Introduction

Content: The learning outcomes-based curriculum framework for a B.Sc degree in Physics is intended to provide a broad
framework within which Physics programmes that respond to the needs of students and to the evolving nature of Physic
subject could be developed. The framework is expected to assist in the maintenance of the standard of Physics
degrees/programmes across the country and periodic programme review within a broad framework of agreed expected
graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The
framework, however, does not seek to bring about uniformity in syllabi for a programme of study in Physics, or in teachi
learning process and learning assessment procedures. Instead, the framework is intended to allow for flexibility and
innovation in programme design and syllabi development, teaching-learning process, assessment of student learning lev

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Learning Outcome based approach to Curriculum Planning
>> Nature and extent of the B.Sc/B.A./B.Com Programme

Content: Physics is normally referred to as the natural science that studies systematically the laws of Nature operating a
diverse length scales (from sub-atomic scales to the entire universe) and their consequences. The scope of Physics as a
subject is very broad. The key areas of study within the disciplinary/subject area of Physics comprise: Classical and Qua
Mechanics, Thermal and Statistical Physics, Nuclear, Atomic and Particle Physics, Optics. Laser and Spectroscopy, Solid
Physics and Materials Science, Electronics, Astrophysics and so on to name a few. Each topic area deals with various asp
of nature as evident from their names in great detail with mathematical descriptions and understanding.

Degree programmes in Physics cover topics that overlap with the areas outlined above and that address the interfaces o
Physics with other subjects (such as Biophysics and Chemical Physics) and with applied fields (such as Environmental Ph
Materials Physics etc.). The depth and breadth of study of ndividual topics dealt with would vary with the nature of speci
Physics programmes. As a part of the efforts to enhance the employability of graduates of Physics programmes, the curr
for these programmes are expected to include learning experiences that offer opportunities for a period of study in indus
These may involve both a major work-related Physics project and some guided study.

Learning Outcome based approach to Curriculum Planning
>> Aims of Bachelor's degree programme in (CBCS) B.SC.(HONS.) PHYSICS

Content: The overall aims of bachelor's degree programme in Physics are to:

- provide students with learning experiences that help instill deep interests in learning Physics, develop broad and balar knowledge and understanding of key concepts, principles, and theories related to Physics and equip students with appro tools of analysis to tackle issues and problems in the field of Physics.

- develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoreti and applied problems in Physics.

- provide students with the knowledge and skill base that would enable them to undertake further studies in Physics an related areas or in multidisciplinary areas that involve Physics and help develop a range of generic skills that are relevan wage employment, self-employment and entrepreneurship.

Graduate Attributes in Subject
>> Disciplinary knowledge

Content: Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, theoretical princ
and experimental findings in Physics and its different subfields (Classical and Quantum Mechanics, Thermal and Statistic
Physics, Nuclear, atomic and particle Physics, Optics. Laser and Spectrocopy, Solid State Physics and Materials Science,
Electronics, Astrophysics etc.), and other related fields of study, including broader interdisciplinary subfields such as life

science, environmental science and material sciences; (ii) ability to use modern instrumentation for analysis and interpretations.

Graduate Attributes in Subject
>> Communication Skills

Content: Ability to transmit complex technical information relating to Physics in a clear and concise manner in writing an oral skills.

Graduate Attributes in Subject
>> Critical thinking

Content: Ability to employ critical thinking in the various basic areas of Physics.

Graduate Attributes in Subject
>> Problem solving

Content: Ability to efficient problem solving skills in the various basic areas of Physics.

Graduate Attributes in Subject
>> Analytical reasoning

Content: Capability for asking relevant/appropriate questions relating to issues and problems in the field of Physics, and planning, executing and
reporting the results of an experiment or investigation.

Graduate Attributes in Subject
>> Research-related skills

Content: Capability for asking relevant/appropriate questions relating to issues and problems in the field of Physics, and planning, executing and
reporting the results of an experiment or investigation.

Graduate Attributes in Subject
>> Cooperation/Team work

Content: Capable of working effectively in diverse teams in both classroom, laboratory and in industry and field-based situations.

Graduate Attributes in Subject
>> Leadership readiness/qualities

Content: Capable of identifying/mobilising appropriate resources required for a project, and manage a project through t
completion, while observing responsible and ethical scientific conduct; and safety regulations and practices.

Graduate Attributes in Subject
>> Information/digital literacy

Content: Capable of using computers for Physics simulation and computation and appropriate software for analysis of da
and employing modern library search tools to locate, retrieve, and evaluate Physics -related information.

Graduate Attributes in Subject
>> Moral and ethical awareness/reasoning

Content: Avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagia
and appreciate environmental and sustainability issues.

Graduate Attributes in Subject
>> Lifelong learning

Content: Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/
development and reskilling.

Qualification Description

Content: The qualification descriptors for a B.Sc (Honours) programme in Physics may include the following:

- Demonstrate (i) a systematic, extensive and coherent knowledge and understanding of the academic field of study as
whole and its applications, and links to related disciplinary areas/subjects of study; including a critical understanding of
established theories, principles and concepts, and of a number of advanced and emerging issues in the field of Physics;
procedural knowledge that creates different types of professionals related to the subject area of Physics, including resea
and development, teaching and government and public service; (iii) skills in areas related to one's specialization area an
current developments in the academic field of Physics, including a critical
understanding of the latest developments in the area of specialization, and an ability to use established techniques of an
and enquiry within the area of specialisation.

- Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to Physics, and techniques and skills required for identifying Physics-related problems and issues.

- Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative data drawing wide range of sources, analysis and interpretation of data using methodologies as appropriate to the subject of Physics f formulating evidence-based solutions and arguments

- Use knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and is relating to the academic field of Physics.
- Communicate the results of studies undertaken in the academic field of Physics accurately in a range of different cont using the main concepts, constructs and techniques of the subject of Physics

- Address one’s own learning needs relating to current and emerging areas of study relating to Physics, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge Physics.

- Apply one’s knowledge and understanding relating to Physics and transferable skills to new/unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.

- Demonstrate subject-related and transferable skills that are relevant to some of the Physics-related jobs and employn opportunities.

Programme Learning Outcome in course

Content: Some examples of expected learning outcomes (subject-specific skills, generic/global skills and attributes) that undergraduate student of a programme of study in Physics should be able to demonstrate for the award of the qualificat may include the following:

- Demonstrate (i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different lea areas and applications, and its linkages with related disciplinary areas/subjects; (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in rese and development, teaching and government/public service; (iii) skills in areas related to one’s specialization area within disciplinary/subject area of Physics and current and emerging developments in the field of Physics.

- Demonstrate the ability to use Physics skills such as formulating and tackling Physics-related problems and identifying applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.

- Recognise the importance of mathematical modeling and computing, and the role of approximation and mathematical approaches to describing the physical world.

- Plan and execute physics-related experiments or investigations, analyse and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Physics.

- Demonstrate relevant generic skills and global competencies such as (i) problem solving skills that are required to sol different types of physics-related problems with well-defined solutions, and tackle open-ended problems that may cross disciplinary-area boundaries; (ii)investigative skills, including skills of independent investigation of physics-related issues problems; (iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically to present complex information in a concise manner to different groups/audiences; (iv) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to physics; (v) ICT skills (vi) personal skills such as the ability to work both independently an group.

- Demonstrate professional behaviour such as (i) being objective, unbiased and truthful in all aspects of work and avoid unethical behavior such as fabricating, falsifying or misrepresenting data or to commiting plagiarism; (ii) the ability to id the potential ethical issues in work-related situations; (iii) appreciation of intellectual property, environmental and sustainability issues; and (iv) promoting safe learning and working environment.

Teaching-Learning Process

Content: As a programme of study in Physics is designed to encourage the acquisition of disciplinary/subject knowledge, understanding, and academic and professional skills required for Physics-based professions and jobs, learning experienc should be designed and implemented to foster active/participative learning. Development of practical skills will constitut important aspect of the teaching-learning process. A variety of approaches to teaching-learning process, including lectur seminars, tutorials, workshops, peer teaching and learning, practicum and project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, games, technology-enable learning, internship in industry and research establishments etc. will need to be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Assessment Methods

Content: The assessment of students' achievement in Physics will be aligned with the course/programme learning outco and the academic and professional skills that the programme is designed to develop. A variety of assessment methods t are appropriate within the disciplinary area of Physics will be used. Learning outcomes will be assessed using the followi oral and written examinations, closed-book and open-book tests; problem-solving exercises, unseen problems in examinations, practical assignment laboratory reports, observation of practical skills, individual project reports, seminar presentation; viva voce interviews; computerized adaptive testing, literature surveys and evaluations, outputs from collaborative work, etc.

Analog Systems and Applications
(32221403)
Core Course - (CC) Credit:6

Course Objective(2-3)

1. This is one of the core papers in physics curriculum where students will get to learn about the physics of semiconductor p-n junction and devices such as rectifier diodes, Zener diode, photodiode etc. and bipolar juncti transistors.

2. Transistor biasing and stabilization circuits are explained. The concept of feedback is discussed in amplifiers a the oscillator circuits are also studied.

3. By the end of the syllabus, students will also have an understanding of operational amplifiers and their applications.

Course Learning Outcomes

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

- *To have knowledge about characteristics of semiconductor materials in terms of band structure, movement of charge carriers and to explain properties of n and p type semiconductors.*
- *To know the basic concepts of PN junction diode, its fabrication, conduction mechanism and determine its barrier potential and width.*
- *To learn structure and operation of simple PN junction devices such as LED, photo diodes, Solar cells, Zener diodes etc.*
- *To apply the basics of diodes to describe working of rectifier circuits and quantitatively explain effect of capacitance filter, line and load regulation*
- *To understand the structure and operation of Bipolar Junction transistors. Also be able to explain various current components and characteristics of different configurations.*
- *To describe the application of transistors for current and voltage applications, need for biasing and stabilization in transistor amplifiers.*
- *To analyze single stage CE and two stage RC coupled transistor amplifier using h-parameter model of the transistor.*

- *To ingest the effect of feedback in amplifiers and apply them to design different type of oscillators.*

- *To distinguish ideal and practical op-amps, comprehend need for op-amps and their electrical parameters.*

- *To understand various operating modes of Op-amps and its linear and non-linear application and acquire skill to design circuits for different Op-amp applications.*

Unit 1

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram.Conductivity and Mobility, Concept of Drift velocity.PN Junction Fabrication (Simple Idea).Barrier Formation in PN Junction Diode. Derivation for Barrier Potential, Barrier Width and Current for abrupt Junction.Equation of continuity, Current Flow Mechanism in Forward and Reverse Biased Diode. (9 Lectures)

Unit 2

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, (2) Zener Diode and Voltage Regulation.Principle, structure and characteristics of (1) LED, (2) Photodiodeand (3) Solar Cell, Qualitative idea of Schottky diode and Tunnel diode. (7 Lectures)

Unit 3

Bipolar Junction transistors: n-p-n and p-n-p Transistors. I-V characteristics of CBand CE Configurations.Active, Cutoff and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. (6 Lectures)

Unit 4

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network.h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. (10 Lectures)

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.

