

INDEX
DEPARTMENT OF PHYSICS AND ASTROPHYSICS
Semester-V

S. No.	Contents	Page No.
1	B. Sc. (Hons.) Physics – Discipline Specific Core (DSC) 1. Electromagnetic Theory 2. Quantum Mechanics – I 3. Digital Electronics	2-11
2	B. Sc. (Hons.) Physics – Pool of Discipline Specific Electives (DSEs) 1. Astronomy and Astrophysics 2. Physics of Materials 3. Communication System	12-19
3	B. Sc. Physical Science with Physics as one of the Core DSC 1. Modern Physics DSEs 1. Astronomy and Astrophysics 2. Digital Electronics 3. Radiation and its Applications	20-32
4	B. Sc. Physical Science with Physics & Electronics as one of the Core Disciplines DSC 1. Modern Physics DSEs 1. Semiconductor Devices Fabrication 2. Electronics Instrumentation 3. Digital Signal Processing	33-46

B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC - 13: ELECTROMAGNETIC THEORY

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electromagnetic Theory DSC – 13	4	3	0	1	

LEARNING OBJECTIVES

This core course develops further the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic waves in vacuum and different media.

LEARNING OUTCOMES

At the end of this course the student will be able to,

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media
- Understand polarization of electromagnetic waves: Linear, circular and elliptical polarization. Production as well as detection of waves in laboratory
- Learn the features of planar optical wave guide
- In the laboratory course, the students will get an opportunity to perform experiments with polarimeter, Babinet compensator, ultrasonic grating and simple dipole antenna. Also, to study phenomena of interference, refraction, diffraction and polarization

SYLLABUS OF DSC – 13

THEORY COMPONENT

Unit - I

(6 Hours)

Review of Maxwell's equations; Coulomb gauge and Lorentz gauge; Poynting's theorem and Poynting's vector; electromagnetic (em) energy density; physical concept of electromagnetic field energy density

Unit – II

(10 Hours)

EM wave propagation in unbounded media: Plane em waves through vacuum and isotropic dielectric medium: transverse nature, refractive index, dielectric constant, wave impedance. Plane em waves through conducting medium: relaxation time, skin depth, attenuation

constant. Wave propagation through dilute plasma: electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth.

Unit – III (9 Hours)

EM waves in bounded media: Boundary conditions at a plane interface between two media; reflection and refraction of plane em waves at plane interface between two dielectric media - Laws of reflection and refraction; Fresnel's formulae for perpendicular and parallel polarization, Brewster's law; reflection and transmission coefficients; total internal reflection, evanescent waves; metallic reflection (normal incidence)

Unit – IV (13 Hours)

Polarization of EM waves: Propagation of em waves in an 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 and extraordinary refractive indices; production and detection of plane, circular and elliptically polarized light; phase retardation plates: quarter wave and half wave plates
Optical rotation; Biot's laws for rotatory polarization; Fresnel's theory of optical rotation; specific rotation

Unit – V (7 Hours)

Wave guides: Planar optical wave guides; planar dielectric wave guide ($-d/2 < x < d/2$); condition of continuity at interface; phase shift on total reflection; Eigenvalue equations; phase and group velocity of guided waves; field energy and power transmission (TE mode only)

References:

Essential Readings:

- 1) Introduction to Electrodynamics, D. J. Griffiths, 3rd edition, 1998, Benjamin Cummings.
- 2) Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd edition, 2003, CBS Publisher
- 3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2010, Wiley
- 4) Principle of Optics, M. Born and E. Wolf, 6th edition, 1980, Pergamon Press
- 5) Optics, A. Ghatak, 6th edition, 2017, McGraw-Hill Education, New Delhi

Additional Readings:

- 1) Electricity, Magnetism and Electromagnetic Theory, S. Mahajan, and S. R. Choudhary, 2017, TMH
- 2) Principles of Electromagnetic Theory, C. Jain, 2017, Narosa Publishing House
- 3) Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
- 4) Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
- 5) Problems and solution in Electromagnetics, A. Ghatak, K. Thyagarajan and Ravi Varshney, 2015
- 6) Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning
- 7) Engineering Electromagnetic, W. H. Hayt, 8th edition, 2012, McGraw Hill.
- 8) Electromagnetics, J. A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- 9) 2008+ Solved Problems in Electromagnetics, S. A. Nasar, 2001, SciTech

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

- Mandatory sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Mandatory sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list

- 1) To verify the law of Malus for plane polarized light.
- 2) To determine the specific rotation of sugar solution using polarimeter.
- 3) To analyse elliptically polarized Light by using a Babinet's compensator.
- 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 verify the Stefan's law of radiation and to determine Stefan's constant.
- 10) To determine Boltzmann constant using V-I characteristics of PN junction diode.
- 11) To find numerical aperture of an optical fibre.

References for laboratory work:

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
- 2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publisher
- 3) Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
- 4) Practical Physics, G. L. Squires, 4th edition, 2015, Cambridge University Press
- 5) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd

DISCIPLINE SPECIFIC CORE COURSE – DSC - 14: QUANTUM MECHANICS – I

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Quantum Mechanics – I DSC – 14	4	3	0	1	Light and Matter, and Elements of Modern Physics papers of this course or their equivalent

LEARNING OBJECTIVES

The development of quantum mechanics has revolutionized the human life. In this course, the students will be exposed to the probabilistic concepts of basic non-relativistic quantum mechanics and its applications to understand the sub atomic world.

LEARNING OUTCOMES

After completing this course, the students will be able to,

- Understand the applications of the Schrodinger equation to different cases of potentials namely finite square potential well, harmonic oscillator potential.
- Solve the Schrodinger equation in 3-D.
- Understand the spectrum and eigen functions for hydrogen atom
- Understand the angular momentum operators in position space, their commutators, eigenvalues and eigen functions.
- In the laboratory course, the students will be able to use computational methods to
 - Solve Schrödinger equation for ground state energy and wave functions of various simple quantum mechanical one- dimensional potentials
 - Solve Schrödinger equation for ground state energy and radial wave functions of some central potentials.

SYLLABUS OF DSC - 14

THEORY COMPONENT

Unit – I

(10 Hours)

General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary conditions and emergence of discrete energy levels. Application to energy eigen states for a particle in a finite square potential well, Momentum space wavefunction, Time evolution of Gaussian Wave packet, Superposition Principle, linearity of Schrodinger Equation, General solution as a linear combination of discrete stationary states, Observables as operators, Commutator of position and momentum operators, Ehrenfest's theorem.

Unit – II

(8 Hours)

Harmonic oscillator: Energy eigen values and eigen states of a 1-D harmonic oscillator using algebraic method (ladder operators) and using Hermite polynomials. Zero point energy and uncertainty principle.

Unit – III **(15 Hours)**

Schrödinger Equation in three dimensions: Probability and probability densities in 3D. Schrödinger equation in spherical polar coordinates, its solution for Hydrogen atom solution using separation of angular and radial variables, Angular momentum operator, quantum numbers and spherical harmonics. Radial wave functions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m_l , s, p, d shells.

