
Semester V

PHY-C11: DIGITAL SYSTEMS AND APPLICATIONS

PHY-C11 (T): DIGITAL SYSTEMS AND APPLICATIONS THEORY

Total Lectures : 60 **Credits: 4**

Objective: *The course covers CRO, basics of integrated circuit technology, binary arithmetic, Logic gates, sequential and combinational circuits, Timers and counters, Microprocessor basics, Computer organization.*

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **(3 Lectures)**

Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs. **(3 Lectures)**

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **(6 Lectures)**

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(6 Lectures)**

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **(5 Lectures)**

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. **(3 Lectures)**

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **(2 Lectures)**

Counters(4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous **(4 Lectures)**

Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. **(6 Lectures)**

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. **(8 Lectures)**

Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions. **(4 Lectures)**

Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate ,2010, Oxford University Press
5. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
8. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

PHY-C11 (P): DIGITAL SYSTEMS AND APPLICATIONS PRACTICALS

Total Lectures : 60 Credits: 2

Objective: *The laboratory exercises have been so designed that the students learn to verify some of the concepts learnt in the theory course of digital electronics. It covers practical* *training on basic Logic gates, flip-flops, sequential and combinational circuits, Timers and counters, Assembly language programming of 8085 Microprocessor.*

Note: *The experiments listed in the Practical Part of the Core Papers, i.e.,* ***PHY-C5 (P): Mathematical Physics - II, PHY-C6 (P): Thermal Physics, PHY- C7 (P): Digital Systems and Applications, PHY- C8 (P): Mathematical Physics - III, PHY- C9 (P): Elements of Modern Physics, PHY- C10 (P): Analog Systems and Applications,*** *are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II.* ***20*** *experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor

a) Addition and subtraction of numbers using direct addressing mode
b) Addition and subtraction of numbers using indirect addressing mode
c) Multiplication by repeated addition.
d) Division by repeated subtraction.
e) Handling of 16-bit Numbers.
f) Use of CALL and RETURN Instruction.
g) Block data handling.

h) Other programs (e.g. Parity Check, using interrupts, etc.).

Reference Books:

1. Modern Digital Electronics, R.P. Jain, 4^{th} Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
3. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
4. Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

PHYSICS-C12: SOLID STATE PHYSICS

PHYSICS-C12 (T): SOLID STATE PHYSICS

THEORY

Total Lectures: 60 **Credits: 4**

Max. Marks : 100

Objective : *The course content covers understanding of crystal structure, band theory of solid, lattice dynamics, magnetic and dielectric properties of matter, ferroelectric materials, and superconductivity phenomenon.*

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **(12 Lectures)**

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law **(10 Lectures)**

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **(8 Lectures)**

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. **(8 Lectures)**

Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **(6 lectures)**

Elementary band theory: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. **(10 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation) **(6 Lectures)**

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8^{th} Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 4^{th} Edition, 2015, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
6. Solid State Physics, Rita John, 2014, McGraw Hill
7. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
8. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PHY-C12 (P): SOLID STATE PHYSICS PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

Objective : *The computer based experiments involve use of C/C++/Scilab for solving the following problems based on Quantum Mechanics.The laboratory experiments forming basis of quantum mechanics Zeeman effect, Electron spin resonance, tunneling effect and quantum efficiency of detectors.*

Note: *The experiments listed in the Practical Part of the Core Papers are to be clubbed together and will be performed by the students during the Semesters V and VI. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

1 To measure magnetic volume susceptibility of liquid - $FeCl_2/MnSo_4$ solution by Quincke's method.

2 To measure the Magnetic susceptibility of Solids.

3 To determine the Coupling Coefficient of a Piezoelectric crystal.

4 To measure the Dielectric Constant of a dielectric Materials with frequency

5 To determine the complex dielectric constant and plasma frequency of metal usingSurface Plasmon resonance (SPR)

6 To determine the refractive index of a dielectric layer using SPR

7 To study the PE Hysteresis loop of a Ferroelectric Crystal.

8 To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

9 To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.

10. To measure dielectric constant of a non-polar liquid and its applications.

11. To determine the Hall coefficient and mobility of given semiconductors.

12. To find conductivity of given semiconductor crystal using four probe method.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Semester VI

PHYSICS-C13: ELECTROMAGNETIC THEORY

PHYSICS-C13 (T): ELECTROMAGNETIC THEORY

THEORY

Total Lectures: 60 **Credits: 4**

Max. Marks : 100

Objective : *The students are exposed to Maxwell equations and their applications, EM wave propagation in unbounded and bounded media,wave guides and optical fibres, polarization properties of em waves.*