(4 Lectures)

Unit 5

Feedback in Amplifiers: Positive and Negative Feedback. Effect of negative feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. (4 Lectures)

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency.Hartley &Colpitts oscillators. (4 Lectures)

Unit 6

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. (4 Lectures)

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Comparator and Zero crossing detector (8) Wein bridge oscillator. (9 Lectures)

Conversion:D/A Resistive networks (Weighted and R-2R Ladder). Accuracy and Resolution. (3 Lectures)

Practical

PHYSICS PRACTICAL-C X LAB

60 Periods

At least 08 experiments from the following:

1. To study the V-I characteristics of a Zener diode and its use as voltage regulator.

2. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.

3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.

4. To study the various biasing configurations of BJT for normal class A operation.

5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.

6. To study the frequency response of voltage gain of a two stage RC-coupled transistor amplifier.

7. To design a Wien bridge oscillator for given frequency using an op-amp.

8. To design a phase shift oscillator of given specifications using BJT.

9. To design a digital to analog converter (DAC) of given specifications.

10. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain

11. (a) To design inverting amplifier using Op-amp(741,351) & study its frequency response

(b) To design non-inverting amplifier using Op-amp (741,351) & study frequency response

12. (a) To add two dc voltages using Op-amp in inverting and non-inverting mode

(b) To study the zero-crossing detector and comparator.

13. To design a precision Differential amplifier of given I/O specification using Op-amp.

14. To investigate the use of an op-amp as an Integrator.

15. To investigate the use of an op-amp as a Differentiator.

16. To design a circuit to simulate the solution of simultaneous equation and 1st/2ndorder differential equation.

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Keywords

Semiconductor, Diodes, Drift current, Diffusion current, Barrier height, Barrier width, transistor, amplifiiers, oscillators, Positive Feedback, Negative feedback

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Digital Systems and Applications
(32221303)
Core Course - (CC) Credit:6

Course Objective(2-3)

1. This is one of the core papers in physics curriculum which introduces the concept of Boolean algebra and the basic digital electronics.

2. In this course, students will be able to understand the working principle of CRO, Data processing circuits, Arithmetic Circuits, sequential circuits like registers, counters etc. based on flip flops.

3. In addition, students will get an overview of microprocessor architecture and programming.

Course Learning Outcomes

This course lays the foundation for understanding the digital logic circuits and their use in combinational and sequential logic circuit design. It also imparts information about the basic architecture, memory and input/output organization in a microprocessor system. The students also learn the working of CRO.

• Course learning begins with the basic understanding of active and passive components. It then builds the concept of Integrated Chips(IC): its classification and uses.

• Differentiating with the Analog and Digital circuits, the concepts of number systems like Binary, BCD, Octal and hexadecimal are developed to elaborate and focus on the digital systems.

• Explains the concepts of logic states and logic gates AND, OR, NOT, NAND, NOR, XOR and XNOR as fundamental, universal and derived gates with its utility.

• Covers the realization of NOT, OR and AND gates using diodes and transistors.

• Students learn how to write logical Boolean statements using the truth table, its simplification using Boolean Algebra, De-Morgan's Theorem and Karnaugh Maps specially the Sum of Products method and realize the corresponding logic circuit.

• Understanding and usage of various important categories of circuits are imparted.

a) Data Processing Circuits that are used in communication systems for data selection and transmission.

b) Some combinational circuits that perform arithmetic functions like addition and subtraction.

c) Sequential Circuits: Beginning with the basic memory elements Flips-Flops, it develops to more elaborate circuits like shift registers and 4-bits counters.

d) Timer circuits using IC 555 to provide clock pulses to sequential circuits and develop multivibrators.

• Expose students to the Input/output devices, memory organization, memory interfacing and maps in computer systems.

• Introduces to basic architecture of processing in an Intel 8085 microprocessor and to Assembly Language.

• Also impart understanding of working of CRO and its usage in measurements of voltage, current, frequency and phase measurement.

Unit 1

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

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

Unit 2

Boolean algebra: 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. (7 Lectures)

Data processing circuits: Multiplexers, De-multiplexers, Decoders, Encoders. (4 Lectures)

Unit 3

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

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. (6 Lectures)

Unit 4

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

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

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

Unit 5

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

Unit 6

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing and Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. (10 Lectures)

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

Practical

PHYSICS PRACTICAL-C VII LAB

60 Periods

At least 06 experiments each from section A and Section B

Section-A: Digital Circuits Hardware design/Verilog Design

1. To design a combinational logic system for a specified Truth Table.

(a) To convert Boolean expression into logic circuit &design it using logic gate ICs.

(b) To minimize a given logic circuit.