Unit – IV **(12 Hours)**

Angular momentum: Commutation relations of angular momentum operators; concept of spin and total angular momentum; ladder operators, eigenvalues, eigenvectors; Pauli matrices; addition of angular momenta

References:

Essential Readings:

- 1) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 6th edition, 2019, Laxmi Publications, New Delhi.
- 2) Introduction to Quantum Mechanics, D. J. Griffith, 2nd edition, 2005, Pearson Education.
- 3) A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd edition, 2010, McGraw Hill.
- 4) Quantum Mechanics, B. H. Bransden and C. J. Joachain, 2nd edition, 2000, Prentice Hall
- 5) Quantum Mechanics: Concepts and Applications, 2nd edition, N. Zettili, A John Wiley and Sons, Ltd., Publication
- 6) Atomic Physics, S. N. Ghoshal, 2010, S. Chand and Company

Additional Readings:

- 1) Quantum Mechanics for Scientists & Engineers, D. A. B. Miller, 2008, Cambridge University Press.
- 2) Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, 1966, Addison-Wesley Publications
- 3) Quantum Mechanics, L. I. Schiff, 3rd edition, 2010, Tata McGraw Hill.
- 4) Quantum Mechanics, R. Eisberg and R. Resnick, 2nd edition, 2002, Wiley
- 5) Quantum Mechanics, B. C. Reed, 2008, Jones and Bartlett Learning.
- 6) Quantum Mechanics, W. Greiner, 4th edition, 2001, Springer.
- 7) Introductory Quantum Mechanics, R. L. Liboff, 4th edition, 2003, Addison Wesley

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

At least 4 programs must be attempted. The implementation may be done in C++/Scilab /Python. Use of available library functions may be encouraged. Similar programs may be added.

Unit 1

- 1) Visualize the spherical harmonics by plotting the probability density for various values of the quantum numbers (l, m)
- 2) Use the analytical solution for a particle in finite potential well. Numerically solve the transcendental equation one gets after putting the continuity and boundary conditions to

determine the energy eigenvalues for various values of the potential width and depth. Plot the corresponding normalised eigen functions.

Unit 2

Solve the Schrödinger equation using shooting/finite difference or any other method for the following simple 1-D potentials and compare with the analytical solutions:

- 1) Particle in a box
- 2) Particle in a finite potential well
- 3) Harmonic Potential

Unit 3

Solve the s-wave Schrodinger equation for the following cases.

$$\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E],$$

- 1) Ground state and the first excited state of the hydrogen atom:

$$V(r) = \frac{-e^2}{r}$$

Here m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take $e = 3.795$ (eVÅ)^{1/2}, $\hbar c = 1973$ (eVÅ) and $m = 0.511 \times 10^6$ eV/c².

- 2) For an atom in the screened coulomb potential

$$V(r) = \frac{-e^2}{r} e^{-r/a}$$

Here m is the reduced mass of the system (which can be chosen to be the mass of an electron). Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $e = 3.795$ (eVÅ)^{1/2}, $m = 0.511 \times 10^6$ eV/c², and $a = 3$ Å, 5 Å, 7 Å. In these units $\hbar c = 1973$ (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

Unit 4

Solve the s-wave Schrodinger equation $\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E]$, for a particle of mass m for the following cases

- 1) Anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940$ MeV/c², $k = 100$ MeV fm⁻², $b = 0, 10, 30$ MeV fm⁻³. In these units, $c\hbar = 197.3$ MeV fm. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

- 2) For the vibrations of hydrogen molecule with Morse potential

$$V(r) = D(e^{-2ar'} - e^{-ar'}), r' = \frac{r - r_0}{r}$$

Here m is the reduced mass of the two-atom system for the Morse potential

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take: $m = 940 \times 10^6$ eV/c², $D = 0.755501$ eV, $\alpha = 1.44$, $r_0 = 0.131349$ Å

References for laboratory work:

- 1) Schaum's Outline of Programming with C++, J. Hubbard, 2000, McGraw-Hill Education.
- 2) C++ How to Program, P. J. Deitel and Harvey Deitel, 2016, Pearson
- 3) Scilab (A Free Software to Matlab): H. Ramchandran, A. S. Nair, 2011, S. Chand and Co
- 4) Documentation at the Python home page (<https://docs.python.org/3/>) and the tutorials there (<https://docs.python.org/3/tutorial/>).
- 5) Documentation of NumPy and Matplotlib: <https://numpy.org/doc/stable/user/> and <https://matplotlib.org/stable/tutorials/>
- 6) Computational Physics, Darren Walker, 1st edition, 2015, Scientific International Pvt. Ltd
- 7) An Introduction to Computational Physics, T. Pang, 2010, Cambridge University Press
- 8) A Guide to MATLAB, B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, 3rd edition, 2014, Cambridge University Press

DISCIPLINE SPECIFIC CORE COURSE – DSC - 15: DIGITAL ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Digital Electronics DSC – 15	4	3	0	1	--

LEARNING OBJECTIVES

The objective of the course is to introduce digital electronics and its simple applications to physics Honours students. The course is designed to familiarize the students with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates and combinational and sequential logic circuits utilised in designing counters and registers.

LEARNING OUTCOMES

This paper is one of the core papers in the Physics curriculum. After studying this paper students will become familiar with,

- Digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
- Students will be able to learn to minimise a given Boolean function using laws of Boolean algebra and Karnaugh map to minimise the hardware requirement of digital logic circuits.
- Understand the working principle of data processing circuits, arithmetic circuits, sequential logic circuits, registers, counters based on flip flops

SYLLABUS OF DSC - 15

THEORY COMPONENT

Unit – I - Integrated circuits

(2 Hours)

Integrated Circuits (Qualitative treatment only), active and 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 ICs

Unit – II - Digital circuits and Boolean algebra

(14 Hours)

Difference between analog and digital circuits, binary number, 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

De Morgan's theorems, Boolean laws, simplification of logic circuit using Boolean algebra, fundamental products, idea of minterms and maxterms, conversion of truth table into equivalent logic circuit by (1) Sum of Products method and (2) Karnaugh map simplification (upto four variables).

Unit – III - Combinational Logic Circuits (9 Hours)

Data processing circuits: Multiplexers and its applications, de-multiplexers, decoders, encoders

Arithmetic logic circuits: Express binary number in signed and unsigned form, 1's and 2's complement representation, binary addition, binary subtraction using 2's complement, half and full Adders, half and full subtractors, 4-bit binary adder/subtractor using 2's complement method.

Unit – IV - Sequential Logic Circuits (8 Hours)

Flip Flops SR, D, and JK clocked (level and edge triggered) flip-flops, preset and clear operations, race-around conditions in JK flip-flop, master-slave JK flip-flop, conversion of one flip flop to another using an excitation table

Unit – V - Application of Sequential Logic Circuits (9 Hours)

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).

Counters: Asynchronous counters, MOD-N synchronous counter designing using excitation table.

Unit – VI – Timers (3 Hours)

IC 555: Pin -out diagram, block diagram and its applications as astable multivibrator and monostable multivibrator

References:

Essential Readings:

- 1) Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th edition, 2011, Tata McGraw
- 2) Fundamentals of Digital Circuits, A. Kumar, 2nd edition, 2009, PHI Learning Pvt. Ltd.
- 3) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
- 4) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
- 5) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
- 6) Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- 7) Digital Electronics G. K. Kharate, 2010, Oxford University Press

Additional Readings:

- 1) Logic circuit design, S. P. Vingron, 2012, Springer
- 2) Digital Principles, R. L. Tokheim, 1994, Schaum's Outline Series, Tata McGraw-Hill
- 3) Solved Problems in Digital Electronics, S. P. Bali, 2005, Sigma Series, Tata McGraw-Hill
- 4) Digital Electronics: An Introduction To Theory And Practice, W. H. Gothmann, 2000, Prentice Hall of India
- 5) Modern Digital Electronics, R. P. Jain, 2003, Tata McGraw-Hill
- 6) Digital Electronics, S. Ghoshal, 2012, Cengage Learning
- 7) Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

**At least five experiments should be performed from the following list.
All designing should be done on the bread boards.**

- 1) (a) To design a combinational logic system for a specified truth table.
(b) To convert Boolean expression into logic circuit and design it using basic logic gate ICs
- 2) To minimize a given logic circuit using K-map and design using NAND gates.
- 3) Designing of Half Adder and Half Subtractor using NAND gates
- 4) Designing of 4-bit binary adder using adder IC.
- 5) To build Flip-Flop (RS, Clocked RS) circuits using NAND gates.
- 6) To build Flip-Flop (D-type and JK) circuits using NAND gate
- 7) To build a 3-bit Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
- 8) To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
- 9) To design an astable multivibrator of given specifications using 555 Timer.