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **(12 Lectures)**

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. **(10 Lectures)**

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence) **(10 Lectures)**

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light **(12 Lectures)**

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter. **(5 Lectures)**

Wave Guides: Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. **(8 Lectures)**

Optical Fibres:- Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). **(3 Lectures)**

Reference Books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
6. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
7. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

1. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
2. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
3. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

PHY-C13 (P): ELECTROMAGNETIC THEORY
PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

Objective : *The laboratory experiments based on refraction, polarization, diffraction properties of e.m. waves.*

Note: *The experiments listed in the Practical Part of the Core Papers are to be clubbed together and will be performed by the students during the Semesters V and VI. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

To verify the law of Malus for plane polarized light.

1. To determine the specific rotation of sugar solution using Polarimeter.
2. To analyze elliptically polarized Light by using a Babinet's compensator.
3. To study dependence of radiation on angle for a simple Dipole antenna.
4. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
5. To study the reflection, refraction of microwaves
6. To study Polarization and double slit interference in microwaves.
7. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
8. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
9. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
10. To verify the Stefan`s law of radiation and to determine Stefan's constant.
11. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
12. To study transmission line modeled as LC ladder and find out its propagation constant.
13. To measure the Numerical Aperture of Optical Fiber and study Propagation Loss and Bending Losses.
14. Refractive index of air using Jamin's Interferometer.
15. To study the Michelson interferometer and its application.
16. To study the intensity profile of the diffraction pattern of single slit and verify the uncertainty principle by using LASER.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

PHYSICS-C14: STATISTICAL MECHANICS

PHYSICS-C14 (T): STATISTICAL MECHANICS

THEORY

Total Lectures: 60 **Credits: 4**

Max. Marks : 100

Objective : *The students are exposed to Classical statistics, Classical and quantum theory of radiation, Bose-Einstein and Fermi-Dirac statistics and their applications.*

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

(18 Lectures)

Classical Theory of Radiation: Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. **(9 Lectures)**

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(5 Lectures)**

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.

(13 Lectures)

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. **(15 Lectures)**

Reference Books:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

PHY-C14 (P): STATISTICAL MECHANICS
PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

Objective : *The computer based numerical simulations involving use of C/C++/Scilab for handling the problems based on Statistical Mechanics.*

Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:

   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations

   b) Study of transient behavior of the system (approach to equilibrium)

c) Relationship of large N and the arrow of time

d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution

e) Computation and study of mean molecular speed and its dependence on particle mass

f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

2. Computation of the partition function $Z(\beta)$ for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:

a) Study of how $Z(\beta)$, average energy $\langle E \rangle$, energy fluctuation ΔE, specific heat at constant volume C_v, depend upon the temperature, total number of particles N and the spectrum of single particle states.

b) Ratios of occupation numbers of various states for the systems considered above

c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

3 Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.

4 Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

5 Plot the following functions with energy at different temperatures

a) Maxwell-Boltzmann distribution

b) Fermi-Dirac distribution

c) Bose-Einstein distribution

Reference Books:

1 Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn . 2007 , Wiley India Edition

2 Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

3 Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987

4 Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.

5 Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

6 Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.

7 Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

8 Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444

9 Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 9786133459274

Discipline Specific Elective Courses (any four) (Credit: 06 each)
PHY-DSE1 to PHY-DSE6

PHY-DSE1: NUCLEAR PHYSICS

Total Lectures: 75 **Credits: 6 (Credits: Theory-05, Tutorials-01)**

Max. Marks : 150

Objective : *The course contents covers general properties of nuclei, nuclear models, radioactive decays, Nuclear reactions, fission and fusion processes and applications,ineraction of gamma ray, charged particles and neutrons radiation with matter and respective detectors.*

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

(10 Lectures)

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force, Meson theory of nuclear forces. **(12 Lectures)**

Radioactivity decay: (a) Alpha decay: basics of α-decay processes, radioactive series, tunnel theory of α emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: β^-, β^+, EC decays, beta energy spectrum, end point energy, Gamma decay: Gamma rays emission & kinematics, internal conversion. **(12 Lectures)**

Nuclear Reactions: Types of Reactions, Coulomb scattering (Rutherford scattering), Coulomb barrier, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction. **(10 Lectures)**