2. Half Adder, Full Adder and 4-bit binary Adder.

3. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.

4. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.

5. To build JK Master-slave flip-flop using Flip-Flop ICs

6. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.

7. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.

8. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO and to design an astable multivibrator of given specifications using 555 Timer.

9. To design a monostable multivibrator of given specifications using 555 Timer.

Section-B:Programs using 8085 Microprocessor:

1. Addition and subtraction of numbers using direct addressing mode

2. Addition and subtraction of numbers using indirect addressing mode

3. Multiplication by repeated addition.

4. Division by repeated subtraction.

5. Handling of 16-bit Numbers.

6. Use of CALL and RETURN Instruction.

7. Block data handling.

8. Parity Check

9. Other programs (e.g. using interrupts, etc.).

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Keywords

CRO, Logic gates, Multiplexer, Demultiplexer, Boolean algebra, Counters, Shift Registers, Flip-Flop, Multivibrator Microprocessor

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Electricity and Magnetism
(32221201)
Core Course - (CC) Credit:6

Course Objective(2-3)

Electricity and Magnetism is one of the core courses in Physics curriculum. The course covers static and dynamic electric and magnetic field, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. By the end of the course student should be able to appreciate Maxwell’s equations and analyze electrical circuits using network theorems.

Course Learning Outcomes

1. Demonstrate the application of Coulomb’s law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.

2. Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution.

3. Exploit alternative coordinate systems (cylindrical and spherical coordinates) to solve problems.

4. Apply Gauss’s law of electrostatics to solve a variety of problems.

5. Demonstrate an understanding of electric dipoles and the role of molecular dipoles in the electrostatic response of dielectrics.

6. Demonstrate an understanding of the behavior of electric conductors.

7. Demonstrate a working understanding of capacitors.

8. Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot-Savart and Ampere laws)

9. Understand the concepts of induction and self-induction, to solve problems using Faraday’s and Lenz’s laws and analyze and solve RL circuits

10. Deal with electromagnetic oscillations, AC currents and oscillation circuits and analyze and solve LCR circuits

11. Understand the basics of electrical circuits and analyze circuits using Network Theorems.

Unit 1

Electric Field and Electric Potential
Electric field: Electric field lines. Electric flux. Gauss’ Law with applications to charge distributions with spherical, cylindrical and planar symmetry.(6 Lectures)
Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace’s and Poisson equations.The Uniqueness Theorem.Potential and Electric Field of a dipole. Force and Torque on a dipole. (6 Lectures)

Electrostatic energy of system of charges.Electrostatic energy of a charged sphere.Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. (10 Lectures)

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss’ Law in dielectrics. (8 Lectures)

Unit 2

Magnetic Field:Magnetic force between current elements and definition of Magnetic FieldB. Biot-Savart’s Law and its simple applications: straight wire and circular loop.Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole).Ampere’s Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements.Torque on a current loop in a uniform Magnetic Field. (9 Lectures)

Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability.Relation between B, H, M. Ferromagnetism.B-H curve and hysteresis. (4 Lectures)

Electromagnetic Induction: Faraday’s Law. Lenz’s Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell’s Equations. Charge Conservation and Displacement current. (6 Lectures)

Unit 3

Electrical Circuits: AC Circuits: Kirchhoff’s laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. (5 Lectures)

Network theorems: Ideal constant-voltage and constant-current Sources. Review of Kirchhoff’s Current Law& Kirchhoff’s Voltage Law. Mesh &Node Analysis. Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity Theorem, Maximum Power Transfer theorem. Applications to dc circuits. (6 Lectures)

Practical

At least 6 experiments from the following

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To compare capacitances using De'Sauty's bridge.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge sensitivity, current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine the mutual inductance of two coils by Absolute method.

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- Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- Electricity and Magnetism, J.H.Fewkes& J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
- Network, Lines and Fields, John D. Ryder, 2nd Edn., 2015, Pearson.
- Schaum's Outline of Electric Circuits, J. Edminister& M. Nahvi, 3rd Edn., 1995, McGraw Hill.
- Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011,Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- Engineering Practical Physics, S.Panigrahiand B.Mallick,2015, Cengage Learning.

Teaching Learning Process

- Chalk and Blackboard approach
- Group discussion in the class
- PPT presentation on special topics.

Assessment Methods

- Assignments
- Class test
- Semester end examination

Electro-magnetic Theory
(32221601)
Core Course - (CC) Credit:6

Course Objective(2-3)

Electromagnetic theory is a core course in B. Sc. (Honours) Physics curriculum. The course covers Maxwell's equations, propagation of electromagnetic (em) waves in different homogeneous-isotropic as well as anisotropic unbounded and bounded media, production and detection of different types of polarized em waves, general information as waveguides and fibre optics.

Course Learning Outcomes

1. Concept of Maxwell Equations
2. Understanding of Poynting Theorem and poynting vector.
3. Physical concept of Electromagnetic field energy density.
4. Electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma.
5. Electromagnetic wave propagation in bounded media.
6. Polarization of Electromagnetic Waves: Linear, Circular and Elliptical Polarization.
7. Knowledge of phase retardation plates Quarter-Wave and Half-Wave Plates.
8. Babinet Compensator and its uses.
9. Experimental verification of Fresnel’s theory.
10. Details of Wave Guides: Planar optical wave guides.

