity sensors, conductivity measurements, PMT, Optical pyrometry (with at least one application of each transducer) References: 9

Module 3: Signal Conditioners and Data Acquisition and Conversion **Credit-1**

3.1 Signal conditioners: Op-amps, instrument amplifier, bridge, phase sensitive detector (References: 9: Chapter 17).

3.2 Data acquisition and conversion D to A and A to D converters, Data loggers, ADC digital transducer (optical transducer) Data acquisition system. ICs available: ADCs, DACs (Ref 9).

Module 4: Indicators, Display System and Recorders **Credit-1**

4.1 Digital display system with LED and LCD. Printers: principle of Laser printers only

4.2 Introduction to microprocessor based instruments, with suitable examples. Stepper motor controller and basic idea of process control (References: 9).

Reference Books:

1. Measurement Systems- Applications and Design.4th Edn E.O. Doeblin.
2. Measurement System – Applications and Design by E.O. Doblin and Manik
3. Instrumentation, Measurement and Systems. Nakra and Chaudhary
4. Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W. D. Cooper (Pearson)
5. Instrumentation, Devices and Systems. Rangan, Mani and Sarma Prentice Hall Of India.18
6. Process Controlled Instrumentation by C.D. Johnson
7. Elements of Electronic Instrumentation and Measurement. 3rd Edn. Joseph Carr. (Pearson)
8. Sensors and Transducers, Patranabis
9. Electronics Instrumentation, Kalsi (Tata Mcgraw-Hill).

PHOP234-O: Communication Electronics

Module 1: Digital Communication **Credit-1**

Fundamentals of digital communication systems. Characteristics of data transmission system such as Band-Width requirement, speeds SNR, cross talk, echo suppressors, distortion equalizer, Digital codes, Baudot code, binary code, ASCII code (EBCDIC), hollerith code, error detection, constant ratio codes, Redundant codes, parity check codes, Communication system using modern interfacing, interconnection of Data circuit to telephone loops, Network organization.

Module 2: Broadband Communication Systems **Credit-1**

Multiplexing – FDM, TDM, Higher order digital multiplexing, Fiber Optic

Communications – Principles of light transmission in a fiber, effect of Index profile on propagation, Modes of propagation, Number of modes a fiber will support, Single-mode propagation, losses in fibers. Dispersion – effect of dispersion on pulse transmission, types of dispersion, intermodal, material and waveguide, total dispersion and maximum transmission rates, Light sources for fiber optics, An Optical Receiver Circuit, Connectors and Splices – loss mechanism, types of connectors and fiber Splices, Fiber communication systems.

Module 3: Telephone and Facsimile Systems **Credit-1**

Wire telephone, telephone subscriber's loop circuit, transmission bridges, four wire terminating set, Two –wire repeaters, Four wire transmission, Public telephone network, Trunk circuits and Private telephone networks, Cellular and mobile phone systems. Facsimile transmission, reception, Transmission of facsimile telegraph, line transmission and radio transmission.

Module 4: Satellite Communication **Credit-1**

Introduction to radar systems, fundamental radar range equation, basic pulsed radar. Satellite frequencies, orbits (geostatics, equatorial/polar, synchronous) station keeping, satellite attitude, transmission path, path loss, noise considerations, satellite system and scanning methods.

Reference Books:

1. Electronic Communications – Rooddy – Coolen (PHI).
2. Communication Systems – George Kennedy (TMH).
3. Telecommunication Switching Systems and Network – T. Vishwanathan.(PHI).
4. Mobile Cellular Tele Communication System – C.Y. Lee.
5. Communication Electronics – Fresnel.
6. Communication Electronics – Katre.

PHOP234-P: Biomedical Instrumentation-I

Module 1: Fundamentals to Biomedical Instrumentation and Patient Safety **Credit-1**

1.1 Basic medical instrumentation system
1.2 System configuration
1.3 Basic characteristics of measuring system
1.4 Problems faced when measuring a human body
1.5 Essentials of biomedical instrumentation
1.6 Electric shock hazards-Gross shock-Micro current shock
1.7 Precautions to minimize electric shock hazards

Module 2: Electrodes and Physiological Transducers **Credit-1**

2.1 Electrode theory, and Biopotential electrodes.
2.2 Electrodes for ECG, EEG, EMG.
2.3 Introduction to physiological transducers.
2.4 Classification of Transducer.
2.5 Performance characteristic of transducer.
2.6 Displacement, position, motion, and pressure transducers.
2.7 Transducer for Body temperature measurement.
2.8 Biosensors

Module 3: Recording Systems and Signal Analysis **Credit-1**

3.1 Basic recording system.
3.2 General consideration for signal conditioners.
3.3 Preamplifiers, Differential, Instrumentation, Isolation amplifier.
3.4 Source of noise in low level measurement.
3.5 Biomedical signal analysis techniques.
3.6 Fourier Transform, FFT and Wavelet Transform.
3.7 Signal processing techniques.

Module 4: Cardiovascular System and Measurements **Credit-1**

4.1 The Heart.
4.2 The Heart and Cardiovascular system.
4.3 Blood Pressure.
4.4 Heart Sounds.
4.5 Block diagram of electrocardiograph.
4.6 The ECG leads.
4.7 Effect of Artifacts on ECG recording.
4.8 Introduction to Pacemakers, their types and need for pacemakers.
4.9 Pacemaker system and its functioning.

Reference Books:

1. Biomedical Instrumentation and Measurements (Second Edition) by Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Pearson Education.
2. Handbook of Biomedical Instrumentation (Second Edition) by R. S. Khandpur (Tata McGraw Hill).
3. Biomedical Instrumentation and Measurement by Carr and Brown-Pearson.

PHOP234-Q: Atmospheric Physics-I

Module 1: Atmospheric Thermodynamics **Credit-1**

Atmospheric compositions, Equation of state for dry and moist air, Adiabatic process, Virtual temperature, humidity parameters, thermodynamic laws, Potential temperature, Pseudo adiabatic process, Clausius - Clapeyron equation, Thermodynamic diagrams-general considerations, Emagram, Tephigram

Module 2: Hydrostatic Equilibrium **Credit-1**

Hydrostatic equation and geo-potential, Height computation for air sounding, The homogeneous atmosphere, The isothermal atmosphere, The constant lapse rate atmosphere, The dry adiabatic atmosphere, The dry and moist adiabatic lapse rate.

Module 3: Atmospheric Aerosols **Credit-1**

Introduction to Aerosols, Aerosol concentration and size distributions and its characteristics, sources of Aerosols, Transformation of Aerosols, Chemical composition of aerosols, Transport of aerosols, Sink of aerosols, residual time of aerosols, Geographical distribution of aerosols, Atmospheric effect of aerosols.

