Vidyasagar University

Curriculum for B.Sc. (Honours) in Physics [Choice Based Credit System]

Course	Course Code	Name of the Subjects	Course Type/ Nature	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
CC- 13		**C13T:** Electromagnetic Theory	Core Course-13	4	0	0	6	75
		- **Lab**		0	0	4		
CC- 14		**C14T**: Statistical Mechanics	Core Course-14	4	0	0	6	75
		- **Lab**		0	0	4		
DSE-3		**TBD**	Discipline Specific Electives -3	4	0	0	6	75
				0	0	4		
DSE-4		**TBD**	Discipline Specific Electives -4				4/5 2/1	75
Semester Total							**24**	**300**

L= Lecture, **T**= Tutorial, **P** = Practical, **CC -** Core Course, **TBD -** To be decided, **DSE:** Discipline Specific Elective.

List of Core Course (CC)

CC-13: Electromagnetic Theory

CC-14: Statistical Mechanics

Discipline Specific Electives (DSE)

DSE-3: Medical Physics
Or
DSE-3: Nano Materials and Applications
Or
DSE-3 Communication Electronics

DSE-4: Digital Signal Processing
Or
DSE-4: Biological Physics
Or
DSE-4: Experimental Techniques

Core Courses (CC)

CC-13: Electromagnetic Theory   Credits 06

CC13T: Electromagnetic Theory   **Credits 04**

Course Contents:

Maxwell Equations

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.

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.

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).

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.

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.

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.

Optical Fibres

Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

Suggested Readings:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Optics, E. Hecht, 2016, Pearson.
3. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
4. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
5. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
6. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
7. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
8. 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

C13P: Electromagnetic Theory   (Lab)   Credits 02

List of Practical:

1. To verify the law of Malus for plane polarized light.

2. To determine the specific rotation of sugar solution using Polarimeter.

3. To analyze elliptically polarized Light by using a Babinet's compensator.

4. To study dependence of radiation on angle for a simple Dipole antenna.

5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.

6. To study the reflection, refraction of microwaves.

7. To study Polarization and double slit interference in microwaves.

8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.

9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

11. To verify the Stefan`s law of radiation and to determine Stefan's constant.

12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Suggested Readings:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

2. Advanced level Physics Practical, 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

CC-14: Statistical Mechanics   Credits 06

CC14T: Statistical Mechanics   Credits 04

Course Contents:

Classical Statistical Mechanics

Macrostate & Microstate, Elementary Concept of Ensemble, Microcanonical ensemble, Phase Space, Entropy and Thermodynamic Probability, Canonical ensemble, 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. Grand canonical ensemble and chemical potential.

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.

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.

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.

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.

Suggested Readings:

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

7. Statistical Mechanics – an elementary outline, A. Lahiri, 2008, Universities Press

C14P: Statistical Mechanics (Lab)   **Credits 02**

List of Practical:

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 $Z(\square)$ 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 $Z(\square)$, average energy $<E>$, energy fluctuation $\square E$, 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

Suggested Readings:

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.

Discipline   Specific Electives (DSE)

DSE-3: Medical Physics   Credits 06

DSE3T: Medical Physics   **Credits 04**

Course Contents:

Physics of the Body-I

Basic Anatomical Terminology: Standard Anatomical Position, Planes. Familiarity with terms like-Superior, Inferior, Anterior, Posterior, Medial, Lateral, Proximal and Distal. **Mechanics of the body:** Skeleton, forces, and body stability. Muscles and dynamics of body movement. Physics of Locomotors Systems: joints and movements, Stability and Equilibrium. **Energy household of the body:** Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation. **Pressure system of body:** Physics of breathing, Physics of cardiovascular system.

Physics of the Body-II

Acoustics of the body: Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. **Optical system of the body:** Physics of the eye. **Electrical system of the body:** Physics of the nervous system, Electrical signals and information transfer.

Physics of Diagnostic and Therapeutic Systems-I (X-Rays)

X Ray: Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. **X-ray tubes & types:** Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit. Single and three phase electric supply. Power ratings. Types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables.