References for laboratory work:

- 1) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
- 2) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
- 3) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
- 4) Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 6: ASTRONOMY AND ASTROPHYSICS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Astronomy and Astrophysics DSE – 6	4	4	0	0	--

LEARNING OBJECTIVES

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics. They will also be introduced to the Indian contribution to astronomy in the modern times, techniques to measure astronomical parameters, the different layers of the Sun and an overview of our Milky Way galaxy.

LEARNING OUTCOMES

- After completing this course, student will gain an understanding of,
- Basic concepts of positional astronomy and astronomical coordinate systems
- Astronomical instruments and the modern telescopes
- Measurement of astronomical parameters such as distance, stellar brightness, stellar mass, radii, temperature and spectra
- The different layers of solar atmosphere and basic results of solar magneto-hydrodynamics
- Basic structure of different galaxies and rotation of the Milky Way galaxy

SYLLABUS OF DSE - 6

THEORY COMPONENT

Unit – I - Introduction to Astronomy (12 Hours)

Overview of the night sky; diurnal and yearly motions of the Sun; basic concepts of positional astronomy: celestial sphere, astronomical coordinate systems and conversion between them (Horizon and Equatorial systems of coordinates), circumpolar stars; sidereal and solar day

Unit – II - Basic Parameters of Stars (14 Hours)

Sources of stellar energy; measurement of astronomical distances (stellar parallax, aberration, proper motion), measurement of brightness, radiant flux and luminosity (apparent and absolute magnitude scales; distance modulus); determination of stellar mass (visual binaries, eclipsing binaries, spectroscopic binaries); measurement of stellar temperature and radius; stellar spectra, dependence of spectral types on temperature; Stellar classification (Harvard and modern Morgan-Keenan classification schemes), H-R diagram

Unit – III - Astronomical Instruments (8 Hours)

Observing through the atmosphere (scintillation, seeing, atmospheric windows and extinction); basic definitions for telescopes (magnification, light gathering power, limiting magnitude, resolving power, diffraction limit); optical telescope (Galilean, Newtonian, Cassegrain); basic overview of Hubble space telescope, James Web space telescope, Fermi gamma ray space telescope, radio astronomy (overview of GMRT)

Unit – IV - Sun (12 Hours)

Solar parameters, Sun's internal structure, solar photosphere, solar atmosphere, chromosphere, corona, solar activity, basics of solar magneto-hydrodynamics

Unit – V - Physics of galaxies and Cosmology (14 Hours)

Physics of galaxies: Basic structure and properties of different types of Galaxies; Nature of rotation of the Milky Way: Differential rotation of the Galaxy and Oort constants, rotation curve of the Galaxy and the dark matter, virial theorem

Cosmology: Standard Candles (Cepheids and SNe Type1a); cosmic distance ladder; expansion of the Universe, Cosmological Principle, Newtonian Cosmology and Friedmann Models

References:

Essential Readings:

- 1) Fundamental Astronomy, H. Karttunen et al., Springer Berlin, Heidelberg
- 2) Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co.
- 3) Introductory Astronomy and Astrophysics, M. Zeilik and S. A. Gregory, Saunders College Publishing.
- 4) Astronomy in India: A Historical Perspective, T. Padmanabhan, Springer
- 5) Foundation of Astrophysics, B. Ryden and B. M. Peterson, Cambridge University Press
- 6) Astronomy: A Physical Perspective, M. Kutner, Cambridge University Press

Additional Readings:

- 1) Seven Wonders of the Cosmos, J. V. Narlikar, Cambridge University Press
- 2) Explorations: Introduction to Astronomy, T. Arny and S. Schneider, McGraw Hill
- 3) Astrophysics Stars and Galaxies, K. D. Abhyankar, University Press
- 4) An introduction to astrophysics, B. Basu, Prentice Hall of India Private Limited.
- 5) The Physical Universe: An Introduction to Astronomy, F. H. Shu, University Science Books
- 6) Telescopes and techniques, C. R. Kitchin, Springer New York, NY
- 7) Fundamentals of solar astronomy, A. Bhatnagar and W. C. Livingston, World Scientific
- 8) Astrophysics for Physicists, A. R. Choudhuri, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7: PHYSICS OF MATERIALS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Physics of Materials DSE – 7	4	2	0	2	--

LEARNING OBJECTIVES

This course intends to provide knowledge of emerging topics in condensed matter physics. In addition, this course aims to provide a general introduction to advanced topics by covering polymers, liquid crystals, carbon-based materials, and Diluted Magnetic Semiconductors. More importantly, the students will be exposed to different characterization techniques used in experimental condensed matter physics.

LEARNING OUTCOMES

After completion of this course the students should be able to,

- Identify different materials of technological importance in appliances and objects around us
- Explain the importance of concepts like density of states and its role in determining device characteristics
- Elucidate the ferroelectric, piezoelectric and pyroelectric materials and their applications.
- Explain the properties of liquid crystals and their application.
- Differentiate between different form of carbon based materials and their applications
- Introduce the importance of dilute magnetic semiconductors as a new technologically advance material for electronic devices
- Explain various characterization techniques used in understanding properties of different material

SYLLABUS OF DSE - 7

THEORY COMPONENT

Unit – I – Semiconductors

(4 Hours)

Basic concept of mobility and conductivity, density of states, determination of electron and hole concentration in doped semiconductor, Fermi level, Fermi energy, Fermi temperature, Fermi wavelength, Fermi surface.

Unit – II - Dielectric and magnetic materials

(9 Hours)

Dielectrics, Ferroelectric, Piezoelectric and Pyroelectric materials, applications of ferroelectrics in capacitors and memory device, Piezoelectrics in micro positioner and actuator, Pyroelectrics in radiation detectors and thermometry
Classification and applications of soft and hard magnetic materials, application in

transformers, memory device, introduction of spintronics based systems (spin transport)

Unit – III - Polymers (3 Hours)

Chemical structure of polymers of few thermoplastic (polyethylene, PVC, PTFE, PMMA, Polyester, Nylons) and thermosetting (Epoxy resin) polymers, conducting polymers-application in organic electronics

Unit – IV – Liquid crystals (3 Hours)

Classification of liquid crystals, structural and orientational ordering (isotropic to Nematic), thermotropic liquid crystals, Phases and phase transitions; anisotropic; Birefringence and display devices

Unit – V – Carbon based materials (3 Hours)

Structure and properties of Fullerenes, C₆₀, single walled and multi walled CNTs, Graphene and their energy band diagram.

Unit – VI – Synthesis of materials (8 Hours)

Ceramic (Calcination, Sintering, Grain), thin films (general idea of vacuum, thermal evaporation, molecular beam epitaxy, pulsed laser deposition), Crystals (qualitative idea of zone refining and Czochralski method), Polymers (Polymerization mechanism)

References:

Essential Readings:

- 1) Solid State Physics, M. A. Wahab, 2011, Narosa Publishing House
- 2) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
- 3) Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd edition, 2002, Wiley India
- 4) Introduction to Polymer Physics, U. Eisele and S. D. Pask, 1990, Springer-Verlag
- 5) The physics of liquid crystals, Pierre-Gilles de Gennes, 2nd edition, 2003, Oxford University Press
- 6) Introduction to Liquid Crystals, P. J. Wojtowicz, E. Priestly and P. Sheng, 1975, Plenum Press
- 7) Dielectric Phenomenon in solids with Emphasis on Physical Concepts of Electronic Processes, K. C. Kao, Elsevier.
- 8) Physics of Ferroelectrics A Modern Perspective, K. M. Rabe Charles H. Ahn Jean-Marc Triscone, Springer
- 9) Carbon Nanotubes: Properties and Applications, M. J. O'Connell, 2006, CRC Press
- 10) Dilute Magnetic Semiconductors, M. Jain, World Scientific.