Module 4: Cloud Physics **Credit-1**

Aerosols as Cloud Condensation Nuclei (CCN), Heterogeneous and homogenous Nucleation process, Curvature and solute effect, Condensation growth of cloud droplet by diffusion, collision and coalescence, Collection efficiency, Freezing nuclei, Mechanism of growth of ice particles in cloud, formation of ice, Rain making experiment, Classification of clouds and hails.

Reference Books:

1. Introduction to Theoretical Meteorology- S.Hess
2. An Introduction to Atmospheric Chemistry – Prof. Peter V.Hobbs
3. Tropical Meteorology Vol- I And II- G.C. Asnani
4. Weather Forecasting – A.A. Ramshastry
5. Cloud Physics-Rogers
6. Cloud Physics-Wallace and Bob
7. Atmosphere, Weather and Climate –K. Siddharth (Kisalaya Publication Pvt.Ltd)
8. Atmospheric Chemistry and Physics - John Seinfeld and S.N.Pandis, Wiley Interscience

PHOP234-R: Nuclear Techniques-I

Module 1: Interaction of radiation with matter **Credit-1**

General description of interaction processes, direct and indirect ionizing radiations, interactions of directly ionizing radiation such as electrons, protons and ions, stopping power, linear energy transfer, range of particles, straggling, interaction of indirectly ionizing radiation such as gamma radiations, attenuation coefficient, energy transfer.

Module 2: Nuclear detectors **Credit-1**

Ionization and transport phenomena in gases, Ionization chamber, Proportional counter, GM counter, general characteristics of organic and inorganic scintillators, scintillation detectors NaI-(Tl), detection efficiency for various types of radiations, scintillators, detection efficiency for various types of radiation, PHYomultiplier gain, semiconductor detectors, surface barrier detector, Si(Li), Gel(Li), HPGedetectors.

Module 3: Pulse processing and related electronics **Credit-1**

Preamplifier, pulse shaping and pulse stretchers networks, delay lines, amplifier, Pulse height analysis and coincidence technique, Discriminators: Single channel analyzer, multichannel analyzer, pulse height spectroscopy, pulse shape discrimination, coincidence and anti- coincidence units.

Module 4: Dosimetry and radiation protection **Credit-1**

Radiation measurements Units: Rontgen, RAD, REM, RBE, BED, Gray, Sievert, kerma, Cema, energy deposit and energy imparted, absorbed dose, main aims of radiation protection, dose equivalent and quality factor, organ dose, effective dose equivalent effects and dose limits, assessment of exposure from natural man-made sources, effects of radiation on human body.

Reference Books:

1. Nuclear Radiation Detectors, S. S. Kappor and V. S. Rmanurthy. (Wiley Eastern Limited, New Delhi,) 1986
2. Introduction to Radiation Protection Dosimetry, J. Sabol and P. S. Weng (World Scientific) 1995
3. Techniques for Nuclear And Particle Physics, W.R. Len (Springer) 1955
4. Nuclear Measurement Techniques, K. Sriram, (Affiliated East-West Press, New Delhi) 1986
5. Fundamentals of Surface and Thin Film Analysis, Leonard C. Feldman and James W. Mayer, (North Holland, New York) 1988
6. Introduction to Nuclear Science And Technology, K. Sriram and Y.R. Waghamare (A.M. Wheeler) 1991
7. Nuclear Radiation Detection, W.J. Price (Mcgraw-Hill, New York) 1964
8. Alphas, Beta and Gamma-Ray Spectroscopy K. Siegbahn, (North Holland, Amsterdam) 1965.
9. Introduction to Experimental Nuclear Physics, R.M. Singru (John Wiley and Sons) 1974.
10. Radioactive Isotopes in Biological Research, Willaim R. Hendee (John Wiley and Sons) 1973.
11. Atomic and Nuclear Physics, Satendra Sharma, Pearson Education, 2008

PHOP234-S: Microcontrollers Based Instrumentation System-I

Preamble: The students are supposed to have studied the following topics at undergraduate and post graduate level:

Analog and Digital Electronics, binary number and other number systems such as bcd, hex with their arithmetic's. Boolean algebra, K map techniques, Basic logic gates, flip-flops such as RS, JK, D flip-flop (bi- stable multivibrators) binary counters using flip-flops, half adder full adder using basic logic gates. Analog to digital converters such as successive approximation ADC, dual slope ADC, binary weighted and R-2R DAC, basic regulated power supply using IC- 723 or three pin regulators, temperature sensors such LM 35, AD 590. Basics of C programing.

Module 1: **Credit-1**

Architecture of 8-bit microprocessors, comparison between microprocessor and microcontroller (8085 and 8051). Introduction to Microcontrollers, Architecture, RISC and CISC processors

8051 Microcontrollers: Architecture and introduction to Instruction set of 8051 Microcontroller. Types of instructions (jumps, loops and call instructions & stack related operations), addressing modes in 8051, Programming 8051 microcontrollers: simple arithmetic and logic programs, codes conversions, look up table handling programs, moving/copy a block of data from one memory location to other etc.

Module 2: **Credit-1**

I/O programming: Four ports of 8051 with their special features (dual role of port 0 and port 2), programs related to setting port(s) as an input/output port(s), I/O ports and bit addressability, timers and interrupts programming in 8051 Timers: Programming 8051 timers, counter programming, 8051 interrupts, interrupts service routine, interrupts vector table, enabling and disabling 8051 interrupts, Interrupt priority in the 8051, programing 8051 timers using interrupts.

Module 3: **Credit-1**

8051 programming using C: Time delay in 8051 C, I/O programing, data conversion ASCII, BCD, binary (Hex) to decimal, accessing code space of 8051, timer and interrupt programming of 8051.

Module 4: **Credit-1**

Interfacing an LCD module, keyboard, ADC (0809) & DAC (0808), a stepper motor, traffic signaling (hardware compatibility and programs using C), data serialization, basics of serial communications, 8051 connections to RS232, 8051 serial port programing using C.

Reference Books:

1. 8051 Microcontroller by Kenneth J. Ayala
2. 8051 Microcontroller and Embedded Systems using Assembly and C by Mazidi, Mazidi and D MacKinlay, 2006 Pearson Education Low Price Edition
3. Microprocessor and Microcontroller by R.Theagarajan, Sci Tech Publication, Chennai
4. Programming Customizing the 8051 Microcontroller by MykePredko, Tata McGraw Hill

Course Code and Title: PHCP 235 Physics Laboratory III

Student has to perform **12 Experiments** **(Credit-4)**

COMPUTER LABORATORY

Expected Background: Course contents of PH-345, C' Programming and Computational Physics (To be covered by the teacher if required).