Fission and Fusion: Nuclear reactors, Breeder reactors, Nuclear fusion in stars, formation of heavier elements, Nuclear reactor accidents – Chernobyl and Fukushima, Nuclear weapons, Fusion reactors, Inetrantional thermonuclear experimental reactor (ITER). **(9 Lectures)**

Interaction of radiation and charged particles with matter : Interaction of gamma rays with matter - photoelectric effect, Compton scattering, pair production, Energy loss of electrons and positrons, Positron annihilation in condensed media, Stopping power and range of heavier charged particles, derivation of Bethe-Bloch formula, neutron interaction with matter. **(12 Lectures)**

Detector for Nuclear Radiations: Gas-filled detectors: ionization chamber, proportional counter and GM Counter. Basic principle of Organic and Inorganic scintillation detectors for gamma and electron radiation, photo-multiplier tube, Semiconductor detectors, Solid state nuclear track detectors, Neutron detector, Cherenkov detector, radiation monitoring devices.

(10 Lectures)

Reference Books:

1 Introductory Nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2 Concepts of Nuclear Physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Concepts of Modern Physics by Arthur Beiser, Shobit Mahajan and S. Rai Choudhury (Tata Mcgraw Hill, 2006).
4. Modern Physics by J. Bernstein, Paul M.. Fishbane, S. G. Gasiorowicz (Pearson, 2000).
5. Introduction to the physics of Nuclei & Particles, R.A. Dunlap. (Thomson Asia, 2004).
6. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
7. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
8. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
9. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991).

PHY-DSE2: EXPERIMENTAL TECHNIQUES

PHY- DSE2 (T): EXPERIMENTAL TECHNIQUES

THEORY

Total Lectures: 60 **Credits: 4**

Max. Marks : 100

Objective : *The course content covers basics of experimental measurements, working principle of transducers and their applications, industrial instrumentation, and vacuum techniques.*

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution. **(7 Lectures)**

Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise **(7 Lectures)**

Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference. **(4 Lectures)**

Transducers & industrial instrumentation (working principle, efficiency, applications):
Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector. **(21 Lectures)**

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

(5 Lectures)

Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge. **(4 Lectures)**

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization). **(12 Lectures)**

Reference Books:

1. Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
2. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
3. Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
4. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
5. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
6. Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
7. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer

PHY-DSE2 (P): EXPERIMENTAL TECHNIQUES
PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

1. Determine output characteristics of a LVDT & measure displacement using LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of level using capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters.
5. Study of distance measurement using ultrasonic transducer.
6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
7. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
8. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
9. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.

10 To design and study the Sample and Hold Circuit.

11 Design and analyze the Clippers and Clampers circuits using junction diode

12 To plot the frequency response of a microphone.

13 To measure Q of a coil and influence of frequency, using a Q-meter.

14 Measurement of thermal relaxation time constant of a serial light bulb.

15 To study the series and parallel L.C.R. circuit and find its Q factor for different resistances.

16 To study the characteristics of given voltage doubler and tripler.

17 To study the clipping and clamping circuits.

18 To study the frequency response of given RC coupled transistor amplifier and determine its band width.

19 To determine the distributed capacity of given inductance coil.

20 To determine the given capacitance using flashing and quenching of a neon bulb.

21 To determine the operating plateau and dead time of a given G.M. Counter.

22 To study the high energy interactions in nuclear emulsion – Energy of star.

23 To study the characteristics of silicon and GaAs solar cells.

24 To study the characteristics of LED and photodiode.

25 To study the variation of the *magneto-resistance* of a sample with the applied magnetic field.

26 To design astable multivibrator using transistors.

27 To study the amplitude modulation.

Reference Books:

1 Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer

2 Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill

3 Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

PHY-DSE3: ATOMIC AND MOLECULAR PHYSICS

Total Lectures: 75 **Credits: 6**

Max. Marks : 150

Objective : *The course contents covers the hydrogen and alkali spectra, coupling schemes, atoms in magnetic fields, Infrared and Raman spectroscopy, and electron spectra, line broadening mechanisms and Lasers.*

UNIT I

Hydrogen and Alkai Spectra: Series in hydrogen, nuclear mass effect, elliptical orbits, Sommerfeld model, spin-orbit coupling, relativistic correction and Lamb shift (qualitative). Alkali Spectra and intensity ratios in doublets

Complex Spectra: LS-Coupling scheme, normal triplets, basic assumptions of the theory, identification of terms, selection rules, jj- coupling, Lande's interval rule, Selection rules, intensity ratios, regularities in complex spectra. Normal and anomalous Zeeman and Paschen Back effects, intensity rules. **(15 Lectures)**