Additional Readings:

- 1) Encyclopaedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al., 1992, Butterworth-Heinemann
- 2) Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, (2nd Ed., CRC Press, 2015).
- 3) Dilute magnetic semiconducting materials, Br. R. Saravanan, MRF

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

- 1) Study phase transition in a ferroelectric sample by measuring its dielectric constant as a function of frequency and temperature.
- 2) Study dielectric properties of given polymer sample as a function of frequency and temperature.
- 3) Study dielectric properties of given piezoelectric sample as a function of frequency and temperature.
- 4) Determine the coupling coefficient of a given piezoelectric crystal.
- 5) BH Hysteresis of different ferromagnetic materials (Loop Tracer).
- 6) Analyse the XRD spectra of a given ferroelectric ceramic sample and determine its lattice parameter.
- 7) Analyse the XRD spectra of a given ferromagnetic sample (basically ferrites, Fe_3O_4 , CoFe_2O_3) and determine its lattice parameter.
- 8) Analyse the XRD spectra of a given compound semiconductor (ZnO , TiO_2 , etc) thin film/ceramic sample and determine its lattice parameter.
- 9) Analyse the UV-Vis spectra of a given wide band gap semiconductor and determine its bandgap.
- 10) Study the IV characteristics of a polymer material by depositing/painting Aluminum electrodes.
- 11) To determine the g-factor of a sample by ESR Spectrometer.
- 12) Analyse the given SEM/TEM/AFM micrographs of the deposited thin film or nanostructure of any material and determine surface roughness, crystallinity, particle size etc.
- 13) Deposition of any kind of thin film by any technique available in the lab.
- 14) Liquid crystals (reading project)

References for laboratory work:

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- 2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
- 3) Elements of Solid State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
- 4) Elements of X-Ray Diffraction, B. D. Cullity and S. R. Stock
- 5) Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, 2nd edition, 2015, CRC Press
- 6) Encyclopedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al., 1992, Butterworth-Heinemann

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8: COMMUNICATION SYSTEM

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Communication System DSE – 8	4	2	0	2	--

LEARNING OBJECTIVES

This paper aims to describe the fundamental concepts of communication systems and communication techniques based on Analog Modulation, Analog and digital Pulse Modulation. Communication and Navigation systems such as GPS and mobile telephony system are also introduced. This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

LEARNING OUTCOMES

At the end of this course, students will be able to,

- Understand fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- Gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- Gain an in-depth understanding of different concepts used in a satellite communication system.
- Study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- In the laboratory course, students will apply the theoretical concepts to gain hands-on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

SYLLABUS OF DSE - 8

THEORY COMPONENT

Unit – I - Electronic communication and analog modulation (8 Hours)

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system, channels and base-band signals

Analog Modulation: Amplitude modulation, modulation index and frequency spectrum. Generation of AM (emitter modulation), amplitude demodulation (diode detector), Single

sideband (SSB) systems, advantages of SSB transmission, frequency modulation (FM) and phase modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM.

Unit – II - Analog Pulse Modulation (4 Hours)

Sampling theorem, basic principles - PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing)

Unit – III - Digital Pulse Modulation (10 Hours)

Need for digital transmission, pulse code modulation, digital carrier modulation techniques, sampling, quantization and encoding, concept of amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), and binary phase shift keying (BPSK)

Unit – IV - Satellite Communication and Mobile Telephony system (8 Hours)

Satellite communication: Need for satellite communication, geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), uplink and downlink, Ground and earth stations

Mobile Telephony System: Concept of cell sectoring and cell splitting, SIM number, IMEI number, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset.

References:

Essential Readings:

- 1) Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- 2) Advanced Electronics Communication Systems, Tomasi, 6th edition, Prentice Hall.
- 3) Electronic Communication systems, G. Kennedy, 3rd edition, 1999, Tata McGraw Hill.
- 4) Principles of Electronic communication systems, Frenzel, 3rd edition, McGraw Hill
- 5) Modern Digital and Analog Communication Systems, B. P. Lathi, 4th edition, 2011, Oxford University Press.
- 6) Communication Systems, S. Haykin, 2006, Wiley India
- 7) Wireless communications, A. Goldsmith, 2015, Cambridge University Press

Additional Readings:

- 1) Electronic Communication, L. Temes and M. Schultz, Schaum's Outline Series, Tata McGraw- Hill.
- 2) Electronic Communication Systems, G. Kennedy and B. Davis, Tata McGraw-Hill
- 3) Analog and Digital Communication Systems, M. J. Roden, Prentice Hall of India

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

- 1) To design an amplitude modulator using transistor
- 2) To design envelope detector for demodulation of AM signal
- 3) To study FM - generator and detector circuit
- 4) To study AM transmitter and receiver
- 5) To study FM transmitter and receiver

- 6) To study time division multiplexing (TDM)
- 7) To design pulse amplitude modulator using transistor.
- 8) To design pulse width modulator using 555 timer IC.
- 9) To design pulse position modulator using 555 timer IC
- 10) To study ASK, PSK and FSK modulators and demodulators

References for laboratory work:

- 1) Electronic Communication system, Blake, 5th edition, Cengage
- 2) Introduction to Communication systems, U. Madhow, 1st edition, 2018, Cambridge University Press

Category II

**Physical Science Courses
with Physics discipline as one of the Core Disciplines
(B. Sc. Physical Science with Physics as Major discipline)**

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 5: MODERN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Modern Physics PHYSICS DSC – 5	4	2	0	2	--

LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. It also introduces concepts of nuclear physics and accelerators

LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering
- The Schrodinger equation in 1-d, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values. Commutator of position and momentum operators.
- Time Independent Schrodinger Equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels.
- Modification in Bohr's Quantum Model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Basic Properties of Nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van de Graaff generator, linear accelerator, cyclotron, synchrotron

SYLLABUS OF PHYSICS DSC – 5

THEORY COMPONENT

Unit - I

(8 Hours)

Origin of Quantum Theory: Black Body Radiation and failure of classical theory, Planck's Quantum Hypothesis, Planck's Radiation Law, Quantitative treatment of Photo-electric effect and Compton scattering. Wave properties of particles: de Broglie hypothesis, Group and Phase velocities and relation between them. Heisenberg's Uncertainty Principle, Gamma ray microscope thought experiment, Position-Momentum Uncertainty, consequences of uncertainty principle.

Unit - II

(7 Hours)

The Schrodinger Equation: The Schrodinger equation in 1-d, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values; Commutator of position and momentum operators

Unit – III (5 Hours)

Time Independent Schrodinger Equation: Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem, energy levels.

Unit – IV (5 Hours)

Atomic Physics: Beyond the Bohr's Quantum model: Sommerfeld theory of elliptical orbits; hydrogen atom energy levels and spectra emission and absorption spectra

Correspondence principle

X-rays: Method of production, X-ray spectra: Continuous and characteristic X-rays, Moseley Law.

Unit – V (5 Hours)

Basic Properties of Nuclei: Introduction (basic idea about nuclear size, mass, angular momentum, spin), semi-empirical mass formula, nuclear force and meson theory.

Accelerators: Accelerator facility available in India: Van de Graaff generator, linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages), discovery of new elements of the periodic table

References:

Essential Readings:

- 1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
- 2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage
- 3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC
- 4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4th edition, 2013, Cengage Learning
- 5) Introduction to Modern Physics, R. Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- 6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
- 7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
- 8) Modern Physics, R. Murugesan, S Chand & Co. Ltd
- 9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
- 10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGraw-Hill Publishing Co. Ltd.
- 11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
- 12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited
- 13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education
- 14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education
- 15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House
- 16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, S. Chand & Co.
- 17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers

18) Atomic and Molecular Physics, Rajkumar, RBSA Publishers

Additional Readings:

- 1) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
- 2) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Mandatory activity:

- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab
- Familiarization with Schuster's focusing; determination of angle of prism.

