Faculty of Science and Technology

M. Sc. (Physics)

Choice Based Credit System (CBCS)

To be implemented from Academic Year 2020-2021

Structure and 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)

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 **(CCTP)**	PHCT-111	Mathematical Methods in Physics		**4**
				PHCT-112	Classical Mechanics		**4**
				PHCT-113	Electronics		**4**
			Choice Based Optional Paper (**CBOP-I**)	PHOT-114	Choose any one from **Group I**	Theory	**4**
				PHOP-114		Practical	**0**
			OR				
			CBOP-I	PHOT-114	Choose any one from **Group I**	Theory	**2**
						Practical	**2**
			Core Compulsory Practical Paper **(CCPP)**	PHCP-115	Physics Lab-I		**4**
		II	**CCTP**	PHCT-121	Electrodynamics		**4**
				PHCT-122	Atoms and Molecules		**4**
				PHCT-123	Quantum Mechanics		**4**
			CBOP-II	PHOT-114	Choose any one from **Group I**	Theory	**4**
				PHOP-114		Practical	**0**
			OR				
			CBOP-II	PHOT-114	Choose any one from **Group I**	Theory	**2**
						Practical	**2**
			CCPP	PHCP-125	Physics Lab-II		**4**

	Year	Semester	Course Type	Course Code	Course Name		Credit
	2	III	CCTP	PHCT-231	Statistical Mechanics		4
				PHCT-232	Solid State Physics		4
				PHCT-233	Experimental Techniques in Physics - I		4
			CBOP-III	PHOT-234	Special–I from **Group II**	Theory	4
				PHOP-234		Practical	0
			OR				
			CBOP-III	PHOT-234 PHOP-234	Special–I from **Group II**	Theory	2
						Practical	2
			CCPP	PHCP-235	Physics Laboratory - III		4
		IV	CCTP	PHCT-241	Nuclear Physics		4
				PHCT-242	Experimental Techniques in Physics-II		4
			CBOP-IV	PHOT-243	Choose any one from **Group I**	Theory	4
				PHOP-243		Practical	0
			OR				
			CBOP-IV	PHOT-243	Choose any one from **Group I**	Theory	2
				PHOP-243		Practical	2
			CBOP-V	PHOT-244	Special–II from **Group II**	Theory	4
				PHOP-244		Practical	0
			OR				
			CBOP-V	PHOT-244	Special–II from **Group II**	Theory	2
				PHOP-244		Practical	2
			CCPC	PHCP-245	Project		4
Total credits of M. Sc. Physics course							**80**

Details of nomenclature and names of the Choice Based Optional Papers (CBOP) and associated laboratories:

The Choice Based Optional Papers are classified in two types, namely **"Electives"** and **"Special"** papers. The number of **CBOPs** to be offered as **Elective papers** and **Special papers** are further categorised into two groups, namely **Group I,** and **Group II**, respectively.

Group I (Elective papers):

Title	Paper name	Sub code	Paper code	Credit	
				Theory	Practical
CBOP I, CBOP II, CBOP IV	Physics of Thin Films	**A**	***PHOT-XXXA4**	4	0
			PHOT-XXXA2	2	0
			PHOP-XXXA2	0	2
	Physics of Nanomaterials	**B**	PHOT-XXXB4	4	0
			PHOT-XXXB2	2	0
			PHOP-XXXB2	0	2
	Lasers and Applications	**C**	PHOT-XXXC4	4	0
			PHOT-XXXC2	2	0
			PHOP-XXXC2	0	2
	Physics of Semiconductor Devices	**D**	PHOT-XXXD4	4	0
			PHOT-XXXD2	2	0
			PHOP-XXXD2	0	2
	Communication Electronics	**E**	PHOT-XXXE4	4	0
			PHOT-XXXE2	2	0
			PHOP-XXXE2	0	2
	Microwave Physics and Applications	**F**	PHOT-XXXF4	4	0
			PHOT-XXXF2	2	0
			PHOP-XXXF2	0	2

1. A student will select any three Electives from the aforesaid list (sub-codes ranging from A to F) as CBOPI, CBOPII, and CBOPIV, irrespective of the sequence.

OR

2. The Post Graduate Center will offer any three Electives from the aforesaid list (sub-codes ranaging from A to F) as CBOPI, CBOPII, and CBOPIV, irrespective of the sequence, and as per availability of the faculty and infrastructure.

3. The student has choice to select all Electives, i.e. CBOPI, CBOPII, and CBOPIV each either of 4 credit theory paper or of 2 credit theory and 2 credit practical.

   OR

   The Post Graduate Center will offer all Electives, i.e. CBOPI, CBOPII, and CBOPIV each either of 4 credit theory paper or of 2 credit theory and 2 credit practical, as per availability of faculty and infrastructure.

4. For smooth conduct of the M. Sc. course, student will not be allowed to select Electives in combination, i.e. in first semester, if a student selects CBOP as 4 credit theory paper, then in the rest of semesters, he/she must select remaining Electives as 4 credit theory papers.

5. ***PHOT-XXXA4:** Here **"XXX"** refers to CBOP I or CBOP II or CBOP IV. For example, if "Thin Film Physics" is selected as **CBOP I**, then its code will be **PHOT114A**. Furthermore, if "Thin Film Physics" is offered as 4 credit theory paper, its code will be **PHOP114A4,** whereas f it is offered as 2 credit theory and 2 credit practical, then the codes will be **PHOT114A2** and **PHOP114A2**, respectively.

One more illustration: Let "Physics of Semiconductor Devices" is selected as **CBOP IV.** If is offered as 4 credit theory paper, its code will be **PHOT243C4,** whereas if it is offered as 2 credit theory and 2 credit practical, then the codes will be **PHOT243C4,** and **PHOT243C4**, respectively.

Group II (Special papers)

Title	Paper name	Sub code	Paper code	Credit	
				Theory	Practical
Semester III, (CBOP III)	Acoustics – I	**G**	PHOT-234G4	4	0
			PHOT-234G2	2	0
			PHOP-234G2	0	2
	Energy Studies – I	**H**	PHOT-234H4	4	0
			PHOT-234H2	2	0
			PHOP-234H2	0	2
	Electronics Instrumentation – I	**I**	PHOT-234I4	4	0
			PHOT-234I2	2	0
			PHOP-234I2	0	2
	Biomedical Instrumentation – I	**J**	PHOT-234J4	4	0
			PHOT-234J2	2	0
			PHOP-234J2	0	2
	Nuclear Techniques – I	**K**	PHOT-234K4	4	0
			PHOT-234K2	2	0
			PHOP-234K2	0	2
	Microcontroller Based Instrumentation System – I	**L**	PHOT-234L4	4	0
			PHOT-234L2	2	0
			PHOP-234L2	0	2
	Material Science - I	**M**	PHOT-234M4	4	0
			PHOT-234M2	2	0
			PHOP-234M2	0	2
	Medical Physics - I	**N**	PHOT-234N4	4	0
			PHOT-234N2	2	0
			PHOP-234N2	0	2
Semester IV, (CBOP V)	Acoustics – II	**G**	PHOT-244G4	4	0
			PHOT-244G2	2	0
			PHOP-244G2	0	2
	Energy Studies– II	**H**	PHOT-244H4	4	0
			PHOT-244H2	2	0
			PHOP-244H2	0	2
	Electronics Instrumentation – II	**I**	PHOT-244I4	4	0
			PHOT-244I2	2	0
			PHOP-244I2	0	2
	Biomedical Instrumentation – II	**J**	PHOT-244J4	4	0
			PHOT-244J2	2	0
			PHOP-244J2	0	2

	Nuclear Techniques – II	**K**	PHOT-244K4	4	0
			PHOT-244K2	2	0
			PHOP-244K2	0	2
	Microcontroller Based Instrumentation System – II	**L**	PHOT-244L4	4	0
			PHOT-244L2	2	0
			PHOP-244L2	0	2
	Material Science - II	**M**	PHOT-244M4	4	0
			PHOT-244M2	2	0
			PHOP-244M2	0	2
	Medical Physics - II	**N**	PHOT-244N4	4	0
			PHOT-244N2	2	0
			PHOP-244N2	0	2