Unit 1

Maxwell Equations: Review of Maxwell’s equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density.Physical Concept of Electromagnetic Field Energy Density. Momentum Density and Angular Momentum Density. (12 Lectures)

Unit 2

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

Unit 3

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

Unit 4

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

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

Unit 5

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

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

Practical

At least 06 experiments from the following
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 Boltzmann constant using V-I characteristics of PN junction diode.
13. To find Numerical Aperture of an Optical Fibre.
14. To verify Brewster's Law and to find the Brewster's angle.

References

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd Ed., 2003, CBS Publisher.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- Electromagnetic field theory fundamentals, B.Guru and H.Hiziroglu, 2015, Cambridge University Press
- Classical Electrodynamics, J.D. Jackson, 3rd Edn., 2010, Wiley
- Principle of Optics, M. Born and E. Wolf, 6th Edn., 1980, Pergamon Press
- Optics, A. Ghatak, 5th Edn., 2012, Tata McGraw Hill Education.
- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Teaching Learning Process

- Chalk and Blackboard approach
- Group discussion in the class
- PPT presentation on special topics.

Assessment Methods

- Assignments
- Class test
- Semester end examination

Elements of Modern Physics
(32221402)
Core Course - (CC) Credit:6

Course Objective(2-3)

This course introduces modern development in Physics that ushered in relativity and quantum physics which not only revolutionized mankind's understanding of time, space, atomic and sub-atomic structures that make up the matter around us, but also led to fascinating developments in technology that are being witnessed all around us.

Beginning with technological marvels like electronics, spectroscopy, semiconductor based devices, IC chips, lasers, harnessing of nuclear energy, satellite communication, atomic clocks, GPS, space travel, scanni tunneling microscope, nano-materials, nano- technology, CCDs, etc. modern physics brought forth useful tools in our daily lives like laptop computers, mobile phones, laser pointers, LEDs, LCD screens, so on and so forth. Therefore, the objective of this course is to teach the physical and mathematical foundations necessary for learning variou topics in modern physics.

Starting from Planck’s law, this course introduces experimental observation of photo-ejection of electrons, idea of wave-particle duality as well as Bohr model of atoms and, then it develops the formulation of Schrodinger equation and the idea of probability interpretation associated with wave-functions.

It also introduces basic underlying concepts involved in laser physics as well as that in nuclear physics, so crucia for high energy physics, nuclear technology and astrophysics.

Course Learning Outcomes

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

1. Students will be acquainted with the modern developments in Physics.
2. Students will develop the idea of wavefunction and its probability interpretation and also the formulation of Schrodinger equation for any physical or Quantum mechanical system.
3. Student can correlate the uncertainty principle in real situations to measure the parameters such as energy with time or position with momentum.
4. Students will also be acquainted with the basic concepts of nuclear physics.

Unit 1

Planck’s quantum, Planck’s constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets.Group and Phase velocities and relation between them. Double-slit experiment with electrons. Probability. Wave amplitude and wave functions.

(12 Lectures)

Unit 2

Position measurement : gamma ray microscope thought experiment; Wave-particle duality leading to Heisenberg uncertainty principle; Uncertainty relations involving canonical pair of variables: Derivation from Wave Packets; Impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle: origin of natural width of emission lines as well as estimation of the mass of the virtual particle that mediates a force from the observed range of the force (7 Lectures)

Unit 3

Two-slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. (10 Lectures)

Unit 4

One dimensional infinitely rigid box : energy eigenvalues, eigenfunctions and their normalization; Quantum dot as an example;

Quantum mechanical scattering and tunneling in one dimension : across a step potential & across a rectangular potential barrier.

Lasers: Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. (14 Lectures)

Unit 5

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy. (6 Lectures)

Unit 6

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Fission : nature of fragments and emission of neutrons. Fusion and thermonuclear reactions driving stellar evolution (brief qualitative discussions). (11 Lectures)

Practical

AT LEAST 5 EXPERIMENTS FROM THE FOLLOWING:

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.

2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of Planck’s constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor & compare with incoherent source– Na.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

References

- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, Cengage Learning 2010
- Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.

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- Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W.

Savin, 2 nd Edn, Tata McGraw-Hill Publishing Co. Ltd.

- Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill

Additional Resources:

- Six Ideas that Shaped Physics:Particle Behave like Waves, T.A.Moore,2003, McGraw Hill
- Thirty years that shook physics: the story of quantum theory, George Gamow, Garden City, NY : Doubleday, 1966
- Quantum Theory, David Bohm, Dover Publications, 1979
- Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

Teaching Learning Process

This course will provide analytical understanding of the following topics:

1. Students will be acquainted with the modern developments in Physics.
2. Students will develop the idea of wavefunction and its probability interpretation and also the formulation of Schrodinger equation for any physical or Quantum mechanical system.
3. Student can correlate the uncertainty principle in real situations to measure the parameters such as energy with time or position with momentum.
4. Students will also be acquainted with the basic concepts of nuclear physics.

Keywords

Modern Physics, Wavefunction, Probability, Stationary states, Schrodinger Equation, Particle in 1-D Rigid Box, Tunneling Effect, Potential Barrier, Step Potential, Radioactivity, Nuclear Fission and Fusion, Nucleus, Lasers, Semiconductor laser, Spontaneous Emission, Stimulated Emission.