At least six experiments to be performed from the following list

- 1) Measurement of Planck's constant using black body radiation and photo-detector
- 2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
- 3) To determine the work function of material of filament of directly heated vacuum diode.
- 4) To determine the Planck's constant using LEDs of at least 4 different colours.
- 5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
- 6) To determine the ionization potential of mercury.
- 7) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
- 8) To show the tunneling effect in tunnel diodes using I-V characteristics.
- 9) To determine the wavelength of a laser source using diffraction of a single slit.
- 10) 10. To determine the wavelength of a laser source using diffraction of double slits.
- 11) 11. To determine angular spread of He-Ne laser using plane diffraction grating
- 12) One innovative experiment designed by the teacher relevant to the syllabus.

References for laboratory work:

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- 2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal.
- 3) Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th edition, reprinted, 1985, Heinemann Educational Publishers.
- 4) A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publisher.
- 5) B.Sc. Practical Physics, H. Singh, S Chand & Co Ltd
- 6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15a: ASTRONOMY AND ASTROPHYSICS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Astronomy and Astrophysics PHYSICS DSE 15a	4	4	0	0	--

LEARNING OBJECTIVES

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics. They will also be introduced to the Indian contribution to astronomy in the modern times, techniques to measure astronomical parameters, the different layers of the Sun, the characteristics of planets in the solar system, an overview of our Milky Way galaxy and astrobiology.

LEARNING OUTCOMES

After completing this course, student will gain an understanding of,

- Basic concepts of positional astronomy and astronomical coordinate systems
- Astronomical instruments and modern telescopes
- Measurement of basic astronomical parameters such as distance, stellar brightness, stellar mass, radii, temperature and spectra
- Different layers of the Sun's atmosphere
- The difference between the terrestrial planets and the Jovian planets
- Basic structure of different galaxies and rotation of the Milky Way galaxy
- Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life

SYLLABUS OF PHYSICS DSE – 15a

THEORY COMPONENT

Unit – I - Introduction to Astronomy (12 Hours)

Overview of the night sky; diurnal and yearly motions of the Sun; basic concepts of positional astronomy: celestial sphere, astronomical coordinate systems (Horizon and Equatorial systems of coordinates), circumpolar stars; sidereal and solar day

Unit – II - Basic Parameters of Stars (16 Hours)

Measurement of astronomical distances (stellar parallax, aberration, proper motion), measurement of brightness, radiant flux and luminosity (apparent and absolute magnitude scales; distance modulus); determination of stellar mass (visual binaries, eclipsing binaries, spectroscopic binaries); measurement of stellar temperature and radius; stellar spectra,

dependence of spectral types on temperature; Stellar classification (Harvard and modern Morgan - Keenan classification schemes), H-R diagram

Unit – III - Astronomical Instruments (8 Hours)

Observing through the atmosphere (scintillation, seeing, atmospheric windows and extinction); basic definitions for telescopes (magnification, light gathering power, limiting magnitude, resolving power, diffraction limit); optical telescope (Galilean, Newtonian, Cassegrain); basic overview of Hubble space telescope, James Web space telescope, Fermi gamma ray space telescope

Unit – IV - Sun and the solar system (12 Hours)

Solar parameters; Sun's internal structure; solar photosphere; solar atmosphere; chromosphere; corona; solar activity; solar system (characteristics of terrestrial and Jovian planets); origin of the solar system

Unit – V- Physics of galaxies, Cosmology, Astrobiology (12 Hours)

Physics of galaxies: Basic structure and properties of different types of Galaxies; Nature of rotation of the Milky Way: Differential rotation of the Galaxy, dark matter

Cosmology: Standard Candles (Cepheids and SNe Type Ia); cosmic distance ladder; expansion of the Universe

Astrobiology: History of the Universe; chemistry of life; origin of life; chances of life in the solar system

References:

Essential Readings:

- 1) Seven Wonders of the Cosmos, J. V. Narlikar, Cambridge University Press
- 2) Fundamental Astronomy, H. Karttunen et al., Springer Berlin, Heidelberg
- 3) Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co.
- 4) Introductory Astronomy and Astrophysics, M. Zeilik and S. A. Gregory, Saunders College Publishing.
- 5) Astronomy in India: A Historical Perspective, T. Padmanabhan, Springer
- 6) Foundation of Astrophysics, B. Ryden and B. M. Peterson, Cambridge University Press
- 7) Astronomy: A Physical Perspective, M. Kutner, Cambridge University Press

Additional Readings:

- 1) Explorations: Introduction to Astronomy, T. Arny and S. Schneider, McGraw Hill
- 2) Astrophysics Stars and Galaxies, K. D. Abhyankar, Universities Press
- 3) An introduction to astrophysics, B. Basu, Prentice Hall of India Private Limited.
- 4) The Physical Universe: An Introduction to Astronomy, F. H. Shu, University Science Books
- 5) Telescopes and techniques, C. R. Kitchin, Springer New York, NY
- 6) Fundamentals of solar astronomy, A. Bhatnagar and W. C. Livingston, World Scientific
- 7) Astrophysics for Physicists, A. R. Choudhuri, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15b: DIGITAL ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Digital Electronics PHYSICS DSE – 15b	4	2	0	2	--

LEARNING OBJECTIVES

The objective of the course is to introduce digital electronics and its simple applications to physics program students. The course is designed to familiarize the students with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates and combinational and sequential logic circuits utilised in designing counters and registers.

LEARNING OUTCOMES

After studying this paper students will become familiar with,

- Digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
- Students will be able to learn to minimise a given Boolean function using laws of Boolean algebra and Karnaugh map to minimise the hardware requirement of digital logic circuits
- Understand the working mechanism of data processing circuits, arithmetic circuits, sequential logic circuits, register and their applications.

SYLLABUS OF PHYSICS DSE 15b

THEORY COMPONENT

Unit – I - Integrated Circuits (qualitative treatment only) (2 Hours)

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 ICs

Unit – II - Digital circuits and Boolean Algebra (13 Hours)

Binary numbers, decimal to binary and binary to decimal conversion, octal and hexadecimal numbers, NAND and NOR gates as universal gates, XOR and XNOR gates and their application as parity checkers

Boolean algebra: De Morgan's theorems, Boolean laws, idea of minterms, simplification of logic circuit using Boolean algebra and Karnaugh map

Unit – III - Combinational logic Circuits (7 Hours)

Data processing circuits: Multiplexers and its applications, de-multiplexers, decoders, encoders

Arithmetic circuits: Binary addition, binary subtraction using 2's complement, half and full adders, half and full subtractor

Unit – IV - Sequential Circuits

(8 Hours)

Flip Flops: SR, D, and JK, clocked (edge triggered) flip-flops, race-around conditions in JK flip-flop, application of flip flops in designing shift register (serial -in- parallel out) and 2- bit (MOD-4) up-down asynchronous counter

References:

Essential Readings:

- 1) Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th edition, 2011, Tata McGraw
- 2) Fundamentals of Digital Circuits, A. Kumar, 2nd edition, 2009, PHI Learning Pvt. Ltd.
- 3) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
- 4) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
- 5) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
- 6) Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- 7) Digital Electronics, G. K. Kharate, 2010, Oxford University Press

Additional Readings:

- 1) Logic circuit design, S. P. Vingron, 2012, Springer
- 2) Digital Principles, Schaum's Outline Series, R. L. Tokheim, 1994, Tata McGraw-Hill
- 3) Solved Problems in Digital Electronics, S. P. Bali, 2005, Sigma Series, Tata McGraw-Hill
- 4) Digital Electronics: An Introduction To Theory And Practice, W. H. Gothmann, 2000, Prentice Hall of India
- 5) Modern Digital Electronics, R. P. Jain, 2003, Tata McGraw-Hill
- 6) Digital Electronics, S. Ghoshal, 2012, Cengage Learning.
- 7) Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Either (1) At least 6 experiments or (2) 4 experiments and one project equivalent to two experiments and all designing should be done on the bread boards.