1. In Semester 3, a student will select any p**aper** from the aforesaid list (sub-codes ranging from G to N) as **Special Paper-I (CBOP III)**, irrespective of the sequence. In the followed semester, he/she has to take **the allied paper** as **Special Paper i.e. CBOP V**. (If a student selects Materials Science-I as Special Paper in Semester 3, then he/she must take Materials Science-II as Special Paper in semester 4).
2. The Post Graduate Center will offer any paper from the aforesaid list (sub-codes ranging from G to N) as a **Special Paper** as per availability of the faculty and infrastructure.
3. The student has choice to select the Special Papers, i.e. CBOP III, and CBOP V each either of 4 credit theory paper or of 2 credit theory and 2 credit practical.
4. The Post Graduate Center will offer the Special Papers, i.e. CBOP III, and CBOP V each either of 4 credit theory paper or of 2 credit theory and 2 credit practical, as per availability of faculty and infrastructure.
5. For smooth conduct of the M. Sc. course, student will not be allowed to select the Special Papers in combination, i.e. in third semester, if a student selects CBOP III as 4 credit theory paper, then in the fourth semester, he/she must select the allied Special Paper, CBOP V as 4 credit theory paper.
6. **Note: In order to offer more flexibility in selecting CBOP-I, II, IV (Group-I) and also considering expertise available at the institute/colleges, an elective paper may be given from the pool of CBOP-III (Group-II). However, if any paper from CBOP-III pool is given as an Elective for Group-I, then such paper cannot be taken as a Special Paper (i.e. CBOP III and/or CBOP V) so as to avoid repetition.**

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 - McGraw 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 McGraw Hill Edition
7. Mathematical Method for Physicists, Arfken and 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 and 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 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 applications 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 ofBoolean 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)

(4 Credits)

Student has to perform Any **12 Experiments**

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 and 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 variable capacitor (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, Horowitz and 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 (6th 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 and Systems: Franklin, C. Fitchen (Van No strand Reinhold Company)
9. Digital Principles and Applications: Leach and Malvino, Tata Mc-Graw Hill Pub. Co. Ltd. N. Delhi (5^{th} Edition, 2002)

Course Code and Title: PHCT-121 Electrodynamics

Module 1: Multipole Expansions and Time Varying Fields 1 credit

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 1 credit

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 1 credit

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, 2, 4, 5, 8, 10)

Module 4: Relativistic Mechanics and Covariance 1 credit

Experimental basis for special theory of relativity (Michelson – Morley experiment), Lorentz transformations, Relativistic velocity addition, Minkowski's space time 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 and P.V. Panat, Narosa Publishing House
3. Classical Electricity and Magnetism, by Panofsky and Phillips, Addison Wesley
4. Foundations of Electromagnetic Theory by Reitz and 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 Atoms and Molecules

Module 1: Atoms **1 credit**

(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 **1 credit**

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 **1 credit**

(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 **1 credit**

(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: PHCT-123 Quantum Mechanics

Module 1: Revision and General Formalism 1 Credit

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 1 Credit

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 1 Credit

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 1 Credit

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: PHCP-125 Physics Laboratory-II (General Lab)

(4 Credits)

Student has to perform any **12 Experiments**

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 Rotati n 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:** Mea urement of magnetic susceptibility of $MnSO_4$

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, Department of Physics, University of Pune, Pune-7 (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 private Ltd. New Delhi.

Course Code and Title: PHCT-231 Statistical Mechanics

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

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

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, 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.

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

Classical partition functions and their properties, Calculations of thermodynamic quantities, Ideal monoatomic gas, Gibbs paradox, Equipartition theorem and its some 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

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 behaviour, 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)(ISBN-10: 0691137447, ISBN-13: 978-0691137445)
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- R.K. Pathria, Bufferworgh Heinemann (2^{nd} Edition)
6. Statistical Mechanics- K. Huang, John Willey and Sons (2^{nd} Edition)
7. Statistical Mechanics- Satya Prakash and Kedar Nath Ram, Nath Publication (2008)
8. Statistical Mechanics-Loknathan and Gambhir

Course Code and Title: PHCT-232 Solid State Physics

Module 1: Crystal Structure and Band Theory of Solids 1 Credit

Revision of crystal structures, structure of atomic form factor, Geometrical structure factor, Atomic scattering factor, calculations for SC, BCC, FCC, HCP and diamond structure

Revision of nearly free electron model, DC and AC electrical conductivity of metals, Bloch theorem (with proof), Kronig-Penney model, Motion of electron in 1-D according to band theory, Fermi sphere, Tight binding approximation, Band structure (in R space) of semiconductor crystal, Cyclotron resonance, Quantization of electronic orbit in a magnetic field

Module 2: Diamagnetism and Paramagnetism 1 Credit

Classical theory of diamagnetism, Langevin theory of Paramagnetism, Quantum theory of Paramagnetism, Paramagnetic susceptibility of conduction electron, Magnetic properties of rare earth ions & iron group ions with graphical representation, Crystal field splitting, quenching of orbital angular momentum

Module 3: Ferromagnetism and Antiferromagnetism 1 Credit

Wiess theory, Curie point, Exchange integral, saturation magnetization and its temperature dependence, Saturation magnetization at absolute zero, ferromagnetic domains, Anisotropy energy, Bloch wall. Antiferromagnetism- Neel temperature and Ferrimagnetism (Explanation only for both)

Module 4: Superconductivity Dielectric Properties of Solids 1 Credit

Properties of Superconductors: Meissner effect, Heat capacity, Energy gap, Isotope effect; Type I and II superconductors; Thermodynamics of superconductivity; London equation and London penetration depth; BCS theory; Quantization in a superconductivity ring and Qualitative discussion of Josephson superconductor tunneling

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-233 Experimental Techniques in Physics-I

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

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 **1 Credit**

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 **1 Credit**

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 **1 Credit**

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, Londonand, New York, 1974)

Course Code and Title: PHCT -241 Nuclear Physics

MODULE 1: General Properties and Concepts of Nuclei 1 Credit

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 1 Credit

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 1 Credit

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 1 Credit

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: PHCT 242 Experimental Techniques in Physics-II

Module 1: Radiation Sources and Detectors 1 credit

Electromagnetic spectrum, Sources of Electromagnetic Radiations: Different types of radiations (γ - rays, X-rays, UV-VIS, IR, microwaves**)** and their sources, Detectors: γ-rays, X-rays, UV-VIS, IR, microwaves

Module 2: Structural Characterization and Thermal Analysis 1 credit

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 – Powder 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), Numericals

Module 3: Morphological and Magnetic Characterization 1 credit

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 Tunnelling 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 only, Numericals

Module 4: Spectroscopic Analysis 1 credit

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), Raman Spectroscopy, Numericals

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. Characterization of Materials, John B. Wachtman and Zwi. H. Kalman, Pub. Butterworth Heinemann (1992)
4. Instrumental Methods of Chemical analysis, G. Chatwal and S. Anand, Himalaya Publishing House
5. Elements of X-ray Diffraction, B. D. Cullity, S. R. Stock, (Printice Hall)
6. Instrumental Methods of Analysis, H. H. Willard, l. L. Merritt, J. A. Dean, CBS Publishers

Course Code and Title: PHCP-235 Physics Laboratory III

Student has to perform **12 Experiments**

(A) **CBOP-III AND V Courses with 2 Credits: Computer Laboratory – Any 6 Experiments of Section I + Any 6 Experiments of Section II**

(B) **CBOP-III AND V Courses with 4 Credits: Computer Laboratory – Any 3 Experiments of Section I + Any 3 Experiments of Section II + Any 6 Experiments given in CBOP-III and V of Group-II with 2 Credit Courses**

COMPUTER LABORATORY

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

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

Note: (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:

(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 $\Sigma_{n=1}^{25} J_{2n}$ (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:

(9) Differential Equation: Find out the motion of a charged particle in a uniform magnetic field. The equation of motion of part Type equation here. icle with charge 'q' and mass 'm' in a uniform magnetic field B is given by

$$\frac{d\vec{r}}{dt} = \frac{q}{m}(v \times \vec{B})$$

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

GROUP – I Papers

(With 4 Credits)

Course Code and Title: PHOTA4: Physics of Thin Films

Module 1: Introduction to Thin Films 1 credit

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 1 credit

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 1 credit

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 1 credit

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)

Course Code and Title: PHOTB4: Physics of Nanomaterials

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

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 **1 Credit**

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 **1 Credit**

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 **1 Credit**

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

Course Code and Title: PHOTC4: Laser Fundamentals and Applications

Module 1 **1 Credit**

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 **1 Credit**

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 **1 Credit**

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

(Ref. 1, 2, 7)

Module 4 **1 Credit**

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: PHOTD4: Physics of Semiconductor Devices

Module 1: Properties of semiconductor (1 credit)

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 (1 credit)

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 (1 credit)

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 (1 credit)

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: PHOTE4: Communication Electronics

Module 1: Digital Communication **1 Credit**

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 **1 Credit**

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 **1 Credit**

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 **1 Credit**

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

Course Code and Title: PHOTF4: Microwave Physics and Applications

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

Module 1: Passive Elements **1 Credit**

Introduction to microwave its applications: 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 **1 Credit**