Objectives: To enable students to use numerical methods in solving problems in Physics and any other areas.

Notes: **1.** The theoretical background relevant to the experiments listed below should be discussed during practical sessions only.

2. Wherever possible, the output should be presented in graphical form also.

Section I: (Any six)

1. Legendre polynomials using the standard recurrence relation. Confirm that the method works well for Legendre functions by comparing with standard tables for special functions. (Use forward recursion.)
2. Bessel functions of the first kind using the standard recurrence relation. Use backward recursion with
   (x)=J_{50} J_{49} 0, (x) = 0.1 X 10^{-30} and the sum rule
   J_0 $\sum_{n=1}^{25} J_{2n}$ (x)+ 2 (x) = 1
3. To generate random numbers. Find out the value of 'π' using Monte-Carlo methods. Obtain your result correct up to five decimal positions.
4. Interpolation: Interpolate the value of a function at a point. Use Lagrange interpolation method.
5. Rotation of matrix: Rotate the elements of a n x n matrix in clockwise/ anticlockwise direction and display the matrices (n>=5).
6. Inverse of a matrix: Find the inverse of an xn matrix and display both matrices.
7. Trapezoidal/ Simpson rule: Evaluate a given function f(x) using Trapezoidal/ Simpson rule correct up to given accuracy by successively halving the step size.
8. Graphics: Write a program and display the Miller planes in the cubic lattice. Display the FCC, BCC and simple cubic lattice on the computer screen.

Section II: (Any six)

9. Differential Equation: Find out the motion of a charged particle in a uniform magnetic field. The equation of motion of partType equation here.icle with charge 'q' and mass 'm' in a uniform magnetic field B is given by
   $\frac{d\vec{r}}{dt} = \frac{q}{m}(\vec{v} \times \vec{B})$
   Where r denotes the position vector.
10. Gauss – Elimination method: Circuit analysis using Kirchhoff's Laws. Write the relations for currents through various branches of a Whetstone's bridge. Find the current using Gauss elimination method.
11. Different equation: Write the differential equation for charging /discharging of a capacitor C through a resistance 'R'. Solve this equation using Euler method and display your result in tabular as well as graphical form.
12. Write a program to graphically display eigen functions and probability density curves for particle in one dimensional rigid box.

13. Differential Equation: Write the one – dimentional time independent Schrodinger's equation. Solve it using Runge – Kutta method for three different harmonic Oscillator potential.
14. Fourier Analysis: perform the Fourier analysis (1) Full wave rectifier (2) Square wave
15. Use modified Euler method to solve the differential equation

$$m\frac{d^2z}{dt^2} = mg$$

For the displacement z of a freely falling body as a function of time t, from a given height z $=z_0$ at t=0. Compare with known analytical results. Add a term due to buoyancy of air on the motion of a spherical body (say a rain drop) of radius r (No damping due to viscosity and drag is considered).Thus,

$$m\frac{d^2z}{dt^2} = (m - \frac{4}{3}\pi r^3 \rho)g$$ ρ is

the density of air.

16. Consider the motion of a point mass under the influence of a harmonic restoring force F=kx. Solve m (d^2x/dt^2)=-kx for x as a function of time. The kinetic energy of the mass=$1/2 mv^2 = 1/2\ m$ $(dx/dt)^2$ and potential energy is $1/2$ kx^2.

Such that the total energy E=T+V=constant throughout the motion. Calculate x, T, V, E for various values of t starting with t=0 and time step h=dt, plot x, T, V, E as a function t and find the period of oscillation from the graph using numerical method. Compare with analytical result.

Reference Books:

1. The C Programming Language: B.W. Kernighan and D.M. Ritchie, Prentice Hall of India Pvt. Ltd., (1985).
2. Schuam's Series "Programming in C".
3. Introductory Methods of Numerical Analysis, S.S. Sastry, Prentice Hall of India Pvt. Ltd. (1990)
4. Computational Physics, R.C. Verma, P.K. Ahluwalia and K.C. Sharma, New Age International Publishers (1999)
5. Computational Physics, S.E. Koonin, Benjamin/Cumming Pub .Co .(1986)
6. Computer Method for Engineering, Y. JalurIa, Allyn and Bacon Inc. (1988)
7. An Introduction to Computational Physics, T. Pang, Cambridge University Press (1997)

Course Code and Title: PHCT 241: Nuclear Physics

Module 1: General Properties and Concepts of Nuclei **Credit-1**

Nuclear Mass & Binding Energy, Systematic of Nuclear Binding Energy, Measurement of Charge Radius- Electron Scattering Experiment, Concept of Mass Spectrograph, Nuclear spin, Magnetic Dipole Moments & Electric Quadrupole Moments of Nuclei , Basic theory of deuteron nucleus and problems, Radioactivity, Unit of Radioactivity, Alpha Decay: Velocity of Alpha Particles, Disintegration Energy, Range-Energy Relationship, Geiger-Nuttal Law, Beta Decay: Conditions for Spontaneous Emission of β^-& β^+ Particles, Selection Rules, Origin of Beta Spectrum-Neutrino Hypothesis, Gamma Decay: Decay Scheme of ^{137}Cs &^{60}Co Nuclei, Internal Conversion, Internal Pair Creation.

Module 2: Radiation Detectors and Nuclear Models **Credit-1**

Detectors: NaI (Tl) Scintillation Detector, Si (Li) and Ge (Li) Detectors, High Purity Germanium Detector, Bubble Chamber, Cloud Chamber, Spark Chamber, Nuclear Models: Shell Model- Square Well Potential, Harmonic Oscillator Potential, Spin-Orbit Coupling, Predictions of the Shell Model, Achievements & Failures of shell Model, Fermi Gas Model, Collective Model.