- 1) Study of truth tables of basic logic gates, universal logic gates XOR and XNOR logic gates
- 2) (a) To design a combinational logic system for a specified truth table.
(b) To convert Boolean expression into logic circuit and design it using basic logic gate ICs
- 3) To minimize a given logic circuit using K-map and design using NAND gates.
- 4) Designing of Half Adder and Half Subtractor using NAND gates.
- 5) Designing of Full adder/Full Subtractor using NAND gates
- 6) Designing of 4-bit binary adder using adder IC.
- 7) To build Flip-Flop (RS, Clocked RS) circuits using NAND gates.
- 8) To build Flip-Flop (D-type and JK) circuits using NAND gate
- 9) To build a 2-bit Asynchronous Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
- 10) To make a 3-bit Shift Register (serial in- and parallel out) using D-type/JK Flip-Flop ICs.

References for laboratory work:

- 1) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
- 2) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
- 3) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
- 4) Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15c: RADIATION AND ITS APPLICATIONS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Radiation and its Applications PHYSICS DSE – 15c	4	2	0	2	--

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows.

- To focus on the applications of nuclear techniques and radiation protection.
- To not only enhance the skills towards the basic understanding of the radiation but also provide the knowledge about the protective measures against radiation exposure.
- To impart all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, jobs dealing with nuclear medicine: chemotherapists, operators of PET, MRI, CT scan, gamma camera etc.

LEARNING OUTCOMES

After studying this course, the student will be able to,

- Understand and use the applications of nuclear techniques and radiation protection to guard against nuclear radiation hazards.
- Understand and use the units of radiations and their safety limits, the devices to detect and measure radiation.
- Understand and use radiation safety management, biological effects of ionizing radiation, operational limits and basics of radiation hazards evaluation and control, radiation protection standards,
- Use the devices which apply radiations in medical sciences, such as X - ray, MRI, PET, CT-scan with the required safety measures.
- Understand and perform experiments like study the background radiation levels using Radiation detectors, Determination of gamma ray linear and mass absorption coefficient of a given material for radiation shielding application.
- Use graphical software to plot the simulations done through SRIM or similar software.

SYLLABUS OF PHYSICS DSE 15c

THEORY COMPONENT

Unit – I

(8 Hours)

Radiation and its interaction with matter: Basic ideas of different type of radiation electromagnetic (X-ray, gamma rays, cosmic rays etc.), nuclear radiation and their origin (stable and unstable isotopes), half life and mean life

Nuclear Radiation: Basic idea of alpha, beta, gamma and neutron radiation and their sources (sealed and unsealed sources). Kinematics of nuclear reactions, Q value

Interaction of charged particles (including alpha particles): Heavy charged particles (e.g.

accelerated ions) - Beth-Bloch formula, scaling laws, mass stopping power, range, straggling. Cherenkov radiation

Interaction of beta particles: Collision and Radiation loss (Bremsstrahlung).

Interaction of photons: Linear and Mass Attenuation Coefficients. Interaction of Neutrons: Collision, slowing down and Moderation.

Unit - II

(8 Hours)

Radiation Units, dosage and safety management:

Radiation Quantities and Units: Biological effects of ionizing radiation, Interaction of ionising and non-ionising radiation at the cellular level. Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, quality factor, radiation and tissue weighting factors, annual limit of intake (ALI) and derived air concentration (DAC).

Radiation safety management: Operational limits and basics of radiation hazards, its evaluation and control: radiation protection standards. Concept of ALARA Principle using Distance, time and shielding

Unit - III

(8 Hours)

Radiation detection and monitoring devices: Basic concepts and working principle of gas detectors, Scintillation Detectors, Solid State Detectors and Neutron Detectors, Types of Radiation Dosimeters: thermoluminescence, radiographic films, calorimetry, semiconductor diodes; Relation between detection and dosimetry, Interaction of ionising and non-ionising radiation at the cellular level.

Unit - IV

(6 Hours)

Application of radiation as a technique: Application in medical science (e.g., basic principles of X- rays, MRI, PET, CT scan, Projection Imaging Gamma Camera, Radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

References:

Essential Readings:

- 1) Basic ideas and concepts in Nuclear Physics: An introductory approach, K. Heyde, 3rd edition, 1999, IOP Publication.
- 2) Nuclear Physics, S. N. Ghoshal, 1st edition, 2010, S. Chand Publication
- 3) Nuclear Physics: Principles and Applications, J. Lilley, 2006, Wiley Publication
- 4) Fundamental Physics of Radiology, W. J. Meredith and B. Massey, 1989, John Wright and Sons, UK
- 5) An Introduction to Radiation Protection by A Martin and S A Harbison, John Willey & Sons, Inc. NewYork, 1981.
- 6) Radioactivity and Radiation, C. Grupen and M. Rodgers, 2016, Springer
- 7) Introduction to Radiation Protection, C. Grupen, 2010, Springer
- 8) An introduction to radiation protection, A. Martin, S. Harbison, K. Beach and P. Cole, H. Arnold, 2012.

Additional Readings:

- 1) Radiation detection and measurement, G. F. Knoll, 4th edition, 2010, Wiley Publications
- 2) Techniques for Nuclear and Particle Physics experiments, W. R. Leo, 1994, Springer
- 3) Thermoluminescence dosimetry, A. F. Mcknlly, Bristol, Adam Hilger (Medical Physics Hand book 5)

- 4) Medical Radiation Physics, W. R. Hendee, 1981, Year book Medical Publishers, Inc., London
- 5) Physics and Engineering of Radiation Detection, S. N. Ahmed, 2007, Academic Press Elsevier
- 6) Nuclear and Particle Physics, W. E. Burcham and M. Jobes, 1995, Harlow Longman Group
- 7) IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interim) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), RS-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least five experiments need to be performed from the following list.

- 1) Estimate the energy loss of different projectiles/ions (at least 3 projectiles between $ZP = 1$ to 92, where ZP is atomic number of projectile/ion) in water and carbon, using SRIM/TRIM etc. simulation software.
- 2) Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H as projectile/ion.
- 3) Comparison of interaction of projectiles with $ZP = 1$ to 92 (where ZP is atomic number of projectile/ion) in a given medium (Mylar, Aluminium, cadmium, lead) using simulation software (SRIM etc).
- 4) SRIM/TRIM based experiments to study ion-matter interaction of heavy projectiles on heavy atoms. The range of investigations will be $ZP = 6$ to 92 on $ZA = 16$ to 92 (where ZP and ZA are atomic numbers of projectile and atoms respectively). Draw and infer appropriate Bragg Curves.
- 5) Calculation of absorption/transmission of X-rays, γ -rays through Mylar, Be, C, Al, Fe and $ZA = 47$ to 92 (where ZA is atomic number of atoms to be investigated as targets) using XCOM, NIST (<https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html>).
- 6) Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Data may be taken from the Department of Physics & Astrophysics; University of Delhi and gamma ray energies are available in the website <http://www.nndc.bnl.gov/nudat2/>).
- 7) Study the background radiation levels using Radiation meter
- 8) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
- 9) Study of counting statistics using background radiation using GM counter.
- 10) Study of radiation in various materials (e.g. K_2SO_4 etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
- 11) Study of absorption of beta particles in Aluminium using GM counter.
- 12) Detection of α particles using reference source & determining its half life using spark counter.
- 13) Gamma spectrum of Gas Light mantle (Source of Thorium).
- 14) Demonstration of Radiation Detection equipment for dose, risk and crime scene management.