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 **1 Credit**

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 **1 Credit** 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

GROUP – I Courses

(With 2 Credits)

Course Code and Title: PHOTA2: Physics of Thin Films

Module 1: Introduction to Thin Films and Deposition Techniques 1 credit

- 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
- Physical Vapour Deposition, Chemical Vapour Deposition, Molecular Beam Epitaxy, Sputtering, Spray pyrolysis, Dip coating and Spin coating, Photolithography, Electron –beam deposition, Pulsed Laser Ablation

Module 2: Measurement of Thickness of Thin Film and Applications of Thin Films 1 credit

- Tolansky technique, Talystep (styles) method, Gravimetric method, Quartz crystal microbalance.
- 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 (2nd revised edition), A. Roth, (North Hollad)

Course Code and Title: PHOPA2: Physics of Thin Films

List of Experiments (Any six) 2 Credit

1. Deposition of metallic thin films by vacuum evaporation method
2. Deposition of thin films by spray pyrolysis method and thickness measurement by gravimetric method
3. Thin film formation by Electro-chemical deposition technique
4. Deposition of thin films by spin coating method and resistance measurement
5. Deposition of thin film by dip coating method / chemical bath method and thickness measurement
6. Thickness measurement of thin film by Tolansky method.
7. Measurement of resistance of thin film by two probe method with variation in temperature
8. Study of oxidation laws.
9. Development of microstructures by photolithography.
10. Measurement of reflectivity and transferability of thin films by using He-Ne laser and Determination of refractive index of a transparent film by Abe's method.
11. Pattern generation by photolithography

Course Code and Title: PHOTB2: Physics of Nanomaterials

Module 1: Introduction and Synthesis of Nanomaterials **1 Credit**

1.1 Introduction to nanosized materials and structures
1.2 Effect of Reduction of Dimension
1.3 Physical Vapour Deposition
1.4 Chemical Bath Deposition
1.5 Hydrothermal method
1.6 Sol gel Method
1.7 Biological Method

Module 2 Properties and Application of Nanomaterials **1 Credit**

2.1 Mechanical Properties
2.2 Thermal Electrical and Optical Properties
2.3 Magnetic Properties
2.4 Graphene, Carbon nanotubes and their Applications
2.5 Mechanical and Biomedical Applications
2.6 Optoelectronic Application

Reference Books:

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

Course Code and Title: PHOPB2: Physics of Nanomaterials

List of Experiments (Any six) **2 Credit**

1. Synthesis of nonmaterial by sol gel method
2. Synthesis of nonmaterial by hydrothermal method
3. Synthesis of nonmaterial by chemical bath deposition
4. Synthesis of nonmaterial by biological method
5. Determination of average crystallite size of nanoparticles from X ray diffraction technique
6. Study of optical absorption (Ultraviolet) of nanoparticles
7. Microwave assisted synthesis of nanomaterials
8. Synthesis of po;yanilene
9. Optical Verification of nanoparticles
10. Synthesis metal nanoparticles like CdS and TiO_2

Course Code and Title: PHOTC2: Laser and Applications

Module 1 **1 Credit**

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 **1 Credit**

(Principle, Construction, Energy level diagram and working of following lasers) Solid state lasers: Ruby laser, Nd:YAG laser, semiconductor lasers(homo junction lasers) Gas lasers : He-Ne laser, CO2 laser, Excimer lasers (Ref.1 ,2,7)

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 -- 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 Publication
10. Experiments With Laser -- Sirohi

Course Code and Title: PHOPC2: Laser and Applications

Note: Students are expected to prepare theory, design the experimental setup and take the measurements for following experiments.

List of Experiments (Any six) **2 Credits**

1. To determine wavelength of He-Ne laser using grating element.
2. To determine wavelength of He-Ne laser using measuring scale.
3. To determine spot size of laser using knife edge.
4. To determine divergence of laser beam.
5. To determine energy and power of laser beam.
6. To determine diameter of wire using laser.
7. To measure contamination in liquid sample using laser beam.
8. Use of laser in optical fiber communication.

Course Code and Title: PHOTD2: Physics of Semiconductor Devices

Module 1: Properties of Semiconductor and p-n Junctions (1 credit)

Basics of semiconductors and pn junctions, carrier concentration at thermal equilibrium for intrinsic and doped semiconductor and calculation of Fermi level, Donor and acceptor impurities, Density of available states, Carrier diffusion, Generation and Recombination processes, pn diode, p-i-n diode, schottky diode, zener diode, and their characteristic, Depletion region and depletion capacitance, Current- Voltage Characteristics (Shockley Equation), Diffusion Capacitance, Junction Breakdown-Thermal instability, Tunneling effect, Avalanche Multiplication.

Module 2: Junction Transistor and Metal Insulator Semiconductor devices (1 credit)

Static characteristics of transistor, Current gain- injection efficiency, base transport factor, Depletion layer and surface recombination, Junction formation and operating characteristics of UJT, JFET and MOSFET, General Energy band diagram, Current transport processes – Thermionic emission theory, Diffusion theory, thermionic emission –diffusion theory, expression for barrier height, metal semiconductor IMPATT Diode, ideal MIS diode – surface space-charge region.

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
6. Introduction to semiconductor devices – K.J.M. Rao
7. Electronic fundamental and application—J.D. Ryder
8. Integrated Circuits – Millman and Halkias

Course Code and Title: PHOPD2: Physics of Semiconductor Devices

Experiments (Any six) 2 Credit

1. Study of optoelectronic properties of semiconductor devices (Solar cell)
2. Studies on the characterization of JFET (Output & transfer characteristic)
3. Studies on the characterization of MOSFET
4. Determination of band gap of semiconductor from temperature dependence of resistivity using four probe method
5. Study of Hall voltage as a function of probe current and magnetic field and determination of Hall coefficient and carrier concentration.
6. Opamp as a differential and substraction application
7. Temperature and frequency dependent dielectric properties of the material.
8. Studies on the diode charactristics such as zener breakdown p-n junction diode etc.

Course Code and Title: PHOTE2: Communication Electronics

Module 1: Digital Communication **1 Credit**

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: Telephone, Facsimile and Satellite Communication **1 Credit**

Wire telephone, telephone subscriber's loop circuit, transmission bridges, four wire terminating set, Two–wire repeaters, Four wire transmission. Facsimile transmission, reception, Transmission of facsimile telegraph.

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.

Reference Books:

1. Electronic communications – Rooddy – Coolen (PHI) electronic
2. Communication Systems – George Keneddy (TMH)
3. Telecommunication switching systems & Network – T.Vishwanathan.(PHI)
4. Mobile Cellular Tele communication System – C.Y.Lee
5. Communication Electronics – Fresnel
6. Communication Electronics – Katre

Course Code and Title: PHOPE2: Communication Electronics

List of experiments (Any six) **2 Credit**

1. Delta pulse Modulation
2. Optical communication with LED and Photo-transistor.
3. Directional characteristics of Dish antenna.
4. Digital Multiplexing
5. Study of cordless telephone
6. Study of PAM, PPM, PWM
7. Study of 3 way intercom system.

Course Code and Title: PHOTF2: Microwave Physics and Applications

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

Module 1: Passive Elements **1 Credit**

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

Module 2: Active Elements **1 Credit**

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.

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

Course Code and Title: PHOPF2: Microwave Physics and Applications

List of experiments (Any six) **2 Credit**

1. Study of Gunn Diode Oscillator
2. Study of Crystal Detector
3. Principle of Magic Tee
4. Principle of Directional Coupler
5. Method of Impedance Matching
6. Power Measurements
7. To Measure guide wavelength for three different frequencies. Calculate wavelength and hence frequency.
8. To Measure small VSWR (S<10) for given load. Take two different independent reading
9. To determine normalized value of given unknown load. Using smith chart and by calculations.