Module 3: Reaction Dynamics, Nuclear Reactors and Accelerators **Credit-1**

Reaction Dynamics: Types of Nuclear Reactions, Conservation Laws in Nuclear Reactions, Q of Nuclear Reaction, Compound Nucleus Hypothesis, Fission and Fusion Reactions, Reactors: Fission Chain Reaction, Four Factor Formula, Multiplication Factor, General Properties and Concepts of Nuclear Reactors, Reactor Materials, Types of Reactors, List of Different Types of Reactors Developed in India, Accelerators: Van de Graff, Microtron, Electron & Proton Synchrotron, Pelletron, Cyclotron, Special Accelerators in world: Light Hydron Collidor (LHC)

Module 4: Nuclear Interactions and Particle Physics **Credit-1**

Nuclear Interactions: Low Energy Neutron-Proton Scattering, Scattering Length, Spin Dependence of n-p Interaction, Proton-Proton and Neutron-Neutron Scattering at Low Energies, Particle Physics: Classification of Elementary Particles, Mass Spectra and Decays of Elementary Particles- Leptons & Hadrons, Quantum Numbers, Conservation Laws, Quarks, Higgs Boson concept

Reference Books:

1. K.S. Krane, Introductory Nuclear Physics, Wiley, India, 1988
2. B.L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill
3. I. Kaplan, Nuclear Physics, 2nd Edition, Narosa, New Delhi, 1989
4. S.N. Ghoshal, Atomic and Nuclear Physics, S. Chand
5. S.B. Patel Nuclear Physics: An Introduction, New Age International, 1991
6. D.C. Tayal, Nuclear Physics, Himalaya Publishing House
7. R.D. Evans, The Atomic Nucleus, Tata McGraw Hill
8. G.F. Knoll, Radiation Detection and Measurement, 3rd Edition, Wiley India
9. S.S. Kapoor and V.S. Ramamurthy, Nuclear Radiation Detectors, Wiley Eastern Limited
10. R.R. Roy, B.P. Nigam, Nuclear Physics-Theory and Experiment, Wiley Eastern Limited
11. Blatt and Weisskopf, Theoretical Nuclear Physics, New York, Wiley
12. S. Sharma, Atomic and Nuclear Physics, Pearson Education 2008

Course Code and Title: PHCT242: Material Science

Module 1: Properties of Materials and Defects in Solids **1 Credit**

a Mechanical, electrical, magnetic, thermal and optical properties (in brief – 2L only)

b Point defects - Vacancies, interstitials, non-stoichiometry, substitution, Schottky and Frenkel defects with proofs

c Line defects - Edge and screw dislocations, properties of dislocations – force on dislocation, energy of dislocation, pinned dislocation (These properties with derivation), dislocation density, interaction between dislocations, motion of a dislocation (cross-slip and climb), dislocation generator (Frank Read source)

d Surface defects – grain boundaries with explanation of high angle, low angle, tilt and twist boundaries, stacking fault

e Volume defect- twin boundary

Module 2: Solid Solutions and Diffusion in Solids **Credit-1**

a Solid solubility with few examples, Types of solid solutions – Substitutional and Interstitial, Factors governing solid solubility (Hume - Rothery rule), Atomic size and size factor in solid solutions, Vegard's law, Explanation of strain in solid solutions

b Mechanism of Diffusion, Fick's first and second laws of diffusion, solution to Fick's second law (without proof, introduction of error function), Factors governing diffusion, Experimental determination of D, Applications of diffusion: Corrosion resistance of duralumin, Carburization of steel, Decarburization of steel, Doping of semiconductors

Module 3: Metallurgical Thermodynamics **Credit-1**

Revision of laws of thermodynamics, Auxiliary thermodynamic functions, measurement of changes in enthalpy and entropy, Richard's rule, Trouton's rule, Phase equilibrium in a one-component system, Chemical reaction equilibrium, Thermodynamic properties of solutions (mixing processes – Rault's law, activity coefficient; regular solution behavior – Henry's law), Gibb's phase rule: proof, explanation and application to single component (H_2O) and binary phase diagram

Module 4: Phase diagrams **Credit-1**

Thermodynamic origin of phase diagrams, Lever rule, Type I (Cu-Ni) phase diagram, Type II (explanation only) phase diagram, Type III (Pb-Sn) phase diagram, Maxima and minima in two-phase regions, Miscibility gaps, Limited mutual solid solubility, Topology of binary phase diagrams (Explanation in short of eutectic, peritectic, Monotectic, eutectoid, peritectoid, syntactic reaction, extension rule), Experimental determination of phase diagrams

Reference books:

1. Elements of Materials Science and Engineering (5^{th} Edition) - Lawrence H. Van Vlack, Addison - Wesley Publishing Co.

2. Materials Science and Engineering - V. Raghvan

3. Physical Metallurgy (PartI) R.W.Cahn and P.Hassen, North Holland Physics Publishing, New York

4. Introduction to Materials Science for Engineers (6^{th} Edition) - J.F.Shaekelford and M.K.Murlidhara - Pearson Education

5. Materials Science – Kodgire and Kodgire

Course code and title: PHCT243 Experimental Techniques in Physics II

Module 1: Radiation Sources, Detectors and Sensors **Credit-1**

Sources of Electromagnetic Radiations: Different types of radiations (γ-rays, X- rays, UV-VIS, IR, microwaves and nuclear) and their sources Detectors: γ-rays, X-rays, UV-VIS, IR, microwaves and nuclear detectors Sensors: Sensor's characteristics, Classification of sensors, Operation principles of sensors such as electric, dielectric, acoustic, thermal, optical, mechanical, pressure, IR, UV, gas and humidity with examples

Module 2: Structural Characterization and Thermal Analysis **Credit-1**

X-ray Diffraction – Production of X-rays, Types (continuous and characteristics), Bragg's diffraction condition, principle, instrumentation (with filters) and working, Techniques used for XRD – Laue's method, Rotating crystal method, Powder (Debye- Scherrer) method, Derivation of Scherrer formula for size determination Neutron Diffraction: Principle, Instrumentation and Working Thermal analysis: Principle, Instrumentation and Working: Thermo-gravimetric (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC); Graphical analysis affecting various factors. Numericals

Module 3: Morphological and Magnetic Characterization **Credit-1**

Optical Microscopy: Principle, Instrumentation and Working of optical microscope Electron Microscopy: Principle, Instrumentation and Working of Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM) – Advantages over SEM, Transmission Electron Microscope (TEM), Selected Area Electron Diffraction (SAED) Probe Microscopy: Principle, Instrumentation and Working of Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM) Magnetic Characterization: Principle, Instrumentation and Working of Vibrating Sample Magnetometer (VSM), Analysis of Hysteresis loop**,** SQUID Technique:Principle, Instrumentation and Working. Numerical

Module 4: Spectroscopic Analysis **Credit-1**

Spectroscopic characterization (principle, instrumentation and working): Infra-Red (IR), Fourier Transform Infra-Red (FTIR), Ultraviolet-Visible (UV-VIS), Diffused Reflectance Spectroscopy (DRS), X-ray Absorption (XPS), Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR). Numerical

Reference Books:

1. Nuclear Radiation Detectors, S.S. Kapoor, V. S. Ramamurthy, (Wiley-Eastern Limited, Bombay)
2. Instrumentation: Devices and Systems, C.S. Rangan, G.R. Sarma and V.S.V. Mani, Tata Mc Graw Hill Publishing Co. Ltd.
3. Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya Publishing House
4. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt, J.A. Dean, CBS Publishers
5. Characterization of Materials, John B. Wachtman & Zwi. H. Kalman, Pub. Butterworth Heinemann (1992)
6. Elements of X-ray diffraction, Bernard Dennis Cullity, Stuart R. Stock, (Printice Hall, 2001 - Science - 664 pages)

Course Code and Title: PHOP244 (Elective-II)

PHOP244-I: Medical Physics II

Module 1: Nuclear Medicine **Credit-1**

Radioactivity, Sources of Radioactivity, Nuclear medicine imaging device rectilinear scanner, Positron emission tomography, Magnetic resonance imaging (MRI), Laser in medicine.