References for laboratory work:

- 1) Schaum's Outline of Modern Physics, 1999, McGraw-Hill
- 2) Schaum's Outline of College Physics, E. Hecht, 11th edition, 2009, McGraw Hill
- 3) Modern Physics, K Sivaprasath and R Murugesan, 2010, S. Chand Publication
- 4) AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011
- 5) AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources., 2007.

Category II

**Physical Science Courses (with Electronics)
with Physics and Electronics discipline as Core Disciplines**

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 9: MODERN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Modern Physics PHYSICS DSC 9	4	2	0	2	--

LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. It also introduces concepts of nuclear physics and accelerators

LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering
- The Schrodinger equation in 1-d, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values; Commutator of position and momentum operators.
- Time Independent Schrodinger Equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels.
- Modification in Bohr's Quantum Model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Basic Properties of Nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van de Graaff generator, linear accelerator, cyclotron, synchrotron

SYLLABUS OF PHYSICS DSC – 9

THEORY COMPONENT

Unit - I

(8 Hours)

Origin of Quantum Theory: Black Body Radiation and failure of classical theory, Planck's Quantum Hypothesis, Planck's Radiation Law, Quantitative treatment of Photo-electric effect and Compton scattering. Wave properties of particles: de Broglie hypothesis, Group and Phase velocities and relation between them. Heisenberg's Uncertainty Principle, Gamma ray microscope thought experiment, Position-Momentum Uncertainty, consequences of uncertainty principle.

Unit - II

(7 Hours)

The Schrodinger Equation: The Schrodinger equation in 1-d, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values; Commutator of position and momentum operators.

Unit – III

(5 Hours)

Time Independent Schrodinger Equation: Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem, energy levels.

Unit – IV

(5 Hours)

Atomic Physics: Beyond the Bohr's Quantum Model: Sommerfeld theory of elliptical orbits; hydrogen atom energy levels and spectra emission and absorption spectra.

Correspondence principle

X-rays: Method of production, X-ray spectra: Continuous and characteristic X-rays, Moseley law

Unit – V

(5 Hours)

Basic Properties of Nuclei: Introduction (basic idea about nuclear size, mass, angular momentum, spin), semi-empirical mass formula, nuclear force and meson theory.

Accelerators: Accelerator facility available in India: Van de Graaff generator, linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages); discovery of new elements of the periodic table

References:

Essential Readings:

- 1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
- 2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage
- 3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC
- 4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4th edition, 2013, Cengage Learning
- 5) Introduction to Modern Physics, R. Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- 6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
- 7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
- 8) Modern Physics, R. Murugesan, S Chand & Co. Ltd
- 9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
- 10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGraw-Hill Publishing Co. Ltd.
- 11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
- 12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited
- 13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education
- 14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education
- 15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House
- 16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, S. Chand & Co.
- 17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers

18) Atomic and Molecular Physics, Rajkumar, RBSA Publishers

Additional Readings:

- 1) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
- 2) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Mandatory activity:

- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab
- Familiarization with Schuster's focusing; determination of angle of prism.

At least six experiments to be performed from the following list

- 1) Measurement of Planck's constant using black body radiation and photo-detector
- 2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
- 3) To determine the work function of material of filament of directly heated vacuum diode.
- 4) To determine the Planck's constant using LEDs of at least 4 different colours.
- 5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
- 6) To determine the ionization potential of mercury.
- 7) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
- 8) To show the tunneling effect in tunnel diodes using I-V characteristics.
- 9) To determine the wavelength of a laser source using diffraction of a single slit.
- 10) 10. To determine the wavelength of a laser source using diffraction of double slits.
- 11) 11. To determine angular spread of He-Ne laser using plane diffraction grating
- 12) One innovative experiment designed by the teacher relevant to the syllabus.

References for laboratory work:

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- 2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal.
- 3) Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th edition, reprinted, 1985, Heinemann Educational Publishers.
- 4) A Laboratory Manual of Physics For Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publisher.
- 5) B.Sc. Practical Physics, H. Singh, S Chand & Co Ltd
- 6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 3: SEMICONDUCTOR DEVICES FABRICATION

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Semiconductor Devices Fabrication PHYSICS DSE 3	4	2	0	2	--

LEARNING OBJECTIVES

This course provides a review of basics of semiconductors such as energy bands, doping, defects etc. and introduces students to various semiconductor and memory devices, thin film growth techniques and processes including various vacuum pumps, sputtering, evaporation, oxidation and VLSI processing are described in detail. By the end of the syllabus, students will have an understanding of MEMS based transducers.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes.

- Learn to distinguish between single crystal, polycrystalline and amorphous materials based on their structural morphology and learn about the growth of single crystals of silicon, using Czochralski technique, on which a present day electronics and IT revolution is based.
- Students will understand about the various techniques of thin film growth and processes.
- Appreciate the various VLSI fabrication technologies and learn to design the basic fabrication process of R, C, P- N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology.
- Gain basic knowledge on overview of MEMS (Micro-Electro-Mechanical System) and MEMS based transducers.

SYLLABUS OF PHYSICS DSE – 3

THEORY COMPONENT

Unit – I

(9 Hours)

Introduction: Review of energy bands in materials, metal, semiconductor and insulator, doping in semiconductors, defects (point, line, Schottky and Frenkel), single crystal, polycrystalline and amorphous materials, Czochralski technique for silicon single crystal growth, silicon wafer slicing and polishing.

Vacuum Pumps: Primary pump (mechanical) and secondary pumps (diffusion, turbomolecular, cryopump, sputter-ion) – basic working principle, throughput and characteristics in reference to pump selection, vacuum gauges (Pirani and Penning)

Unit – II

(10 Hours)

Thin film growth techniques and processes: Sputtering, evaporation (thermal, electron beam),

pulse laser deposition (PLD), chemical vapour deposition (CVD), epitaxial growth
Thermal oxidation process (dry and wet) passivation, metallization, diffusion

Unit – III

(7 Hours)

VLSI Processing: Clean room classification, line width, photolithography: resolution and process, positive and negative shadow masks, photoresist, step coverage, developer, electron beam lithography, etching: wet etching, dry etching (RIE and DRIE), basic fabrication process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology, wafer bonding, wafer cutting, wire bonding and packaging issues (qualitative idea)

Unit – IV

(4 Hours)

Micro Electro-Mechanical System (MEMS): Introduction to MEMS, materials selection for MEMS devices, selection of etchants, surface and bulk micromachining, sacrificial subtractive processes, additive processes, cantilever, membranes, general idea of MEMS based pressure, force, and capacitance transducers

References:

Essential Readings:

- 1) Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
- 2) Fundamentals of Semiconductor Fabrication, S.M. Sze and G. S. May, John-Wiley and Sons, Inc.
- 3) Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons
- 4) VLSI Fabrication Principles (Si and GaAs), S. K. Gandhi, John Wiley & Sons, Inc.