Radiation Physics

Radiation units exposure, absorbed dose, units: rad, grey, relative biological effectiveness, effective dose- Rem & Sievert, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, linear attenuation coefficient. **Radiation Detectors:** ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid State detectors, TFT.

Medical Imaging Physics

Evolution of Medical Imaging, X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. **Radiography:** Filters, grids, cassette, X-ray film, film processing, fluoroscopy. **Computed tomography scanner**- principle and function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display).

Radiation Oncology Physics

External Beam Therapy (Basic Idea): Telecobalt, Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. **Contact Beam Therapy (Basic Idea):** Brachytherapy- LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines, Medical linear accelerator. Basics of Teletherapy units, deep X-ray, Telecobalt units, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume.

Radiation and Radiation Protection

Principles of radiation protection, protective materials-radiation effects, somatic, genetic stochastic and deterministic effect. **Personal monitoring devices:** TLD film badge, pocket dosimeter, OSL dosimeter. Radiation dosimeter. Natural radioactivity, Biological effects of radiation, Radiation monitors. Steps to reduce radiation to Patient, Staff and Public. Dose Limits for Occupational workers and Public. AERB: Existence and Purpose.

Physics of Diagnostic and Therapeutic Systems- II

Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography. **Therapeutic nuclear medicine:** Interaction between radiation and matter Dose and isodose in radiation treatment. Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes.

Suggested Readings:

1. Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
2. Basic Radiological Physics Dr. K. Thayalan - Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
3. Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
4. Physics of the human body, Irving P. Herman, Springer (2007).
5. Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3rd edition (2003)
6. The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
7. Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I. Publication Pvt Ltd.
8. The Physics of Radiology-H E Johns and Cunningham.

DSE3P: Medical Physics (Lab)   **Credits 02**

List of Practical:

1. Understanding the working of a manual Hg Blood Pressure monitor and measure the Blood Pressure.
2. Understanding the working of a manual optical eye-testing machine and to learn eye-testing procedure.

3. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.

4. Correction of Hypermetropia/Hyperopia (long sightedness) using a combination of lenses on an optical bench/breadboard.

5. To learn working of Thermoluminescent dosimeter (TLD) badges and measure the background radiation.

6. Familiarization with Geiger-Muller (GM) Counter and to measure background radiation.

7. Familiarization with Radiation meter and to measure background radiation.

8. Familiarization with the Use of a Vascular Doppler.

Suggested Readings:

1. Basic Radiological Physics, Dr. K. Thayalan - Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)

2. Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)

3. Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3rd edition (2003)

4. The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)

5. Handbook of Physics in Diagnostic Imaging: Roshan S. Livingstone: B. I. Publications Pvt Ltd.

6. The Physics of Radiology-H E Johns and Cunningham.

Or

DSE-3: Nano Materials and Applications   Credits 06

DSE3T: Nano Materials and Applications   Credits 04

Course Contents:

Nanoscale Systems

Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well,

potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

Synthesis of Nanostructure Materials

Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

Characterization

X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy.

Optical Properties

Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostructures and nanostructures.

Electron Transport

Carrier transport in nanostrucutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

Applications

Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

Suggested Readings:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).

2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).

3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).

4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).

6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.

7. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

DSE3B: Nano Materials and Applications (Lab)   Credits 02

List of Practical:

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

Suggested Readings:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).

3. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).

4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

Or

DSE-3: Communication Electronics   Credits 06

DSE3T: Communication Electronics   **Credits 04**

Course Contents:

Electronic communication

Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

Analog Modulation

Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

Analog Pulse Modulation

Channel capacity, sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

Digital Pulse Modulation

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).

Introduction to Communication and Navigation systems:

Satellite Communication - Introduction, need, geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink.

Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only).

GPS navigation system (qualitative idea only).

Suggested 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 Edn, 1999, Tata McGraw Hill.
4. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
5. Communication Systems, S. Haykin, 2006, Wiley India
6. Electronic Communication system, Blake, Cengage, 5th edition.
7. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

DSE3P: Communication Electronics (Lab)   Credits 02

List of Practical

1. To design an Amplitude Modulator using Transistor.
2. To study 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 study Pulse Amplitude Modulation (PAM).
8. To study Pulse Width Modulation (PWM).
9. To study Pulse Position Modulation (PPM).
10. To study ASK, PSK and FSK modulators.