Reference for experiments:

1. X Band microwave Lab Kit (series B)

Group-II

(With 4 Credits)

Course Code and Title: PHOT234G4: Acoustics-I

Module 1: Measurement and Perception of Sound (1 Credit)

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 (1 Credit)

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 (1 Credit)

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 (1 Credit)

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

Course Code and Title: PHOT244G4: Acoustics-II

Module1: Acoustic transducers **1 Credit**

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 **1 Credit**

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 **1 Credit**

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

Module 4: Technical acoustics and music **1 Credit**

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

Course Code and Title: PHOT234H4: Energy Studies-I

Module 1: Energy Sources **1 Credit**

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 environmental climatic 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 **1 credit**

Importance of Solar Energy: Nature of solar radiation, Sun as a fusion rector, spectral distribution of terrestrial and extra-terrestrial radiation, Estimation of extra-terrestrial 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 **1 credit**

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 **1 credit**

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 and Sons) 1980
9. Heat and Thermodynamics, M.W. Zemansky (McGraw Hill Publication)

Course Code and Title: PHOT244H4: Energy Studies-II

Module 1: Solar Photovoltaics (SPV) 1 credit

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 1 credit

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 1 credit

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 1 credit

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

Course Code and Title: PHOT234I4: Electronic Instrumentation- I

Module 1: General Background and Measurements 1 Credit

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, and 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, 9

Module 2: Transducers 1 Credit

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 1 Credit

3.1 Signal conditioners: Op-amps, instrument amplifier, bridge, phase sensitive detector
References: 9: Ch 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
References: 9

Module 4: Indicators, Display System and Recorders 1 Credit

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)

Course Code and Title: PHOT244I4: Electronic Instrumentation- II

Module 1:

1.1 Introduction to Process Control **1 Credit**

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 **1 Credit**

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 **1 Credit**

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: **1 Credit**

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

Course Code and Title: PHOT234J4: Biomedical Instrumentation- I

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

- Sources and characteristics of bio-signals.
- Resting and action potential, propagation of action potential, Passive and active conduction.
- Basics of signal measuring system
- Basic and essentials of biomedical instrumentation system.
- Problems faced when measuring on human body.
- Precautions and safety conditions of biomedical instruments, grounding
- Electric shock hazards-Gross shock-Micro current shock

Module 2: Electrodes and Physiological Transducers 1 Credit

- Electrode theory
- Biopotential electrodes
- Electrodes for ECG, EEG, EMG.
- Introduction to physiological transducers
- Classification of Transducer
- Performance characteristic of transducer
- Displacement, position and motion transducer
- Pressure transducer
- Transducer for Body temperature measurement
- Biosensors

Module 3: Recording Systems and Signal Analysis 1 Credit

- Basic recording system
- General consideration for signal conditioners
- Preamplifiers, Differential, Instrumentation, Isolation amplifier
- Source of noise in low level measurement
- Biomedical signal analysis techniques
- Fourier Transform, FFT and Wavelet Transform
- Signal processing techniques

Module 4: Cardiovascular System and Measurements 1 Credit

- Heart and Cardiovascular system
- Blood Pressure measurement
- Heart Sounds, Phonocardiography
- Pulse oximetry
- Block diagram of electrocardiograph, ECG machine maintenance and trouble shooting
- The ECG leads
- Effect of Artifacts on ECG recording
- Introduction to pacemakers
- Types of pacemakers, 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
4. Biomedical Instruments and Measurements (Second Edition) by R. Ananda Natarajan Eastern Economy Edition
5. A textbook of Biomedical Engineering Edited by R.M. Kenedi, Blackie (Glasgow & London)
6. Medical Instrumentation: Application and Design (Third Edition) John G. Webster, Willey India Education

Course Code and Title: PHOT244J4: Biomedical Instrumentation- II

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

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

Module 2: Biomedical Recorders **1 Credit**

- Introduction to nervous system and neural signals
- Neuromuscular transmission, muscle potentials
- Electroencephalograph (EEG), EMG recording system
- Electromyography (EMG), Block diagram, Computerized Analysis of EEG

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

- Diagnostic ultrasound
- Physics of ultrasonic waves
- Medical ultrasound
- Basic pulse echo apparatus
- Imaging modes
- Real time ultrasonic imaging systems
- Mechanical sector scanner, multi-element linear array scanner, Duplex scanners
- Modern ultrasound imaging system , area array system
- 3D ultrasound imaging system
- Biological effect of ultrasound

Module 4: Respiratory System and Special Care Instruments **1 Credit**

- The Physiology of the respiratory system.
- Tests and instrumentation of the mechanics of breathing
- Respiratory Therapy Equipment
- ICU/CCU equipment, Bedside monitor
- ECG / Physiological Telemetry

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
4. Biomedical Instruments and Measurements (Second Edition) by R. Ananda Natarajan Eastern Economy Edition
5. A textbook of Biomedical Engineering Edited by R.M. Kenedi, Blackie (Glasgow & London)
6. Medical Instrumentation: Application and Design (Third Edition) John G. Webster, Willey India Education

Course Code and Title: PHOT234K4 Nuclear Techniques-I

Module 1: Interaction of radiation with matter (1 Credit)

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 (1 Credit)

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, PHDTomultiplier gain, semiconductor detectors, surface barrier detector, Si(Li), Gel(Li), HPGedetectors.

Module 3: Pulse processing and related electronics (1 Credit)

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 (1 Credit)

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

Course Code and Title: PHOT244K4 Nuclear Techniques-II

Module 1: Basic parameters of radioactive disintegration process (1 Credit)

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 (1 Credit)

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 (1 Credit)

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 (1 Credit)

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

Course Code and Title: PHOT234L4: 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: **1 Credit**

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: **1 Credit**

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: **1 Credit**

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: **1 Credit**

Interfacing an LCD module, keyboard, ADC (0809) & DAC (0808), a stepper motor, traffic signaling (hardware compatibility and programs using C programming), data serialization, basics of serial communications, 8051 connections to RS 232, 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: PHOT244L4: Microcontrollers Based Instrumentation System-II

Module 1: **1 Credit**

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: 1 Credit

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: **1 Credit**

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: **1 Credit**

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

Course Code and Title: PHOT234M4: Material Science - I

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 **1 Credit**

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 **1 Credit**

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 behaviour – Henry's law), Gibb's phase rule: proof, explanation and application to single component (H_2O) and binary phase diagram

Module 4: Phase diagrams **1 Credit**

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 (Part I) 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: PHOT244M4: Material Science - II

Module 1: Ceramic Materials **1 Credit**

Ceramics phases ceramic crystals (AX) Ceramic crystals (AmXp), multiple compounds, silicates, mechanical behaviour of ceramics, processing of ceramic materials (review and study), Numerical

Module 2: Magnetic Properties of Materials **1 Credit**

Ferromagnetic (briefly) and ferrimagnetic materials, magnetic domains, hysteresis, Hard magnets and soft magnets, Origin of interaction in Ferromagnetic material, rare earth garnets orthoferrites and Haemitite, Hexagonal ferrites, magnetic bubbles), Numerical

Module 3: Semiconductors **1 Credit**

Intrinsic semiconductors, Band structure impurities, semiconductors III-V and II-VI compounds, p-n Diodes (details), transistor FET, tunnel diode, Gunn effect, Contact diode, microelectronic circuits-elementary level), Numerical

Module 4: New Materials **1 Credit**

High Tc materials, Giant magneto-resistance (GMR) materials (with brief discussion on magneto-resistance), Quasi crystals, optical materials, piezoelectric and ferroelectric material, nanoparticles

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. Introduction to Materials Science for Engineers-Pearson
4. Introduction to Ceramics-W.D. Kingery et al., 2^{nd} Edition, Wiley, 1991

Course Code and Title: PHOT234N4: Medical Physics-I

Module 1: Biomechanics **1 credit**

- 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
- Muscle contraction and its regulation

Module 2: Bioelectricity and Biomagnetism **1 credit**

- Nervous system and neuron
- Passive and active electrical properties of nerve membrane
- Equivalent circuit of neuron
- Nernst Equation, Goldmann equation
- Biopotentials EMG, ECG, EEG, EOG, ERG
- Magnetic signals from heart and brain

Module 3: Physics of Hearing **1 credit**

- Basic definition of Audibility,
- Physics of ear, Mechanoreceptor
- 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 **1 credit**

- Optics of eye
- Optical pathway, Photorecptors
- 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. Radiation Biophysics by Edward Alphan, Prentice Hall Advance Referes
3. T.B. of Biophysics by R.N. Roy, Central Publication
4. Clinical Biophysics: Principles and Techniques by P. Narayanan

Course Code and Title: PHOT244N4: Medical Physics-II

Module 1: Radiation Physics **1 credit**

- Ionizing Radiation and sources
- Biological effects of radiation
- Interaction of radiation with Bio system
- Radiotherapy and Brachytherapy: Treatment Planning
- Radiation protection in therapy.