Additional Readings:

- 1) Handbook of Thin Film Technology, L. I. Maissel and R. Glang

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

- 1) Deposition of thin films using dip coating and deposition of metal contacts using thermal Evaporation and study its IV characteristics
- 2) Deposition of thin films using spin coating and deposition of metal contacts using thermal evaporation and study its I-V characteristics
- 3) Fabrication of p-n Junction diode and study its I-V characteristics
- 4) Create vacuum in a small tube (preferably of different volumes) using a mechanical rotary pump and measure pressure using vacuum gauges.
- 5) Selective etching of different metallic thin films using suitable etchants of different concentrations.
- 6) Wet chemical etching of Si for MEMS applications using different concentration of etchant.
- 7) Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75)
- 8) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150C) by four-probe method.
- 9) To fabricate a ceramic and study its capacitance using LCR meter.
- 10) To fabricate a thin film capacitor using dielectric thin films and metal contacts and study its capacitance using LCR meter

References for laboratory work:

- 1) The science and Engineering of Microelectronics Fabrication, S. A. Champbell, 2010, Oxford University Press
- 2) Introduction to Semiconductor Devices, F. Kelvin

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 4: ELECTRONICS INSTRUMENTATION

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electronics Instrumentation Physics DSE 4	4	2	0	2	--

LEARNING OBJECTIVES

This course aims to provide an exposure on basics of measurement and instrumentation and its various aspects and their usage through hands-on mode. It also aims to provide exposure of various measurement instruments such as power supply, oscilloscope, multivibrators, signal generators are also discussed. It also aims to develop an understanding of virtual instrumentation and transducers.

LEARNING OUTCOMES

At the end of this course, students will have understanding of,

- Basic principles of the measurement and errors in measurement, specifications of basic Measurement instruments and their significance with hands on mode.
- Principles of voltage measurement, advantages of electronic voltmeter over conventional multimeter in terms of sensitivity etc.
- Measurement of impedance using bridges, Power supply, Filters, IC regulators and Load and line regulation.
- Specifications of CRO and their significance, the use of CRO and DSO for the measurement of voltage (dc and ac), frequency and time period.
- Multivibrators, working circuits of astable and monostable multivibrators.
- Explanation and specifications of Signal and pulse Generators
- The Interfacing techniques, Arduino microcontroller and interfacing software,
- Understanding and usage of transducers

SYLLABUS OF PHYSICS DSE 4

THEORY COMPONENT

Unit – I

(12 Hours)

Measurements: Shielding and grounding, electromagnetic interference

Basic Measurement Instruments: DC measurement-ammeter, voltmeter, ohm meter, AC measurement, digital voltmeter systems (integrating and non-integrating), digital multimeter, block diagram, principle of measurement of I, V, C, measurement of impedance - A.C. bridges, measurement of self-inductance (Anderson's bridge), measurement of capacitance (De-Sauty's bridge), measurement of frequency (Wien's bridge)

Unit - II

(6 Hours)

Power supply: Using IC regulators (78XX and 79XX), line and load regulation, short circuit

protection, idea of switched mode power supply (SMPS) and uninterrupted power supply (UPS)

Oscilloscope: Block diagram, CRT, deflection (qualitative), screens for CRT, oscilloscope probes, measurement of voltage, frequency, and phase by oscilloscope, digital storage oscilloscope

Unit – III (3 Hours)

Multivibrators (IC 555): Block diagram, astable and monostable multivibrator circuits

Signal Generators: Function generator (black box approach)

Unit – IV (9 Hours)

Virtual Instrumentation: Introduction, interfacing techniques (RS 232, GPIB, USB), idea about Arduino microcontroller and interfacing software like lab View

Transducers: Classification of transducers, measurement of temperature (RTD, semiconductor IC sensors), light transducers (photo resistors and photovoltaic cells)

References:

Essential Readings:

- 1) Electronic Instrumentation and Measurement Techniques, W. D. Cooper and A. D. Helfrick, 2005, Prentice Hall
- 2) Measurement Systems: Application and Design, E. O. Doebelin, 5th edition, 2003, McGraw Hill Book
- 3) Electronic Devices and Circuits, D. A. Bell, 2015, Oxford University Press

Additional Readings:

- 1) Instrumentation Devices and Systems, S. Rangan, G. R. Sarma and V. S. Mani, 1998, Tata McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.”

At least eight experiments to be performed from the following list

- 1) Measurement of resistance by Wheatstone bridge and measurement of bridge sensitivity.
- 2) Measurement of Capacitance by De Sauty’s bridge.
- 3) Design a regulated power supply of given rating (5 V or 9V).
- 4) To determine the Characteristics of Thermistors and RTD.
- 5) Measurement of temperature by Thermocouples.
- 6) To design an astable multivibrator of given specification using IC 555 Timer.
- 7) To design a monostable multivibrator of given specification using IC 555 Timer.
- 8) To design and study the sample and hold circuit.
- 9) To plot the frequency response of a microphone.
- 10) Glow an LED via USB port of PC.
- 11) Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

References for laboratory work:

- 1) Measurement and Instrumentation Principles, A. S. Morris, 2008, Elsevier (Butterworth Heinmann)
- 2) Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino and M. A. Miller, 1990, Mc-Graw Hill

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 5: DIGITAL SIGNAL PROCESSING

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Digital Signal Processing Physics DSE 5	4	2	0	2	--

LEARNING OBJECTIVES

This paper describes the discrete-time signals and systems, Fourier transform representation of aperiodic discrete time signals. This paper also highlights the concept of filters and realization of digital filters. At the end of the syllabus, students will develop an understanding of discrete and fast Fourier transform.

LEARNING OUTCOMES

At the end of this course, students will be able to develop following learning outcomes.

- Students will learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- The student will be in position to understand use of different transforms and analyse the discrete time signals and systems. They will learn to analyse a digital system using z-transforms and discrete time Fourier transforms, region of convergence concepts, their properties and perform simple transform calculations.
- The student will realize the use of LTI filters for filtering different real world signals. The concept of transfer Function and difference-equation system will be introduced. Also, they will learn to solve difference equations.
- Students will develop an ability to analyse DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Students will be able to understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Students will be able to learn the realization of digital filters, their structures, along with their advantages and disadvantages. They will be able to design and understand different types of digital filters such as finite and infinite impulse response filters for various applications.

SYLLABUS OF PHYSICS DSE 5

THEORY COMPONENT

Unit – I

(7 Hours)

Discrete-Time Signals and Systems: Classification of signals, transformations of the independent variable, periodic and aperiodic signals, energy and power signals, even and odd signals, discrete time systems, system properties, impulse response, convolution sum, graphical and analytical method, properties of convolution (general idea), sum property system response to periodic inputs, relationship between LTI system properties and the

impulse response

Unit – II

(9 Hours)

Discrete time Fourier transform: Fourier transform representation of aperiodic discrete time signals, periodicity of DTFT, properties; linearity; time shifting; frequency shifting; differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z- Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Differentiation in the z-Domain; Power Series Expansion Method (General Idea). Transfer Function and Difference-Equation System.

Unit – III

(10 Hours)

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters. Only Qualitative treatment

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation (General Idea), Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution).

Unit – IV

(4 Hours)

Realization of Digital Filters: FIR Filter structures; Direct-Form; Cascade-Form

Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR Filters

References:

Essential Readings:

- 1) Digital Signal Processing, T. K. Rawat, 2015, Oxford University Press, India
- 2) Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
- 3) Principles of Signal Processing and Linear Systems, B. P. Lathi, 1st edition, 2009, Oxford University Press.
- 4) Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press
- 5) Digital Signal Processing Principles Algorithm & Applications, J. G. Proakis and D. G. Manolakis, 4th edition, 2007, Prentice Hall.

Additional Readings:

- 1) Digital Signal Processing, A. Kumar, 2nd edition, 2016, PHI learning Private Limited.
- 2) Digital Signal Processing, P. S. R. Diniz, E. A. B. da Silva and S. L. Netto, 2nd edition, 2017, Cambridge University Press

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Introduction to numerical computation software Scilab/Matlab/Python be introduced in the lab.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab”

References for laboratory work:

- 1) A Guide to MATLAB, B. R. Hunt, R. L. Lipsman and J. M. Rosenberg, 3rd edition, 2014, Cambridge University Press.
- 2) Fundamentals of Digital Signal processing using MATLAB, R. J. Schilling and S. L. Harris, 2005, Cengage Learning.
- 3) Getting started with MATLAB, R. Pratap, 2010, Oxford University Press.