Module 2: Radiation physics **Credit-1**

Ionizing Radiation, Interaction of radiation with matter, Dosimetry, Radiation isotopes, Biological effects of radiation, Radiation protection in therapy

Module 3: X-ray in medicine **Credit-1**

Discovery and Production of X-ray, Basic components of X ray machine, Making of X-ray image, Fluoroscopy, Computer tomography (CT Scan), X-ray in diagnosis, X-ray in therapy, Hazards of X-ray

Module 4: Biomaterials and new trends in Medical Physics **Credit-1**

Biomaterials – Introduction, Bio-ceramics, Bio-polymer, Bio-steel, Bio-chip, Blood as a Biomaterial, Introduction to Bio- Nanomaterial, Telemedicine, New trends in Medical Informatics Embedded system in Hospital

Reference Books:

1. Medical Physics by John R. Cameron, J. G. Skofronick, John Wiley and Sons, Int. Publication

2. Essential of Biophysics by Narayanan, New Age Publication

3. Radiation Biophysics by Edward Alphan, Prentice Hall

4. T.B. of Biophysics by R.N. Roy, Central Publication

5. Biophysics by Mohan Arora, Himalaya Publication House, Mumbai (2004).

6. Ophthalmology by A.K. Khurana, New Age Publication

7. Introduction to Biomedical Engineering by Enderle, Elsevier Publication

8. Websites of the related topics

PHOP244-J: Acoustics II

Module1: Acoustic transducers **Credit-1**

Loudspeakers: Direct-radiator loudspeaker: equivalent circuit and efficiency; effect of voice-coil parameters on acoustic output; loudspeaker cabinet; Horn loudspeaker: wave equation for horns, pressure response of loudspeakers; woofers, squawkers, tweeters; Crossover networks

Module2: Acoustic transducers **Credit-1**

Microphones: Carbon, Condenser, Moving-coil electrodynamics and Velocity-ribbon microphones; polar response characteristics; Electroacoustic Reciprocity Theorem; reciprocity calibration of microphones

Module3: Sound recording and reproducing systems **Credit-1**

Monophonic and Stereophonic sound systems; Compact disc audio; Audio file formats; Dynamic range, Volume compressors, expanders and limiters; Graphic equalizer; Dolby noise reduction

Module4: Technical acoustics and music **Credit-1**

Active noise control; Ultrasonic transducers: principle and applications; Anechoic chamber; Bioacoustics: animal sounds – synthesis and analysis; Music: pitch and timbre; Characteristics of musical notes: Vibrato, Tremolo, Portamento; Musical Instruments Digital Interface (MIDI)

Reference Books:

1. Fundamentals of Acoustics, II or III Edn., L.E. Kinsler and A. R. Frey, Wiley Eastern, 1982
2. Acoustics, W.W. Seto, Schaum's Outline, 1978
3. Basic Acoustics, D.E. Hall, Oxford University Press
4. Technical Aspects of Sound, Richardson, Prentice Hall, 1962
5. Noise Reduction, L.L. Baranek, M.LT. Press, 1970
6. Handbook of Sound Engineers (The New Audio Cyclopedia), G.M. Ballou, Academic Press, 1998
7. Design for good Acoustics and Noise Control, J.E. Moore, University Press, 1998
8. Acoustics Sourcebook, S. Parker, McGraw Hill, 1996
9. Introduction to Acoustics, Robert D. Finch, Pearson, 2005

PHOP244-K: Energy Studies II

Module 1: Solar Photovoltaics (SPV) **Credit-1**

Solar photovoltaic (SPV) Conversion: Basic principles, Types of solar cell materials, Fabrication of solar photovoltaic cells, solar cell parameters and characteristics, Modules.
Block diagram of general SPV conversion system and their characteristics, Different configurations, Application (such as street light, water pumps, Radio/TV, Small capacity power generation) Solar photovoltaic (SPV) Systems Designing: Load estimation, selection of inverters, battery sizing, and array sizing. Ref. no. 2, 15.

Module 2: Photo-thermal Applications of Solar Energy **Credit-1**

Selective coatings: Ideal characteristics of selective coating for various applications, Types of selective coatings, materials and techniques for selective coatings, Effect of selective coating on the efficiency of solar collectors. Solar Thermal Devices and Systems: Different types of collectors, Flat plate collector (Basic principle, construction, Energy balance equation of steady state, Testing, Methods to reduce losses), Solar cookers, Domestic hot water system, Solar dryers, solar pond, Solar still, Solar furnace, Solar refrigeration, Solar concentrators, systems based on use of solar concentrators. Ref. no. 2, 6.

Module 3: Hydrogen Energy **Credit-1**

Hydrogen Fuel: Importance of Hydrogen as a future fuel, Sources of Hydrogen, Fuel of vehicles.
Hydrogen production: Production of Hydrogen by various methods, Direct electrolysis of water, Direct thermal decomposition of water, Biological and biochemical methods of hydrogen production.
Hydrogen storage: Gaseous, Cryogenic and Metal hydride. Utilization of hydrogen: Fuel cell – Principle, construction and applications. Ref. no. 2, 11, 12.

Module 4: Wind and Bio Energy **Credit-1**

Wind Energy: Introduction, Basic principle of wind energy conversion, Extraction of maximum power from wind and its dependence on various parameters. Wind Mills: Types of wind mills, Vertical axis and Horizontal axis wind mills their performance, Merits and Demerits, Limitations of wind energy conversions.
Bio Energy: Biomass, Generation and utilization, Property of biomass, Agriculture crop and Forestry residues used as fields. Physical, Chemical and biological conversion of biomass into useful form of energy. Gasification, Biomass gasifiers and types.
Biogas: Introduction, Generation of biogas, Aerobic and anaerobic bioconversion process. Substances used to produce biogas (Cow dung, Human and other agricultural waste, municipal waste etc.), Digesters and their designs, Pyrolysis and gasification, Fermentation process.
Biofuels: Types of biofuels, Production processes, Biofuel applications, Ethanol as a biofuel.
Ref. no. 2, 9, 14**.**

Reference Books:

1. Climatological and Solar Data for India, Seshadri (Sarita Prakashan) 1969
2. Solar Energy Utilization, G.D. Rai, (Khanna Publishers) 1995
3. Energy Technology, S. Rao and B.B. Parulekar (Khanna Publishers) 1995