Module 2: X-ray and Digital Radiography **1 Credit**

- Discovery and Production of X-ray
- Basic components of X ray machine
- X ray dosimetry
- Portable and Mobile x ray unit
- X ray detector
- Digital radiography
- Computer tomography (CT Scan)
- Fluoroscopy
- X-ray in diagnosis
- Hazards of X-ray

Module 3: Nuclear Medicine **1 Credit**

- Radioactivity and units
- Radioactive isotopes and radionuclide
- Dosimetry Chemical and TL
- Scintillation detectors for Thyroid and renal function
- Nuclear medicine imaging
- Gamma ray scintillation camera
- Positron emission tomography,
- Magnetic resonance imaging(MRI), Applications
- NMR signals

Module 4: Biomaterials / New Trends in Medical Physics **1 Credit**

- Biomaterials
- Introduction, Bio-ceramics, Bio-polymer, Bio-steel, Bio-chip, Blood as a Biomaterial, Introduction to Bio- Nanomaterial, new trends in Medical Physics
- Telemedicine
- New trends in Medical informatics
- Embedded system in Hospital.
- Laser in medicine

Reference Books:

1. Medical Physics by John R. Cameron, J. G. Skofronick, John Wiley and Sons, International Publications
2. Radiation Biophysics by Edward Alphan, Prentice Hall Advance Referes.
3. T.B. of Biophysics by R.N. Roy, Central Publication
4. Clinical Biophysics: Principles and Techniques by P. Narayanan

Group – II

(With 2 Credits)

Course Code and Title: PHOT234G2: Acoustics-I

Module 1: Perception of Sound, Resonators and Filters (1 Credit)

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); Equivalent continuous sound pressure level (L_{Aeq}); Perceived noise level (L_{EPN}); Haas effect and delay; Helmholtz resonator; acoustic, electrical and mechanical analogues

Module 2: Transmission Phenomenon and Architectural Acoustics (1 Credit)

Transmission from one fluid medium to another: Reflection at the surface of a solid, Significance of standing wave ratios; Sabine equation; Eyring approach, Millington and Sette approach; Optimum reverberation time; Methods of measuring reverberation time; Sound absorption coefficients; Room modes

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

Course Code and Title: PHOP234G2: Acoustics-I

List of Experiments (Any six) 2 Credit

1. Expansion chamber muffler
2. Audiometry: Threshold of audibility
3. Acoustics evaluation of a classroom: Estimation and measurement of reverberation time
4. Fourier analysis of a noise source
5. Signal muitiplier wave analyser
6. Acoustical power output of a source

Course Code and Title: PHOT244G2: Acoustics-II

Module 1: Acoustic Transducers (1 Credit)

Direct-radiator loudspeaker - equivalent circuit and efficiency, effect of voice-coil parameters on acoustic output, woofers, squawkers and tweeters, Crossover networks, loudspeaker cabinet; Horn loudspeaker: wave equation for horns*;* Microphones: Moving coil, Condenser and Velocity-ribbon; polar response characteristics of microphones; Electroacoustic Reciprocity Theorem; Reciprocity calibration of microphones

Module 2: Sound Systems and Technical Acoustics (1 Credit)

Monophonic and stereophonic sound systems; Dynamic range; Volume compressors, expanders, limiters; Graphic equalizer; Dolby Audio, Dolby Atmos, Audio file formats; Active noise control; Ultrasonic transducers: principle and applications

Reference Books:

1. Fundamentals of Acoustics, II or lll 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
9. Introduction to Acoustics, Robert D. Finch, Pearson, 2005

Course Code and Title: PHOP244G2: Acoustics-II

List of Experiments (Any six) 2 Credit

1. Reciprocity calibration of microphone
2. Constant pressure frequency response of a microphone
3. Loudspeaker systems: Crossover networks
4. Frequency response of a loudspeaker
5. Polar response characteristics of a microphone
6. Graphic equalizer

Course Code and Title: PHOT234H2: Energy Studies-I

Module 1: Energy Sources **1 Credit**

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, Importance of Solar Energy: Nature of solar radiation, Sun as a fusion rector, spectral distribution of terrestrial and extra-terrestrial radiation Estimation of extra-terrestrial 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. no. 8

Module 2: Basics of Heat Transfer and Energy Storage **1 credit**

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. Types of energy storage systems: sensible and latent heat storage systems, Electric energy storage systems, Chemical energy storage systems, Heat exchanges, Hydro storage, solar pond as an energy storage, Green house. Ref.no. 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 and 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

Course Code and Title: PHOP234H2: Energy Studies-I

List of Experiments (Any six) **(2 Credits)**

1. Determination of Calorific value of Wood/Cow dung.
2. Study of Optical Properties of selective coatings.
3. Determine the I-V and P-V characteristics of PV module with varying intensity of solar radiation.
4. Study of power versus load characteristics of Solar Power Photovoltaic Systems.
5. Study of Series and Parallel Combination of Solar Photovoltaic panels.
6. Study of Solar Collector (Efficiency versus $\Delta T/I$).
7. Determine the I-V and P-V characteristics of series and parallel combination of PV modules.
8. Study the bomb calorimeter and estimate the calorific value of a given solid or liquid sample.
9. Visit to solar energy farm and visit report (Solar PV plant/Wind energy/ Thermal energy/ Hydroelectric/Co-generation plant) (equivalent two experiments)

Course Code and Title: PHOT244H2: Energy Studies-II

Module 1: Photothermal and Photovoltaic applications of Solar Energy 1 credit

Introduction to selective coating and non-selective coating. Solar Thermal Devices and Systems: Different types of collectors Flat plate collector, Evacuated Tube Collector (Basic principle, construction, Energy balance equation of steady state, Methods to reduce heat losses) Solar cookers box type and Parabolic concentrator cooker, Domestic hot water system, Solar dryers, solar pond, Solar still, Solar refrigeration, Introduction to Solar concentrators (Brief description of each concentrator). Solar Photovoltaics (SPV) Conversion: Basic working principles of solar cell, Types of solar cells, Fabrication of solar cells, Typical IV characteristics of solar Modules.

Block diagram of general SPV conversion system and their characteristics, Different configurations. Applications: street light, water pumps, Radio/TV, Small capacity power generation SPV Systems Designing: Load estimation, selection of inverters, battery sizing, array sizing.

Module 2: Wind, Bio Energy and Hydrogen Energy 1 credit

Wind Energy: Basic principle of wind energy conversion, Extraction of maximum power from wind and its dependence on various parameters. Wind Mills: Vertical axis wind mills and Horizontal axis wind mills (Performance, Merits and Demerits), Bio Energy: Biomass, Generation and utilization, Properties of biomass. Biogas: Generation of biogas, Aerobic and anaerobic bioconversion process, Digesters and their designs, Pyrolysis and gasification, Fermentation process. Hydrogen Fuel: Importance of Hydrogen as a future fuel, Sources of Hydrogen. Production of Hydrogen by various methods (Direct electrolysis of water, Direct thermal decomposition of water). Hydrogen storage: Gaseous, Cryogenic and Metal hydride.

Reference Books:

1. Climatological and Solar data for India, Seshadri. (Sarita Prakashan) 1969
2. Solar Energy Utilization, G.D.Rai, 9Khanna 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 9 Tata Energy Research Institute, New Delhi) 1996
8. Fundamentals of Solar Cells, F.A. Faherenbruch and R.H. Bube 9Academic 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
13. Wind energy Conversion Systems, L.L. Freris (Prentice Hall)1990
14. Solar Photovoltaics. - C.S. Solanki

Course Code and Title: PHOP244H2: Energy Studies-II

List of Experiments (Any six) (2 Credits)

1. Determination of overall heat Loss Coefficient in Evacuated Tube Collector.
2. Determination of overall heat Loss Coefficient in Flat Plate Collector.

3. Study of Solar Dryer.
4. Study of Solar Still.
5. Performance Evaluation of Box Type solar cooker.
6. Study of Parabolic Type Solar Cooker.
7. Determination of Energy content in wind using anemometer.
8. Evaluate the performance of Fresnel lens solar concentrator.
9. Visit to solar energy farm and report (Wind energy/ Thermal energy/ Hydroelectric/ Co generation plant) (equivalent two experiments)

Course Code and Title: PHOT234I2: Electronic Instrumentation-I

Preamble: The students are supposed to have studied the following topics at undergraduate and post graduate level. Analog and digital electronics. This includes diodes, half and full wave rectifiers, different types of transistors, transistor amplifiers, basic operational amplifiers circuits such as inverting and non-inverting amplifier, OpAmp as an adder, subtractor, integrator & differentiators. 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, binary arithmetic, number system (binary, BCD, Hexadecimal) 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. Errors and error analysis, Static performance characteristics of an instrument such as accuracy, precision resolution, sensitivity, hysteresis, errors and their classification

Module 1: Measuring Instruments and Transducers (Sensors) 1 Credit

1.1 General configuration and functional description of measuring instruments, examples of instruments and their functional description. Static performance characteristics of measuring instruments such as accuracy resolution sensitivity, hysteresis, errors, their types (Static performance characteristics should only be mentioned without discussion since it has been discussed elsewhere in other core subject)

1.2 Dynamic characteristics: Generalized mathematical model of measurement System, order of instruments: zero, first, second and higher order. Step, ramp and sinusoidal frequency response of first order instruments (thermistor & thermocouple only)

1.2a Displacement sensors classification of displacement: linear, rotary and absolute. Time dependent, Ref.1, 2 & 3.