Suggested Readings:

1. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.

2. Electronic Communication system, Blake, Cengage, 5th edition.

DSE-4: Digital Signal Processing   Credits 06

DSE4T: Digital Signal Processing   Credits 04

Course Contents:

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 Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response.

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; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations.

Filter Concepts

Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.

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, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing.

Fast Fourier Transform

Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.

Realization of Digital Filters

Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I.

Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.

Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method.

Suggested Readings:

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India

2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.

3. Modern Digital and Analog Communication Systems, B.P. Lathi, 1998, 3rd Edn. Oxford University Press.

4. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.

5. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.

6. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

DSE4P: Digital Signal Processing (Lab)   **Credits 02**

List of Practical

Simulations experiments based problems like:

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence u(n), (c) ramp sequence r(n) , (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \le n \le 50$

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself or N=5

$$x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \le n \le N \\ 0 & otherwise \end{cases}$$

3. An LTI system is specified by the difference equation

$$y(n) = 0.8y(n-1) + x(n)$$

   a. Determine $H(e^{jw})$
   b. Calculate and plot the steady state response $y_{ss}(n)$ to

$$x(n) = cos(0.5\pi n)u(n)$$

4. Given a casual system

$$y(n) = 0.9y(n-1) + x(n)$$

   a. Find H(z) and sketch its pole-zero plot
   b. Plot the frequency response $IH(e^{jw})I$ and $<H(e^{jw})$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = sin\ 7t + sin\ 200t$. The sampling frequency is fs = 500 Hz. Plot its pole zero diagram, magnitude response, input and output of the filter.

6. Let *x(n)* be a 4-point sequence:

$$x(n) = \frac{\{1,1,1,1\}}{\uparrow} = \begin{cases} 1 & 0 \le n \le 3 \\ 0 & otherwise \end{cases}$$

   Compute the DTFT $x(e^{jw})$ and plot its magnitude

   a. Compute and plot the 4 point DFT of x(n).
   b. Compute and plot the 8 point DFT of x(n) (by appending 4 zeros).
   c. Compute and plot the 16 point DFT of x(n) (by appending 12 zeros).

7. Let x(n) and h(n) be the two 4-point sequences,

$$x(n) = \{1, 2, 2, 1\}$$
$$\qquad\qquad\uparrow$$

$$h(n) = \{1, -1, -1, 1\}$$
$$\qquad\qquad\uparrow$$

Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications: pass band edge F_p = 2 KHz stop band edge Fs = 5 KHz Pass band attenuation A_p = 2 dB Stop band attenuation A_s = 42 dB Sampling frequency F_s = 20 KHz

10. The frequency response of a linear phase digital differentiator is given by

$$Hd\ (e^{jw}) = jwe^{-jrw} \qquad |w| \leq \pi$$

 Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

Suggested Readings:

1. Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.

2. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

3. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.

4. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.

5. Fundamentals of signals and systems, P.D. Chaand J.I. Molinder, 2007, Cambridge University Press.

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

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Or

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DSE-4: Biological Physics   **Credits 06**

DSE4T: Biological Physics   **Credits 06**

Course Contents:

Overview

The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.

Molecules of life

Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.
Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.
Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.

The complexity of life

At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem.

At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.
Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics.

At the level of an ecosystem and the biosphere: Food webs. Feedback cycles and self - sustaining ecosystems.

Evolution

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

Suggested Readings:

1. Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)

2. Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)

3. Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)

4. An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)

5. Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

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Or

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DSE-4: Experimental Techniques   **Credits 06**

DSE4T: Experimental Techniques   **Credits 04**

Course Contents:

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.

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.

Shielding and Grounding

Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.

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.

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.

Impedance Bridges and Q-meter

Block diagram and working principles of RLC Bridge. Q - meter and its working operation. Digital LCR bridge.

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).

Suggested Readings:

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

DSE4P: Experimental Techniques (Lab)   **Credits 02**

List of Practical

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.

Suggested Readings:

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.

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