Mathematical Physics - I
(32221101)
Core Course - (CC) Credit:6

Course Objective(2-3)

- The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists.
- To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems
- To help students develop critical skills and knowledge that will prepare them not only for doing fundament and applied research but also prepare them for a wide variety of careers.

Course Learning Outcomes

Theory:
After completing this course, student will be able to

- approximate single and multi-variable function by Taylor's Theorem.
- Solve first order differential equations and apply it to physics problems
- solve linear second order homogeneous and non-homogeneous differential equations with constant coefficients.
- Calculate partial derivatives of function of several variables
- Understand the concept of gradient of scalar field and divergence and curl of vector fields.
- perform line, surface and volume integration
- Use Green's, Stokes' and Gauss's Theorems to compute integrals

Practical:
After completing this course, student will be able to

- design, code and test simple programs in python
- learn Monte Carlo techniques,
- fit a given data to linear function using method of least squares
- find roots of a given non-linear function
- Use above computational techniques to solve physics problems

Unit 1

Calculus:Plotting of functions. Approximation: Taylor and binomial series (statements only). First Order Differential equations (variable separable, homogeneous, non-homogeneous),exact and inexact differential equations and Integrating Factor. Application to physics problems. **(6 Lectures)**

Unit 2

Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution.Particular Integral with operator method, method of undetermined coefficients and variation method of parameters. Application to physics problems. Euler differential equation and simultaneous differential equations of First and Second order. **(15 Lectures)**

Unit 3

Vector Algebra:

Properties of vectors. Scalar product and vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

(6 Lectures)

Unit 4

Vector Calculus

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field.Del and Laplacian operators. Vector identities.

(10 Lectures)

Unit 5

Vector Integration

Ordinary Integrals of Vectors. Double and Triple integrals, change of order of integration, Jacobian.Notion of infinitesimal line, surface and volume elements.Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes' Theorems and their verification (no rigorous proofs).

(16 Lectures)

Unit 6

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(7 Lectures)**

Practical

PHYSICS LAB-CI LAB:

60 Periods

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- *Highlights the use of computational methods to solve physics problems.*
- *The course will consist of lectures (both theory and practical) in the Lab. The recommended group size is not more than 15 students.*
- *Evaluation to be done on the basis of formulating the problem and using computational techniques to solve it.*
- *At least 12 programs must be attempted covering the entire syllabus.*
- *The list of programs here is only suggestive. Students should be encouraged to do more practice.*

Introduction and Overview: Brief introduction to computer architecture and organization, memory and Input/output devices

Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, single and double precision arithmetic, machine epsilon, underflow and overflow.

Algorithms and Flow charts: writing algorithms: Sequence, Selection and Repetition. Purpose, symbols and description of flow charts.

Introduction to Python: The Python Interpreter, Basic Syntax, Variable and assignment, Data Types, Conversion & casting, Mathematical, Relational, Logical Operators. Precedence of Operators, Expressions and Statements, input and output, importing 'math' module and use of its functions
Programs: (1)To calculate area of a rectangle and circle, (2)volume of a sphere (3) converting plane polar to Cartesian coordinates and vice versa.

Control Statements: if, if-else, nested if-,Else-if statement, Unconditional and Conditional looping, While loop, For loop, nested loops, break, continue and pass statements.

Programs: (1)To find roots of a quadratic equation, (2) To find largest of three numbers, (3)To check whether a number is prime or not, (4)To list Prime numbers up to 1000

Functions: User defined functions, local and global variables, recursive functions.

Programs: (1) to write python functions that returns factorial of a positive integer (2) to make a temperature converter (deg Celsius to Fahrenheit and vice versa.

Lists and Arrays: lists, operations on lists, adding and removing values from lists, numpy arrays, use of numpy functions, reading from file and writing array to a file. 2-d arrays.
Programs: (1)Sum and average of a list of numbers, (2)largest of a given list of numbers and its location in the list, (3)sorting of numbers in ascending and descending order using Bubble sort and Sequential sort, (4)Linear and Binary search. (5) programs involving matrix operations.

Plotting Graphs: Using Matplotlib to plot customized 2-d and 3-d graphs.
Programs: Plotting of elementary functions and their combinations. Scatter plot of data stored in a file.

Random Number generator: Generating pseudo random numbers from a uniform distribution using built in functions.

Programs: To find value of pi using Monte Carlo simulations, integration using Monte Carlo method.

Data Analysis: Uncertainty, error and precision, mean, standard deviation and error in the mean. combining uncertainties, Least squares method for fitting data (linear, power law and exponential), Goodness of Fit, finding slope, intercept, and errors in slope and intercept of the least square fit line. Comparing output of self written code with inbuilt function *scipy.stats.linregres* ,
Programs: Ohms law (calculate R), Hooke's law (Calculate spring constant)

Root Finding: Solution of non-linear Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods.
Programs: (1)square root of a number, (2) solving x = tan(x)

References

References for Theory:

- An introduction to ordinary differential equations, E.A.Coddington, 2009, PHI learning.
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Advanced Engineering Mathematics,D.G.Zill and W.S.Wright, 5 Ed.,2012,Jones and Bartlett Learning.
- Mathematical Physics, Goswami, 1st edition, Cengage Learning.
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press.
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.Mathematical Physics, A.K. Ghatak, I.C. Goyal and S.J. Chua, Laxmi Publications Private Limited (2017)
- Vector Analysis: Schaum Outline Series, M. Spiegel, McGraw Hill Education (2017).