(i) Resistive type: (Potentiometric linear and rotary (angular)), strain gauges- responding to dimensional changes and resistivity change namely electrical and semiconductor type.

(ii) Capacitive type: linear and angular type, responding to change in distance,

(iii) Inductive type: Responding to change in Mutual inductance (LVDT) derivation of output of an LVDT not expected), Self inductance, Variable reluctance, Eddy current sensors.

(iv) Hall effect sensors for displacement measurement. Ref.2 (v) Digital (optical) displacement sensors (rotary and linear and also absolute and incremental (introduction only)) Ref.2

(vi) Level measurements

1.2b Temperature Measurements: Ref. 2,3,1: Temperature scales, basis of temperature scales Transduction techniques: Liquid filled thermometer, Resistance type: Platinum resistance temperature sensor, and (PT 100) thermistors. Thermocouples – Seebeck effect, Peltier effect &Thompson effect, types of thermocouples: T, E, J, K, R, S, B types. With their ranges, thermocouple laws (construction of thermocouple probe not expected)

Solid state temperature sensors AD-590, IC LM-35. (for both sensors introduction only from data sheets) optical pyrometers (total radiation and selective radiation type)

Module 2: Signal conditioning processing & Data acquisition (1 Credit)

Signal conditioners: Signal conditioning of the inputs: Ratiometric conversion, Logarithmic compression. Instrumentation amplifier using three OpAmps- derivation of equation for output voltage, phase sensitive detection (for LVDT displacement sensors), Ref.2 basic bridge circuit for platinum resistance thermometer, Ref.2, Thermocouple amplifier with cold junction temperature compensation (Ref 2, Using solid state temperature sensor(AD-590 or LM-35) or thermistor or diode) Data acquisition systems Block diagram of generalized data acquisition system, single channel and multichannel data acquisition systems, microcontroller based data acquisition system. Ref.2 Data

loggers, Ref. 2 & Ref. 4 general block diagram and increasing fuel efficiency of a petrol engine using microprocessor based data loggers, Sample and hold circuits. Ref. 5

Reference Books:

1 Measurement Systems Applications and Design By E.O. Doebelin, 4th Edition, McGraw Hills Publishing Company
2 Instrumentation Devices and Systems, by C.S, Rangan, G.R. Sarma and V.S.V. Mani, 2nd Edition, TMH Publishing Company
3 Instrumentation, Measurement and Analysis By B.C. Nakra, K.K. Chaudhry, TMH Publishing Company
4 Electronic Instrumentation By H.S. Kalsi, 3rd Edition McGraw Hills Education
5 Design with Operational Amplifiers and Analog Integrated Circuits, 4th Edition By Sergio Franco McGraw Hills Publishing Company

Course Code and Title: PHOP234I2: Electronic Instrumentation-I

List of experiments (any six) **2 Credit**

1 To design, build and test absolute value circuits.
2 To design, build and test thermocouple amplifier having cold junction temperature compensation.
3 To design, build and test Instrumentation amplifier for load cell.
4 Study of IC 7107 as DPM. To design build and test 3 &1/2 DPM for load cell.
5 To design, build and test displacement sensor using potentiometer, variable capacitor.
6 Study of accelerometer module.
7 To design build and test sample & hold amplifier.
8 To design, build and test bipolar DAC using binary weighted ladder and Op-amps. & IC
9 To design, build and test Log amplifier using Op-amps and diodes
10 To Design, build and test phase sensitive detector.
11 Temperature characteristics of thermistors or strain gauge and applications
12 V/F converters as a basic concept of ADC
13 Characteristics and applications of photo electric devices.(photo diode led, photo transistor)
14 Study of data acquisition system.
15 Study of LVDT sensor.
16 To design, build and test Voltage to Frequency converters using OpAmps.
17 Study of Characteristics of Solar cell.

Course Code and Title: PHOT244I2: Electronic Instrumentation-II

Module 1: Introduction to Process Control **0.5 Credit**

Introduction to Control systems: Process control block diagram, Control system Evaluation, Control system Objectives, Stability, Regulation, Transient Regulation, Evaluation Criteria, Damped response, Cyclic response, Sensor time response, References: 1

Discrete Process Control: Introduction, definitions of discrete state process control characteristics of the systems , relay, controllers and ladder diagrams (ladder programs for elevator and automatic bottle filling machine only) PLC's, **(programmed ladder diagrams not expected)** References: 1

Module 2: Principles of Analog Controllers **1.5 Credit**

Discontinuous Controller Modes Two Position Neutral Zone (Examples) Applications, Continuous controller modes: Proportional Control Mode, Integral Control Mode, Derivative Control Mode, Composite Control, P-I Control, P-D Control Mode, Three Mode Controller (P-I-D controllers). Numerical problems based on chapter 9 & 10 of Reference1 References: 1 A Short Introduction to MATLAB. Chapter 1 to 3 Ref.3

References Books:

1. Process Control Instrumentation Technology, Curtis D. Johnson, 8_{th} Edition, Prentice Hall India Pvt. Ltd.
2. Computer Based Industrial Controls by K. Kant PHI Publications
3. Matlab an Introduction and Applications by Amos Gilat, Wiley Students Edition

Course Code and Title: PHOP244I2: Electronic Instrumentation-II

List of Experiments (any six) **2 Credit**

After successful completion of practical course the students should get well introduced to MATLAB basics, loop structures & programming, using MATLAB to plot 2D and 3D plots. Teacher should take problems from quantum mechanics, Physics of semiconductor devices, lasers, atoms and molecular spectra and in general physics related computational problems. Minimum eight such practical sessions are to be conducted for the course.

Reference Books:

1. MATLAB an introduction with applications Book by Rao A Dukkipati New Age International Publication
2. Matlab an introduction and applications", by Amos Gilat, Wiley Students Edition.
3. Semiconductor device fundamentals By R F Pierret Pearson Education India Publication and other Physics problem related Books Following is an example(s) problem(s). Teacher should choose appropriate problems from the reference books

1. Given that at T = 300oK, the electron concentration in silicon is 1.52 x 10^{10} electrons /cm^3 and Eg = 1.1 eV at 300 K. (a) Find the constant A of Equation (b) Use MATLAB to plot the electron concentration versus temperature T= 300 K.

The average number of carriers (mobile electrons or holes) that exist in an intrinsic semiconductor material may be found from the mass-action law: ni =$AT^{1.5}$exp (-Eg/kT) where T=is the absolute temperature in 0 K k is Boltzmann's constant k = 1.38x10^{-23} J/K Eg is the width of the forbidden gap in eV. Eg is 1.21 and 1.1eV for Si at 0 K and 300 K, respectively. It is given as Eg = Ec - Ev

A is a constant dependent on a given material and it is given as $A = (2/h^3)(2\pi m_0 k)^{3/2}(m^*_n m^*_p/m_0.m)^{3/4}$ h is Planck's constant $h = 6.62 \times 10^{-34}$ Js, m_o is the rest mass of an electron m_n^* is the effective mass of an electron in a material, m_p^* is effective mass of a hole in a material

2 Problem 5.3 Page No. 163 Ref 2 Vth Edition, electric field at a point due to a charge is a vector E. The magnitude of E is given by Coulomb's law $E = (q/4\pi\varepsilon_0 r^2)$, where q is magnitude of the charge, r is the distance between the charge and the point, and ε0 is the permittivity constant (8.8542×10^{-12} C^2/Nm^2). The electric field E at any point is obtained by superposition of the electric field of each charge. An electric dipole with $q = 12 \times 10^{-19}$ C is created. Write a MATLAB program to determine and plot the magnitude of the electric field along the x-axis from x = – 8 cm to x = 8 cm.

3 Ladder programming using Trilogy Ladder Programming software. (This software is available free of cost on web https://i-trilogi.software.informer.com/6.2/) or any other ladder programming software.