4. Terrestrial Solar Photovoltaics, Tapan Bhattacharya, (Namsa: Publication House, New Delhi)
5. Solar Cells-operating Principles, Technology and System Applications, Martin A. Green (Prentice Inc. USA).
6. Solar Thermal Engineering, J.A. Duffie (Academic Press)
7. Renewable Energy Sources and Conversion Technology, N.K. Bansal, M. Kleeman and S.N. Sreinivas (Tata Energy Research Institute, New Delhi) 1996
8. Fundamentals of Solar Cells, F.A. Faherenbruch and R.H. Bube (Academic Press)
9. Biomass Energy Systems, Venkata Ramala and S.N. Srinivas (Tata Energy Research Institute, New Delhi, New Delhi) 1996
10. Thin Film Solar Cells, K.L. Chopra and S.R. Das (Plenum Press) 1983
11. Solar Hydrogen Energy Systems, T. Ohta (Pergamon Press) 1979
12. Hydrogen Technology for Energy D.A. Maths (Noyes Data Corp.)1976
13. Handbook Batteries and Fuel Cell, Linden (McGraw Hill)1984
14. Wind energy Conversion Systems, L.L. Freris (Prentice Hall)1990
15. Solar Photovoltaics, C.S. Solanki

PHOP244-L: Physics of Nanomaterials

Module 1: Introductory Concept for Nanomaterials **Credit-1**

1.1 Introduction to nano-sized materials and structures
1.2 Effect of Reduction of Dimension, Quantum size effect
1.3 Surface Effect and Interface Effect
1.4 Nucleation and Growth Phenomenon
1.5 Growth Kinematics

Module 2: Synthesis Methods of the Nanomaterials **Credit-1**

2.1 High energy ball milling
2.2 Physical Vapour Deposition
2.3 Chemical Bath Deposition
2.4 Sol gel Method
2.5 Hydrothermal method
2.6 Chemical bath deposition
2.7 Metal Reduction Method
2.8 Biological Method

Module 3: Properties of Nanomaterials **Credit-1**

3.1 Mechanical Properties
3.2 Thermal Properties
3.3 Electrical Properties
3.4 Optical Properties
3.5 Magnetic Properties

Module 4: Special Nanomaterials and Applications **Credit-1**

4.1 Fullerene
4.2 Graphene
4.3 Carbon nanotubes and their types
4.4 Aerogel
4.5 Nano-composites
4.6 Biomedical Application
4.7 Optoelectronic Application
4.8 Mechanical Applications

Reference Books:

1. Nanotechnology: Principal and Practices; by Sulbha Kulkarni; Capital Publication
2. Nanostructures and Nanomaterials: Synthesis, Properties and Application; by Guozhong Cao; Imperical College Press, London
3. Nanomaterials: Synthesis, Properties and Application; by A. S. Edstein and R.C. Commorta; Institute of Physics publishing Bristol and Philadelphia
4. Introduction to Nanotechnology: by C. P. Poole, Jr. Frank J. Owens: Willey student Edition

PHOP244-M: Astronomy and Astrophysics II

Module 1: The Milky Way **Credit-1**

Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way, Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms, Stars and Star Clusters of the Milky Way, Properties of and Around the Galactic Nucleus

Module 2: Galaxies **Credit-1**

Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies, The Intrinsic Shapes of Ellipticals, de Vaucouleurs Law, Stars and Gas, Spiral and Lenticular Galaxies, Bulges, Disks, Galactic Halo, The Milky Way Galaxy Gas and Dust in the Galaxy, Spiral Arms, Active Galaxies 'Activities' of Active Galaxies, How 'Active' are the Active Galaxies?, Classification of the Active Galaxies, Some Emission Mechanisms Related to the Study of Active Galaxies, Behaviour of Active Galaxies, Quasars and Radio Galaxies Seyferts, BL Lac Objects and Optically Violent Variables, The Nature of the Central Engine, Unified Model of the Various Active Galaxies

Module 3: Astronomical Techniques **Credit-1**

A. Electro-magnetic spectrum. Radio Window, Radio telescopes, Interferometry, Basic parameters of an antenna, Various types of antennas. Infrared, Ultraviolet and X-ray telescopes, Solar telescopes

B. Detectors for optical and infrared regions. Application of CCD's to stellar imaging, photometry and spectroscopy, Observing technique with a photometer, Correction for atmospheric extinction. Transformation to a standard photometric system. Astronomical spectroscopy. Spectral classification. Simple design of astronomical spectrograph. Radial velocity measurements.

C. Radio Astronomical Techniques: Design and construction of a simple radio telescope, Receiver systems and their calibration. Design and construction of a simple radio interferometer, MST Radar for Ionospheric studies, LB and VLBI Systems. Aperture Synthesis.

Module 4: Large Scale Structures and the Expanding Universe: **Credit-1**

Cosmic Distance Ladder. An Example from Terrestrial Physics Distance Measurement using Cepheid Variables Hubble's Law, Distance-Velocity Relation, Clusters of Galaxies, The Virial Theorem and Dark Matter, Friedman Equation and its Solutions, Cosmology, Cosmological models, Early Universe and Nucleo synthesis, Cosmic Background Radiation, Evolving vs. Steady State Universe

Reference Books:

1. K.D. Abhyankar: Astrophysics: Stars and Galaxies
2. R. Bowers and T. Deeming: Astrophysics (John and Barlett. Boston)
3. L.H. Aller: Astrophysics
4. Hynek: Astrophysics
5. E. Ambartzumian: Theoretical Astrophysics
6. Introduction to Cosmology, J. V. Narlikar, (Cambridge University Press)
7. Quasars and Active Galactic Nuclei, A. K. Kembhavi and J. V. Narlikar, (Cambridge University Press)
8. K.D. Abhyankar: Astrophysics - Stars and Galaxies. Tata McGraw Hill Publication

9. M. Sandage and J. Kristian: (Ed.) Galaxies and the Universe. University of Chicago Press
10. C.R. Kitchin: Astrophysical Techniques.
11. Gordon Walker: Astronomical Observations - an Optical Perspective (Cambridge University Press)
12. Henden and Kaitchuck: Astronomical Photometry
13. W.A. Hiltner (Ed): Astronomical Techniques
14. Kraus-‘‘Antennas”, McGraw Hill, 1950

PHOP244-N: Electronic Instrumentation II

Module 1:

1.1 Introduction to Process Control: **Credit-1**

Introduction, Control systems, Process control block diagram, Control system Evaluation
Control system Objective Stability, Regulation, Transient Regulation, Evaluation Criteria, Damped response, Cyclic response, Sensor time response, Process Control Drawing and symbols with their meaning. References: 1, 2