References for Practical:

- Core Python Programming, Wesley J. Chun, Prentice Hall (2006).
- Introduction to computation and programming using python, John V. Guttag, MIT Press (2013).
- Documentation at the Python home page, https://docs.python.org/3/
- Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015).
- An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., PHI Learning Pvt. Ltd. (2012).
- Applied numerical analysis, Cutis F. Gerald and P.O. Wheatley, Pearson Education, India (2007).
-

Additional Resources:

- Mathematical Methods for Physicists,G.B.Arfken, H.J.Weber, F.E.Harris,2013, 7th Edn., Elsevier.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
- Numerical Recipes : TheArt of Scientific Computing, 3rd edition, W.H. Press et.al.,,Cambridge University Press.
- Numerical Analysis, Timothy Sauer, Pearson (2013).
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Teaching Learning Process

The emphasis of course is on applications in solving problems of interest to physicists.

Assessment Methods

The students are to be examined entirely on the basis of problems, seen and unseen

Keywords

calculus, differential equations, vector calculus,python, root finding, least square fit

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Mathematical Physics III
(32221401)
Core Course - (CC) Credit:6

Course Objective(2-3)

- The emphasis of the course is on applications in solving problems of interest to physicists. Students are tc be examined on the basis of problems, seen and unseen.
- Demonstrate understanding of the basic concepts underlying complex analysis and complex integration
- Develop an understanding of Fourier and Laplace Transform to solve real world problems

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Course Learning Outcomes

Theory:
After completing this course, student will be able to

- determine continuity, differentiability and analyticity of a complex function and find the derivative of a function;
- understand properties of elementary complex functions (polynomials, reciprocals, exponential, trigonometric, hyperbolic,etc) of single complex variable.
- work with multi-valued functions (logarithmic, complex power, inverse trigonometric function) and determine branches of these functions
- evaluate a contour integral using parametrization, fundamental theorem of calculus and Cauchy’s integral formula;
- find the Taylor series of a function and determine its radius of convergence;
- determine the Laurent series expansion of a function in different regions and find the residues
- use the residue theory to evaluate a contour integral and real integral.
- find the Fourier transform and the inverse Fourier transform of a function and understand their properties
- understand the properties of Laplace transform and use it to solve boundary value problems.

Practical:
After completing this course, student will be able to

- solve boundary value problems represented by ordinary differential equations.
- perform numerical integration using Gauss quadrature methods
- approximate a periodic function by a few terms in the Fourier series and understand the behavior at the point of discontinuity
- understand the limit in which a Gaussian function behaves like a Dirac Delta Function
- solve partial differential equations numerically
- find fast Fourier transform of a given function numerically

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Unit 1

Complex Analysis

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy-Goursat Theorem, Cauchy's Inequality. Cauchy"s Integral formula. Simply and multiply connected region. Laurent and Taylor"s expansion. Residues and Residue Theorem.Application in solving Definite Integrals.

(30 Lectures)

Unit 2

Integrals Transforms

Fourier Transforms: Fourier Integral theorem(Statement only). Fourier Transform.Fourier sine and cosine transform, Examples. Fourier transform of single pulse, trigonometric,exponential and Gaussian functions. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). One dimensional Wave Equations

(12 Lectures)

Unit 3

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations:Coupled differential equations of 1st order. Solution of heat flow along semi infinite bar using Laplace transform. **(15 Lectures)**

Unit 4

Dirac delta function: Definition and properties. Representation of Dirac delta function as a Fourier Integral. Laplace and Fourier Transform of Dirac delta function. **(3 Lectures)**

Practical

PHYSICS PRACTICAL-C VIII LAB

60 Periods

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of lectures(both theory and practical) in the Computer Lab. The recommended group size is not more than 15 students. Evaluation done not only on the basis of programming but also on the basis of formulating the problem. At least eight programs must be attempted taking at least one from each programming section.The program list is only suggestive and students should be encouraged to do more problems.

1. Solution to Ordinary Differential equation (Boundary Value Problems): finite Difference and shooting methods

Programs : Solve the boundary value problems and plot the solutions, e.g.

$y''(x) + y(x) = 0$ with $y(0) = 1,\ y(\pi/2) = 1$

Solve for the steady state concentration profile y(*x*) in the reaction-diffusion problem given by .

$y'' - y = 0$ with $y(x=0) = 1,\ y'(x=1) = 0$ in the domain $0 \le x \le 1$

2. Fourier Series:

- Program to sum $\sum_{n=1}^{\infty} (0.2)^n$
- Evaluate the Fourier coefficients of a given periodic function (e.g. square wave, half wave and full wave rectifier) using Gauss Legendre quadrature method. compare the value of integration with built in function.

3. Gauss Quadrature Integration methods.: Gauss Quadrature methods of integrations, importance of orthogonal polynomials, method of Gauss Legendre, Gauss Lagaurre and Gauss Hermite quadrature.

Programs:

Verification of Orthogonality of Legendre Polynomials

Integration of $\int_0^{\infty} \frac{1}{x^2+2}\, dx$ and $\int_0^{\infty} \frac{e^{-x}}{x^2+2}\, dx$ numerically using Gauss Lagaurre quadrature and check with complex integration.