4 To design, build and test two position controller using OpAmps.

5 To design build and test 4 - 20 mA current loop (voltage to current converter for input voltage range 0-1 Volt or any other suitable range and corresponding output current 4 to 20 mA)

6 Practical based on PLC's (cards) available in the market.

7 To Design, build and test Proportional, differential and integral controller circuits

Course Code and Title: PHOT234J2: Biomedical Instrumentation-I

Module 1: Fundamentals to Biomedical Instrumentation, Patient Safety, Electrodes and Transducers 1 Credit

- Sources and characteristics of bio-signals.
- Resting and action potential, propagation of action potential, Passive and active conduction.
- Basic and essentials of biomedical instrumentation system.
- Problems faced when measuring on human body.
- Precautions and safety conditions of biomedical instruments, Electric shock hazards-Gross shock-Micro current shock
- Electrode Theory, Bio potential Electrodes: types and Characteristics, Electrodes for ECG, EEG, EMG.
- Introduction, Classification and Performance characteristic of transducer.
- Displacement, position and motion transducer.
- Transducer for Body temperature measurement

Module 2: Recording Systems, Cardiovascular System and Measurements 1 Credit

- Basic recording system.
- General consideration for signal conditioners
- Preamplifiers, Differential, Instrumentation, Isolation amplifier.
- Heart and Cardiovascular system
- Blood Pressure measurement
- Pulse oximetry
- Block diagram of electrocardiograph, ECG machine maintenance and trouble shooting
- The ECG leads
- Effect of Artifacts on ECG recording
- Introduction to pacemakers, Types of pacemakers, 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.
4. Biomedical instruments and measurements (Second edition), by R. Ananda Natarajan Eastern economy edition
5. A textbook of Biomedical engineering edited by R.M. Kenedi, blackie (Glasgow & London)
6. Medical instrumentation: Application and design (Third edition) John G.Webster, Willey India Education

Course Code and Title: PHOP234J2: Biomedical Instrumentation-I

List of Experiments (Any six) 2 Credit

1. Active filters for Bio-signals- Design and Filtering (Low pass and High pass filter)
2. Design and build a Notch filter (To reduce noise of 50 Hz).
3. ECG preamplifier-Instrumentation amplifier and testing.
4. Use of sphygmomanometers for measurement of blood pressure.
5. Concept of ECG, system and placement of electrodes ECG signal recording with surface electrodes.
6. Design and build a Wide/ Narrow band pass filters for measurement for Bio-signals
7. To study LVDT Characteristic.

8. To study Thermistor Characteristic.
9. Measurement of physical parameter using embedded system
10. Measurement of pulse parameter using pulse oxymetry/pulse measuring instrument

Course Code and Title: PHOT244J2: Biomedical Instrumentation-II

Module 1: The Computer in Biomedical Instrumentation and Biomedical Recorders 1 Credit

- The digital computer-computer hardware-Computer Software.
- Microprocessors –Types of Microprocessors, Microprocessors in Biomedical instrumentation
- Interfacing the computer with medical instrumentation and other equipment.
- Biomedical computer applications.
- Introduction to nervous system and neural signals, Neuromuscular transmission, muscle potentials
- Electromyography (EMG), EMG recording system
- Electroencephalograph (EEG), Block diagram, Computerized Analysis of EEG.

Module 4: Respiratory system, special care instruments and ultrasonic imaging system

1 Credit

- The Physiology of the respiratory system.
- Tests and instrumentation of the mechanics of breathing
- Respiratory Therapy Equipment
- ICU/CCU equipment, Bedside monitor
- ECG / Physiological Telemetry
- Diagnostic and Medical ultrasound, Physics of ultrasonic waves, biological effect of ultrasound
- 3D ultrasound imaging system, imaging modes
- Basic pulse echo apparatus

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
3. McGraw Hill).
4. Biomedical Instrumentation and Measurement by Carr and Brown-Pearson.
5. Biomedical instruments and measurements (Second edition), by R. Ananda Natarajan Eastern economy edition
6. A textbook of Biomedical engineering edited by R.M. Kenedi, blackie (Glasgow & London)
7. Medical instrumentation: Application and design (Third edition) John G.Webster, Willey India Education

Course Code and Title: PHOP244J2: Biomedical Instrumentation-II

List of Experiments (Any six) 2 Credit

1. Recording of pulse signal using pulse oximetry/Pulse recording system.
2. Glucometer as a sensors/strain gauge, measurement of BMR, BMI and fats using fat monitor
3. Design and built data acquisition system using microprocessor/Microcontroller
4. Skin temperature using thermo sensor
5. Operation and function of all the controls of hospital X-ray machine/ C. T. Scan / Ultrasound scanner (Visit at Hospital)
6. To study Lead I , II and III of standard bipolar Lead configuration
7. To study AVR, AVF and AVL lead of standard unipolar leads configuration
8. To study the abnormalities present in Human Cardiovascular System
9. To study of operating principles and characteristics of the D/A 10.To study Respiration rate monitor.

Course Code and Title: PHOT234K2: Nuclear Techniques-I

Module 1: Interaction of Radiations and Dosimetry (1 Credit)

Interactions of directly ionizing radiation (electron, proton and ions), stopping power, range of particles, straggling, interaction of gamma radiations, attenuation coefficient, Units: Rontgen, RAD, REM, RBE, BED, Gray, Sievert, Kerma. Absorbed dose, dose equivalent and quality factor, organ dose, effective dose, equivalent effects, dose limits, effects of radiation on human body

Module 2: Nuclear Detectors and related Electronics (1 Credit)

Ionization chamber, proportional counter, GM counter, general characteristics of organic and inorganic scintillators, scintillation detectors NaI-(Tl), detection efficiency, semiconductor detectors, surface barrier detector- Si(Li), GeI(Li), HPGe detectors, preamplifier, amplifier, Discriminators: Single channel analyzer, Multichannel analyzer

Reference Books:

1. Nuclear Radiation Detectors, S. S. Kapoor 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

Course Code and Title: PHOP234K2: Nuclear Techniques-I

List of Experiments (any six) 2 Credit

1. To determine resolving/dead time of a GM counter by double source method.
2. To study Compton scattering using 6.66% MeV gamma-rays.
3. To determine energy resolution of a Nal(TI) detector and show that it is independent of the gain of the amplifier.
4. To determine energy of a given gamma-ray source by calibration method.
5. To study various operations of 1024 channel analyzer and to calculate energy resolution, energy of gamma ray, area under photopeak etc.
6. To study beta-ray spectrum of Cs-137 source and to calculate binding energy of Kshell electron of Cs-137.
7. To determine and compare the linear absorption coefficient of gamma radiation for different metals.

Course Code and Title: PHOT244K2: Nuclear Techniques-II

Module 1: Radioactive disintegration process and neutrons (1 Credit)

Law of radioactive disintegration, units of activity, basic concepts of half life, mean life time of nuclei, activity measurement, Neutron sources, neutron detectors, measurement of cross-sections for nuclear reaction, thermal and fast reactors, production of radioisotopes. Reactor operation, thermal neutrons.

Module 2: Nuclear reaction analysis and radioisotopes (1 Credit)

Elemental analysis by neutron activation technique, proton induced X-ray emission technique, Rutherford backscattering, applications of radioisotopes (industrial, agricultural) dating of archeological and other ancient object, Medical uses of Radioisotopes, Carbon-14

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 an 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

Course Code and Title: PHOP244K2: Nuclear Techniques-II

List of Experiments (any six) 2 Credit

1. To make a short lived isotope using thermal/fast neutrons and measure its half life time.
2. To determine activity of a given gamma-ray source using radiation monitor.
3. Measurement of neutron flux using activation method.
4. To study designing of a D/A converter using R-2R ladder network.
5. To design and study the different modes of scalar using IC 7490 and observe the output on CRO.
6. To determine the efficiency of GM counter/NaI(Tl) detector for different energy gamma radiations.
7. To determine the efficiency of GM counter for beta particles.

Course Code and Title: PHOT234L2: 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 etc. binary airthmetics, Boolean algebra, K-map techniques, Basic logic gates and derived gates (NAND, NOR, Ex-OR, Ex-NOR), RS, D, J-K, T -flip-flops (bi- stable multivibrators) binary counters, half adder full adders. Analog to digital converters such as successive approximation ADC, dual slope ADC, microprocessor compatible ADC's, binary weighted and R-2R DAC, microprocessor compatible DAC's, basic regulated power supply using IC- 723 or three pin regulators, temperature sensors such LM-35, AD-590, basics of C- programing.

Module 1 **1 Credit**

Architecture of 8-bit microprocessors, comparison of microprocessors and microcontrollers.

(8085 and 8051), 8051 Microcontrollers: Architecture and introduction to Instruction set of 8051 Microcontrollers., Types of instructions (jumps, loops and call instructions & stack related operations), addressing modes in 8051, Programming 8051 microcontrollers: Assembler directives, simple arithmetic and logic programs, code(s) conversion, moving a block of data from one memory location to other etc.

Module 2 **1 Credit**

I/O programming: ports of 8051 with their special features (of port 0 and port 2), Timers (timer 0 & timer1) various modes of the 8051 timers, program timers to generate time delays programming counters of 8051 for event counting. Interrupts programming in 8051: comparing polling versus interrupts, ISR (interrupt service routine) six interrupts of 8051, interrupt vector table, program the timers of 8051 using interrupts, enabling and disabling 8051 interrupts, Interrupt priority in the 8051, programing 8051 timers using interrupts.