UNIT II

Infrared and Raman Spectra: Rigid rotator, energy levels, spectrum, intensity of rotational lines, Harmonic oscillator: energy levels, eigenfunctions, spectrum, Raman effect, Quantum theory of Raman effect, Rotational and Vibrational Raman spectrum. Anharmonic oscillator: energy levels, Infrared and Raman Spectrum, Vibrational frequency and force constants, Dissociation of molecules. Non-rigid rotator including symmetric top: energy levels, spectrum, Vibrating-rotator energy levels, Infrared and Raman spectrum, Symmetry properties of rotational levels, influence of nuclear spin, isotope effect on rotational spectra.

Electronic Spectra: Classification of electronic states: Orbital angular momentum, Electronic energy and potential curves, resolution of total energy, Vibrational Structure of Electronic transitions. Vibrational analysis, Rotational Structure of Electronic bands: General relations, branches of a band, band-head formation, Intensity distribution in a vibrational band system. Franck-Condon Principle and its wave mechanical formulation. **(40 Lectures)**

UNIT III

Lasers : Temporal and spatial coherence, shape and width of spectral lines, line broadening mechanism, natural, collision and Doppler broadening.

II. Laser Pumping and Resonators: Resonators, modes of a resonator, number of modes per unit volume, quality factor, threshold condition.

III. Dynamics of the Laser Processes: Rate equations for two, three and four level systems, production of a giant pulse – Q switching, mode-locking.

IV. Types of Lasers: He-Ne gas laser, Nitrogen Laser, CO_2 laser, Ruby laser, Semiconductor lasers, dye lasers.

V. Applications: Holography, non-linear optics: harmonic generation, second harmonic generation, phase matching and optical mixing. **(20 Lectures)**

TUTORIALS: Problems pertaining to the topics covered in the course.

Recommended Books:

1. Atomic Spectra: H. Kuhn (Longman Green) 1969.
2. Molecular Spectra and Molecular Structure I: G. Herzberg (Van-Nostrand Rein-hold), 1950.
3. Atomic Spectra: H.E. White (McGraw Hill) 1934.
4. Fundamentals of Molecular spectroscopy: Banwell and McCash (Tata McGraw Hill), 1994.
5. Molecular Spectroscopy: S. Chandra (Narosa), 2009.
6. Atomic, Molecular and Photons, Wolfgang Damtrodes (Springer), 2010.
7. Lasers and Non-linear Optics: B.B. Laud. (Wiley Eastern), 1991.
8. Principles of Lasers: O. Svelto (Plenum Press), 4th edition, 1998.
9. An Introduction to Lasers and their applications: D.C.O’Shea, W. Russell and W.T. Rhodes (Addition –Wesley), 1977.
10. Laser Theory and Applications : Thyagarajan and A. Ghatak (Plenum) 1981 (reprint : MacMillan)

PHY-DSE4: PARTICLE PHYSICS

Total Lectures: 75 **Credits: 6 (Theory-05, Tutorials-01)**

Max. Marks : 150

Objective : *The course contents covers the elementary particles, cosmic rays, particle properties and their reactions, evolution of universe, Partcle accelerators, colliding beams, and detectors for high energy physics.*

Elementary Particles : Historical introduction, fermions and bosons, particles and antiparticles, Classification of elementary particles and their interactions - electromagnetic, weak, strong and gravitational interactions. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, Discovery of quarks, concept of quark flavor, color quantum number, Interactions among quarks, Yukawa theory, Field bosons, Standard model and beyond, Higgs boson. **(18 Lectures)**

Cosmic Connection: Cosmic rays, sources of cosmic rays and production of secondary cosmic rays in atmosphere, Van allen radiation belt, Carbon-14 and other isotopic datings, soft and hard cosmic rays, cosmic ray experiments: discovery of particles, Brief about ground based experiments – GRAPES. **(12 Lectures)**

Particle Properties and their reactions: Properties and life time of muon, pions: Determination of mass, spin and parity. Lifetime of neutral pion and isotopic spin. Strange particles: V particles, charged K-mesons, mass and life time for charged K-mesons. Observations of different strange particles ($\Lambda°$, $\Sigma°$, $\Sigma\pm$, $\Xi°$, $\Xi+$, Ω), strange particle production and decay.Strangeness and Hypercharge. **(15 Lectures)**

VIII. Particles and evolution of Universe: Big bang expansion: size, time and temperature, formation of particles, relic radiation. Source of energy in Stars: fusion reactions, solar and atmospheric neutrinos, Black holes, Neutron stars, Concept of dark matter and dark energy. **(12 Lectures)**

Particle Accelerators: Acceleartors, Ion sources, Introduction to beam optics, beamline components – magnets and vacuum systems.