1.2 Discrete Process Control:

Introduction, definitions of discrete state process control characteristics of the systems, relay, controllers and ladder diagrams, PLC's, Interfacing with LAN, SCADA systems. References: 1

Module 2: Controller Principles **Credit-1**

Introduction, Process Characteristics Process Load, Transient, Process Lag, Control System Parameters, Error, Variable Range, Control Parameter Range, Control Lag, Dead Time, Cycling, Controller Modes, Reverse And Direct Action, Discontinuous Controller Modes Two Position Neutral Zone (Examples) Applications, multi position controller floating control mode(eliminate single speed and multiple speed) Continuous controller modes Proportional Control Mode Integral, Control Mode, Derivative Control Mode, Composite Control , PI Control, PD Control Mode, Three Mode Controller (PID). References: 1

Module 3: Controllers **Credit-1**

3.1Analog Controllers:

Electronic controller with design considerations: Proportional (P), Integral (I), Derivatives (D) PI, PD and PID

3.2 Digital Control: Introduction two position controls and multivariable alarms. References: 1

Module 4: **Credit-1**

4.1: Introduction to Modelling and Simulation:

Mathematical model, equivalent circuit model, Empirical Model, methodology, concept and need of simulation and its applications. References: 2

4.2: Introduction to MATLAB/ Sci. Lab programming:

All chapters are taken from "MATLAB: An Introduction and Applications", by Amos Gilat, Wiley Students Edition. References: 3

References Books:

1. Process Control Instrumentation Technology, Curtis D. Johnson, 7th Edition, Prentice Hall India Pvt. Ltd.
2. Computer based Industrial Controls K. Kant PHI publications.
3. MATLAB: An Introduction and Applications by Amos Gilat, Wiley Students Edition

PHOP244-O: Microwave Physics and Applications

Prerequisite: Electron Motion in electric field, Magnetic field and electromagnetic field, Electric and Magnetic wave equation.

Module 1: Passive Elements **Credit-1**

Introduction to microwave its application: transmission line theory, their equations and Solutions, reflection coefficient, standing wave ratio (SWR), admittance resonant lines.

Module 2: Impedance matching, Wave guides and wave guide components **Credit-1**

Impedance matching, single stub and double stub, rectangular wave guides, circular wave guides, TE & TM modes of propagation Q – of cavity resonator, use of Smith chart. Attenuators, filters, junctions, Tee's – magic Tee, (hybrid T), directional couplers, hybrid rings (Rat – Race), wave guide corners, bends.

Module 3: Active Elements **Credit-1**

Microwave generation problems and principles, Reflex Klystron, two cavity Klystron, operation as amplifiers and oscillators, bunching process, Applegate diagram, Magnetron traveling wave tube amplifier, BWA Semiconductor devices, Microwave transistor: Cut-off frequency, power gain, maximum available gain, frequency limitation. Johnson four equations, Gun diode, Tunnel diode, MOSFET, PIN diode, read diode, parametric amplifiers.

Module 4: Microwave other devices and measurements **Credit-1**

Ferrite isolators, Bolometers, TR and ATR switches, Microwave measurements: Impedance, power, frequency attenuation, dielectric constant Q measurements.

Reference Books:

1. Introduction to Microwave Theory and Measurements: Lance PUB Mcgraw Hill
2. Foundations of Microwave Engineering: Collins PUB Mcgraw Hill
3. Microwave Semiconductor Devices and Their Circuit Applications: Watson PUB Mcgraw Hill
4. Microwave Devices And Circuits: Liao, PHL
5. Physics of Semiconductor Devices: S.M. Sze, Willey Eastern Ltd.
6. Microwave Electronics: V.Kulkarni, 1 Up Publication
7. Microwave Application: Sisodia, Raghuvanshi
8. Microwave Principles: Rich, Addion Wesley

PHOP244-P: Biomedical Instrumentation II

Module 1: The Computer in Biomedical Instrumentation **Credit-1**

1.1 The digital computer-computer hardware-Computer Software.
1.2 Microprocessors –Types of Microprocessors
1.3 Microprocessors in Biomedical instrumentation
1.4 Microcontrollers in Biomedical instrumentation
1.5 Examples of Microcontroller Based system (data acquisition)
1.6 Interfacing the computer with medical instrumentation and other equipment.
1.7 Biomedical computer applications.

Module 2: Biomedical Recorders **Credit-1**

2.1 Introduction to nervous system,
2.2 Neuromuscular transmission, muscle potentials, receptors, Neurotransmitters
2.3 Electroencephalograph (EEG), Block diagram, Computerized Analysis of EEG
2.2 Electromyography (EMG)
2.3 Pulse Oximetry

Module 3: Ultrasonic Imaging Systems **Credit-1**

3.1 Diagnostic ultrasound
3.2 Physics of ultrasonic waves
3.3 Characteristics impedance, wavelength and frequency, velocity of Propagation
3.4 Absorption of ultrasonic energy beam width, resolution
3.5 Generation and detection of ultrasound
3.6 Basic pulse echo apparatus
3.7 Diagnostic scanning mode A-mode, B-mode

Module 4: Respiratory system, measurements and basic of radiology **Credit-1**

4.1 The Physiology of the respiratory system
4.2 Tests and instrumentation of the mechanics of breathing
4.3 Respiratory Therapy Equipment
4.4 Heart lung machine
4.5 Basic definition in radiology
4.6 Generations and detection of ionizing radiation
4.7 Instrumentation for diagnostic x-rays.
4.8 Instrumentation for the medical use of radio isotopes

Reference Books:

1. Biomedical Instrumentation and Measurements (Second Edition) By Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer Pearson Education
2. Handbook of Biomedical Instrumentation (Second Edition) by R.S. Khandpur (Tata McGraw Hill)
3. Biomedical Instrumentation and Measurement by Carr and Brown-Pearson

PHOP244-Q: Atmospheric Physics II

Module 1: Upper Atmosphere **Credit-1**

Thermal structure of Troposphere, Stratosphere and Mesosphere, Ionosphere, D,E, F regions, Radio wave propagation through Ionospheric circulation and warming, Pressure and density measurements from moving Rockets, Meteors in the mesospheres

Module 2: Atmospheric Ozone **Credit-1**

Temporal and spatial variation of ozone Umkehr effect, stratospheric ozone, ozone flux from stratosphere to the troposphere, tropopsheric ozone, Chapman mechanism, ozone depletion on ozone Hole

Module 3: Solar and Terrestrial Radiations **Credit-1**

Nature of radiations, scattering (Rayleigh and Mie), Black body radiations, Radiative transfer, Nature of solar radiations, Terrestrial radiation, optical depth, radiative equilibrium in stratosphere, short wave radiation, long wave radiation