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: PHOP234L2: Microcontrollers Based Instrumentation System-I

List of Experiments (any six) **2 Credit**

1 Introduction to Kiel/pinnacle (any other suitable assembler and simulator for 8051) software to load, assemble and execute assembly language programs (ALP's) & C- programs for 8051 microcontrollers. (equivalent to two practicals)

2 To write, assemble and execute Simple arithmetic programs (addition, subtraction, multiplication and unsigned 8 bit no division, addition of string of natural numbers, to find largest and smallest of given numbers) in ALP and C- programing.

3 To write a C-program for code conversion hex to BCD, BCD to ASCII, hex to decimal etc. and such other code conversion.

4 Write a C-program to generate time delay using timers of 8051.

5 Write a C- program to generate time delay using timers of 8051 and external (hardware) interrupt(s) to start and stop timers.

6 Arrange the given numbers in ascending/ descending order.

Course Code and Title: PHOT244L2: Microcontrollers Based Instrumentation System-II

Preamble: The students are supposed to have studied the following topics at undergraduate and post graduate level. **Basics of Analog and Digital Electronics,** Analog to digital converters,basics of C-programing. Thorough background of microcontroller architecture and programming is necessary.

Module 1:

Introduction to embedded system, Different types of arduino modules(list), Arduino UNO microcontroller**,** Introduction to AT 328 microcontrollers, block diagram, a short introduction to each functional block, brief introduction to serial communication, UART, USART Boot loaders and Boot loading process for Microcontroller a short introduction to programming languages, Arduino IDE, programing Arduino UNO, Detailed Pin Mapping

Module 2:

Basic concepts of embedded designing: Understanding the functional blocks of different modules: temperature, Ultrasonic, audio (microphone), hall effect, speed, IR photo diode, humidity, gyro and accelerometer, actuator modules: stepper motor, relay, dc motor, servo motor, Interfacing ADC module HX 711, DAC MCP 4725, array of LED, interfacing LCD module, interfacing seven segment display, interfacing stepper motor, interfacing RTC module.

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

Course Code and Title: PHOP244L2: Microcontrollers Based Instrumentation System-II

List of Experiments (any six) **2 Credit**

1. Getting used to Arduino IDE.
2. Blinking LEDs in a given pattern
3. Displaying Digits on Seven Segment Displays
4. Displaying, blinking and Scrolling Text on LCD module.
5. Development of temperature indicator/controller system. (equivalent to three practical)
6. Development of stepper motor controlled robotic hand. (equivalent to three practical)
7. Development of poly house environment controller system. (humidity, temperature and moisture) (equivalent to three practical)
8. Development of home automation system using blue-tooth. (equivalent to three practical)
9. Distance measurement using ultrasonic sensors.

Course Code and Title: PHOT234M2: Material Science-I

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 **1 Credit**

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

Reference Books:

1. Elements of Materials Science and Engineering (5^{th} Edition) - Lawrence H. VanVlack, Addison - Wesley Publishing Co.
2. Materials Science and Engineering - V. Raghvan
3. Physical Metallurgy (PartI) R.W. Cahn and P. Hassen, North Holland 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: PHOP234M2: Material Science-I

List of Experiments (any six) **2 Credit**

1. Study of creep behaviour for binary Sn-Pb alloy
2. Plotting of crystal structures using Software
3. Density of ceramic material using XRD
4. Humidity measurement
5. Average grain size by SEM
6. To determine the dipole moment of a given liquid
7. To determine the magnetic susceptibility of $FeCl_3$
8. To determine specific heat of graphite
9. Temperature dependent resistivity measurement of a material

Course Code and Title: PHOT244M2: Material Science-II

Module 1: Metallurgical Thermodynamics **1 Credit**

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 (H2O) and binary phase diagram

Module 2: Phase diagrams **1 Credit**

Thermodynamic origin of phase diagrams, Lever rule, Type I (Cu-Ni) phasediagram, 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: PHOP244M2: Material Science-II

List of Experiments (any six) **2 Credit**

1. Preparation of particles of different sizes by chemical method. (e.g. CdS, ZnS, Au, Ag etc.)
2. Study of the particles (e.g. CdS, ZnS, Au, Ag etc.) using UV/VIS spectroscopy for the particle size, colour, (Luminiscence/Fluroscence) and gap energy.
3. Study of oxidation laws
4. Determination of Band gap of given material by UV-Visible-IR spectroscopy.
5. Determination of interatomic bond length in diatomic molecules by studying Rotational vibrational IR spectra.
6. Study of Beer and Lamberts law in absorption spectroscopy by using UV-Vis spectroscopy.
7. Study of Hystersis of hard and soft ferrites
8. Determination of resonance frequency of ferroelectric element
9. Study of Thermogravimatric analysis
10. Differential Thermo-Analysis
11. Measurement of Magnetoresistance
12. Hysteresis loop tracing / VSM and determination of magnetic moment

13. Phase equilibrium diagram for binary Sn-Pb alloy
14. Study of microstructure of copper
15. Measurement of stress in a transparent conducting oxide

Course Code and Title: PHOT (N2) Medical Physics-I

Module 1: Biomechanics, Bioelectricity and Biomagnetism **1 credit**

- 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, muscle contraction and its regulation
- Nernst Equation, Goldmann equation
- Biopotentials- Electric signals from body- EMG, ECG, EEG, EOG, ERG
- Magnetic signals from heart and brain – MCG, MEG

Module 3: Physics of Hearing and Vision **1 credit**

- Basic definition of Audibility, Physics of ear, Mechanoreceptor, 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
- Optics of eye, Photorecptors
- 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, Inter. Publications
2. Radiation Biophysics by Edward Alphan, Prentice Hall Advance Referes
3. T.B. of Biophysics by R.N. Roy, Central Publication
4. Clinical Biophysics: Principles and Techniques by P. Narayanan

Course Code and Title: PHOP (N2) Medical Physics-I

List of Experiments (Any six) **2 Credit**

1. ECG Recording and analysis.
2. Measurement of sound intensity using SPL.
3. Audiometry and analysis.
4. Comparison of resolving limit of eye and telescope.
5. Study of ophthalmoscope, Retinoscope.
6. Visit to Hospital (for study of Instruments used in Ophthalmology).
7. Study of Snellen's chart / Tonometer

8. Speech Analysis
9. Measurement of Physical parameter (BMR,Fat,BP) and Comparison of the parameters in uncontrolled stress condition using statistical techniques.
10. Study of Hematometer to measure Hb

Course Code and Title: PHOT (N2) Medical Physics-II

Module 1: Radiation physics, X-ray and Digital Radiography **1 Credit**

- Ionizing Radiation and sources, Biological effects of radiation
- Interaction of radiation with Bio system
- Radiotherapy and Brachytherapy: Treatment Planning, Radiation protection in therapy.
- Discovery and Production of X-ray, Basic components of X ray machine, X ray dosimetry, Portable and Mobile x ray unit, X-ray in diagnosis, Hazards of X-ray.
- Digital radiography
- Computer tomography (CT Scan), Fluoroscopy

Module 2: Nuclear Medicine, biomaterials and new trends in Medical Physics **1 Credit**

- Radioactivity and units, Radioactive isotopes and radionuclide, Dosimetry
- Scintillation detectors for Thyroid and renal function
- Nuclear medicine imaging
- Gamma ray scintillation camera, Positron emission tomography, Magnetic resonance imaging (MRI, NMR signals)
- Biomaterials , Introduction, Bio-ceramics, Bio-polymer, Bio-steel, Bio-chip, Blood as a Biomaterial, Introduction to Bio- Nanomaterial
- New trends in Medical Physics- Telemedicine, New trends in Medical informatics, Embedded system in Hospital
- Laser in medicine

Reference Books:

1. Medical Physics by John R. Cameron, J. G. Skofronick, John Wiley and Sons, International Publications
2. Radiation Biophysics by Edward Alphan, Prentice Hall Advance Referes
3. T.B. of Biophysics by R.N. Roy, Central Publication
4. Clinical Biophysics: Principles and Techniques by P. Narayanan

Course Code and Title: PHOP (N2) Medical Physics-II

List of Experiments (Any six) **2 Credit**

1. Measurement of Heart Rate, Pulse rate, respiration rate, and BP using Multipara.
2. Blood analysis, Absorption spectra of Blood using Spectrophotometer.
3. Medical Informatics using Internet.
4. Study of pacemakers Trainer Kit.
5. Visit to Hospital for study of nuclear medicine.
6. Measurement of Viscosity of blood.
7. Mechanical properties of bone.
8. ECG simulator
9. Study of UV-Visible /FTIR for characterization of Biomaterial
10. Measurement of physical parameter using embedded system