Linear accelerator, Cockroft accelerator, Van-de Graaff generator, Tandem accelerator, Cyclotron, Electron synchrotron, Accelerator facilities in India. Introduction to colliding beam machines CERN LHC facility. **(10 Lectures)**

Detectors : Nuclear emulsions, Bubble chamber, Cloud chamber, Position-sensitive gas-filled and scintillator detectors, electromagnetic calorimeter and hadron calorimeter.

(8 Lectures)

Reference Books:

1. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
2. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
3. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
4. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
5. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
6. Concepts of Modern Physics by Arthur Beiser, Shobit Mahajan and S. Rai Choudhury (Tata Mcgraw Hill, 2006).
7. Modern Physics by J. Bernstein, Paul M.. Fishbane, S. G. Gasiorowicz (Pearson, 2000).

PHY-DSE5: PHYSICS OF RESONANCE TECHNIQUES

Total Lectures: 75 **Credits: 6**

Max. Marks : 150

Objective : *The students are exposed to physics of hyperfine inert=actions, Mossbauer spectroscopy, electron spin resonance, Nuclear magnetic resonance and other resonance techniques.*

I. Hyperfine Interactions: Electrostatic hyperfine interaction, Monopole and quadrupole interactions.

Magnetic hyperfine interaction, Origin of magnetic hyperfine flux density, Combined electric and magnetic hyperfine interactions.

II. Mossbauer Spectroscopy: Spectral line-shape of □-rays, Recoilless emission of □-rays, Resonance fluorescence and nuclear gamma resonance, Mossbauer spectrum – Isomer shift, Quadrupole splitting, Magnetic hyperfine structure, Combined electric and magnetic hyperfine splitting, line intensity, line width.

Mossbauer spectrometer, Applications.

III. Electron Spin Resonance: Basic resonance condition, absorption of electromagnetic energy and relaxation, ESR spectrometer, Spin Hamiltonian, Hyperfine structure, The ESR spectrum – line position, line intensity, line width. Applications.

IV. Nuclear Magnetic Resonance: Quantum mechanical description of NMR; The Bloch equation and its solutions – free precession; steady state in weak r.f. field, in-phase and out-of-phase susceptibilities, power absorption; Saturation effects at high radio-frequency power; intense r.f. pulses. Fourier Transform NMR. The NMR spectrum – Chemical shift, spin-spin coupling. NMR spectrometer. Applications.

V. Other Resonance Phenomena: Nuclear quadrupole resonance and its applications, Ferromagnetic resonance – shape effects and applications.

TUTORIALS: Relevant problems on the topics covered in the course.

Recommended Books:

1. Spectroscopy (Vol. I) eds.: B.P. Straughan and S. Walker (Chapman & Hall) 1976.
2. Hyperfine Interactions: A.J. Freeman and R.B. Frankel (Academic Press) 1967.
3. Chemical Applications of Mossbauer Spectroscopy: V.I. Goldanskii and R.H. Herber (Academic Press) 1968.
4. Principles of Magnetic Resonance: C.P. Slichter (Springer – Verlag) 1990.
5. Introduction to Solid State Physics: C. Kittel (John Wiley) 8^{th} ed. 2005.
6. Molecular Structure and Spectroscopy: G. Aruldhas (Prentice Hall of India), 2007.

PHY-DSE6: DISSERTATION

Total Lectures: 75 **Credits: 6**

Max. Marks : 150

The aim of project work in B.Sc (H.S.) 5^{th} semester is to expose the students to **Advanced Physics Synthesis, Characterisation and Analytical / Data Analysis Techniques.** It may include development of equipment in a research laboratory, or fabrication of a device. Project work based on participation in some ongoing research activity or analysis of data or review of some research papers is excluded. A student will work under the guidance of a faculty member from the department before the end of the 5^{th} semester. **Scientists and Engineers from other departments of the university and Institutes in and around Chandigarh can act as co-supervisors.** A report of nearly 50 pages about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the UGAPMEC. Assessment of the work done under the project will be carried out by a committee on the basis of grasp of the problem assigned, effort put in the execution of the project, degree of interest shown in learning the methodology, report prepared, and viva-voce/seminar, etc as per guidelines prepared by the UGAPMEC.