Module 4: Atmospheric Electricity **Credit-1**

Elementary principle of electricity, electric field, electrostatic potential, charge separation in clouds, origin and distribution of ions, rate of ion pair production by cosmic rays as a function of height, conductivity, The lightning discharge

Reference Books:

1. Introduction to Theoretical Meteorology-S. Hess
2. An Introduction to Atmospheric Chemistry – By Prof. Peter V. Hobbs
3. Tropical Meteorology Vol- I And II-G.C. Asnani
4. Weather Forecasting – A.A. Ramshastry
5. Cloud Physics-Rogers
6. Cloud Physics-Wallace And Bob
7. Atmosphere, Weather and Climate –K. Siddharth (Kisalaya Publication Pvt.Ltd)
8. An Introduction to Atmospheric Physics: By Robert G. Fleagle and J.A. Businger, Academic Press.
9. Atmospheric Chemistry and Physics By John Seinfeld And S.N. Pandis, Wiley Interscience
10. The Upper Atmosphere, Meteorology and Physics By Richard Craig, Academic Press

PHOP244-R: Nuclear Techniques II

Module 1: Basic parameters of radioactive disintegration process **Credit-1**

Law of radioactive disintegration, units of activity, basic concepts of half-life, mean life time of nuclei. Measurement of lifetime of nuclear excited states using techniques such as conversion line shift recoil distance, delayed coincidence, activity measurement and other methods. Measurement of Beta-Beta and Beta-gamma coincidence

Module2: Generation and detection of neutrons **Credit-1**

Neutron sources, neutron detectors, measurement of cross-sections for nuclear reaction, thermal and fast reactors, production of radioisotopes. Reactor operation, thermal neutrons, neutron scattering and applications.

Module3: Nuclear reaction analysis **Credit-1**

Elemental analysis by neutron activation technique, proton induced X-ray emission technique, Rutherford backscattering, Resonance nuclear reaction, ERDA, channelling, ion scattering and other such methods.

Module 4: Radioisotopes and its Applications **Credit-1**

Radioisotopes, Radioactive waste disposal applications of radioisotopes (industrial, agricultural) dating of archaeological and other ancient object, Medical uses of radioisotopes and electron beams, radiotherapy, Carbon-14 and potassium-argon dating

Reference Books*:*

1. Nuclear Radiation Detectors, S.S. Kapoor and V. S. Ramamurthy (Wiley Eastern Limited, New Delhi) 1986
2. Introduction to Radiation Protection Dosimetry, J. Sabol and P.S. Weng (World Scientific) 1995.
3. Techniques for Nuclear and Particle Physics, W.R. Leo (Springer) 1995
4. Nuclear Measurement Techniques, K. Sriram, (Affiliated East-West Press, New Delhi) 1986
5. Fundamentals of Surface and Thin Analysis, Leonard C. Feldman and James W. Mayer, (North Holland, New York), 1988.
6. Introduction to Nuclear Science And Technology, K. Sriram and Y.R. Waghamare, (A. M. Wheeler) 1991
7. Nuclear Radiation Detection, W. J. Price, (Mcgraw-Hill, New York) 1964
8. Alpha, Beta A Gamma-Ray Spectroscopy, K. Siegbahn (North Holland, Amsterdm) 1965
9. Introduction to Experimental Nuclear Physics, R.M. Singru (John Wiley and Sons) 1974
10. Radioactive Isotopes in Biological Research, William R. Hendee, (John Wiley and Sons) 1973
11. Atomic and Nuclear Physics, Satendra Sharma, Pearson Education, 2008

PHOP244-S: Microcontrollers Based Instrumentation System-II

Module 1: **Credit-1**

Introduction to Embedded Systems, types of arduino modules (list only), Arduino Uno Microcontroller**,** Introduction to architecture of AT 328, block diagram, types, programing arduino UNO, Detailed Pin Mapping, Boot loaders and Boot loading process for Microcontroller, brief introduction to serial communication, UART, USART

Module 2: Basic Electronic Concepts of Embedded Designing, Signal Conditioning Circuits: Credit-1

Input signal conditioning: Designing a bridge amplifier module using an instrumentation amplifier (three Op Amps configuration) for PT-100 temperature sensor (RTD) and strain gauge bridge, (student is expected to select/choose design for bridge excitation voltage and output in the range of 0 – 5 volts for a given range of measurand (quantity to be measured) i. e. temperature and force/ pressure), current to voltage converter (0 – 5 volts output for 4 – 20 mA input) for a 4 – 20mA current loop, interfacing an ADC module H X- 711

Output signal conditioning: designing a driver module for dc motor (5 volts) for rotating in clock and counter clockwise direction, driver module for dc motor speed control or led intensity control using pwm (using transistor darlington configuration or mosfet), relay driver module, seven segment display (two digit) driver module , interfacing a DAC module mcp 4725 interfacing RTC module.

Module 3: **Credit-1**

Interfacing modules to Arduino uno: interfacing a single key (push to ON/OFF), light dependent resistor (intensity, on/off output control) , LED & LCD module, IR photo diode, temperature(on/off temperature control), moisture and humidity, multiple analog input (humidity, temperature, moisture) , Ultrasonic (level/ distance, on/off control), (all above interfaces are analog input and digital output (single input -single output & on/off type output control) speed sensor (photo, fork type), hall effect sensor, (digital input digital output) , stepper motor, servomotor, dc motor, power MOSFET module, Relay Module (or other compatible module(s)) and multiple output (on/off type)

(Student is expected to write a program(s) using arduino IDE for all above interfaces)

Module 4: **Credit-1**

DC motor speed control using potentiometer(pot) and DC motor using voltage control or power control (PWM technique), Designing a car reverse alarm system with ultrasonic sensor and speaker output. (sound level and frequency of output audio signal will go on increasing as the car approaches near to the obstacle, analog input and analog output). Designing a poly house environmental controller system for monitoring and controlling humidity, moisture and temperature. (analog input and digital output (on/off control)), coffee vending machine: customer can choose one of three options 1] black coffee, 2] black coffee with sugar and 3] coffee with sugar and cream. Three push button will initiate the process of choosing one of three above options. Hot coffee will be served if there is empty coffee cup at the outlet tap. Once chosen the option customer cannot change the option and also to ensure that coffee will not be served twice in the same amount.

Reference Books:

1. Beginning Arduino Programming by Brian Evans
2. Beginning Arduino by Michael McRoberts
3. Arduino Project Handbook: 25 Practical Projects to Get You Started by Mark Geddes
4. Arduino Projects for Dummies by Brock Craft