4. Dirac Delta Function: representations of Dirac delta function as a limiting sequence of functions. Verify the properties of Dirac Delta function. e.g. Evaluate

$\frac{1}{\sqrt{2\pi\sigma^2}}\int_{-\infty}^{\infty} exp\left[\frac{-(x-2)^2}{2\sigma^2}\right](x+3)\,dx$ for $\sigma = 1, 0.1, 0.01$ and show that it tends to value 5. Use Hermite Gauss quadrature method and also Simpson method with appropriate limits.

5. Solution to Partial Differential equation : Finite Difference and Crank-Nicholson methods to solve Laplace equation, wave equation, and Heat Equation.

6. Integral Transform: Discrete Fourier transform (DFT), fast fourier transform algorithm (FFT) . Evaluation of FFT of a tabulated function and simple functions like e^{-x^2}.

References

References for Theory:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- **Mathematical Physics, A.K. Ghatak, I.C. Goyal and S.J. Chua, Laxmi Publications Private Limited (2017)**
- Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- Complex Variables, A.K. Kapoor, World Scientific (2014)
- Complex Variables and Applications, J.W.Brown& R.V.Churchill, 7th Ed. 2003, Tata McGraw-Hill
- Schaum's Outline of Fourier Analysis with Applications to Boundary Value Problems (Schaum's Outline Series), Murray Spiegel McGraw-Hill Education
- Schaum's Outline of Laplace Transforms (Schaum's Outlines of Theory and Problems), Murray Spiegel McGraw-Hill Education

References for Practical:

- Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015).
- An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., PHI Learning Pvt. Ltd. (2012).
- **Learning Scientific Programming with Python, Christian Hill, Cambridge University Press (2016)**
- Partial Differential Equations for Scientists and Engineers, Stanley J. Farlow Dover Publications

Additional Resources:

- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Complex Analysis: Fundamentals of the Classical Theory of Functions , John Stalker, Birkhäuser Publishers
- Mathematical Physics with Applications, Problems and Solutions, V. Balakrishnan, Ane Books (2017).
- Complex Analysis (Undergraduate Texts in Mathematics), Joseph Bak (Author), Donald J. Newman, pringer (2010)
- Fourier Transform and Its Applications, 2nd Edition (McGraw-Hill electrical and electronic engineering series), Ronald Newbold Bracewell , McGraw-Hill; 2d ed edition (1978)
- Fourier Analysis and Its Applications (Wadsworth and Brooks/Cole Mathematics Series) , Gerald B. Folland, , Thomson Brooks/Cole (1992)
- Computational Modeling and Visualization of Physical Systems with Python, Jay Wang, Wiley (2015)

Assessment Methods

The students are to be examined entirely on the basis of problems, seen and unseen.

Keywords

Complex, contour integration, residue, Dirac Delta function, Fourier transform, Laplace transform

Mathematical Physics-II
(32221301)
Core Course - (CC) Credit:6

Course Objective(2-3)

- The emphasis of course is to equip students with the mathematical tools required in solving problems interest to physicists.
- To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems
- To help students develop critical skills and knowledge that will prepare them not only for doing fundament and applied research but also prepare them for a wide variety of careers.
- This course will aim at introducing the concepts of Fourier series, special functions, solving linear partial differential equations by separation of variable method.

Course Learning Outcomes

Theory:

After completing this course, student will be able to

- represent a periodic function by a sum of harmonics using Fourier series.
- expand an odd or even function as half range sine and cosine Fourier series.
- obtain power series solution of differential equation of second order with variable coefficient using Frobenius method
- understand properties and applications of special functions like Legendre polynomials, Bessel functions and gamma and beta functions.
- Solve linear partial differential equations of second order with separation of variable method.

Practical:

After completing this course, student will be able to

- apply appropriate numerical method to solve selected physics problems both using computer program in Python and using the inbuilt functions from scipy.
- analyze the errors obtained in numerical solution to problems and compare different algorithms with respect to accuracy and efficiency.
- understand the algorithms of Newton and Lagrange interpolation and use them to find intermediate value in a tabulated data
- perform numerical differentiation and integration (trapezoidal and Simpson methods) of a given function in mathematical or tabulated form
- solve initial value problems using Euler and Runge Kutta methods.
- obtain approximate solution to a system of linear equations using Gauss Elimination and Gauss Seidel methods
- generate and plot Legendre polynomials and Bessel functions and verify their recurrence relation

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Unit 1

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only).Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients.Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Parseval Identity and its application to summation of infinite series. **(17 Lectures)**

Unit 2

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations.Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality. **(24 Lectures)**

Unit 3

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. **(4 Lectures)**

Unit 4

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of wave equation for vibrational modes of a stretched string, rectangular and circular membranes. Solution of 1D heat flow equation (equation not to be derived). **(15 Lectures)**

Practical

PHYSICS LAB-C V LAB

60 Periods

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of lectures(both theory and practical) in the Computer Lab. The recommended group size is not more than 15 students. Evaluation done not only on the basis of programming but also on the basis of formulating the problem. At least ten programs must be attempted taking at least one from each programming section.The program list is only suggestive and students should be encouraged to do more problems.

Introduction to Scipy functions: Importing scipy functions in program and compare the output of following programs with the output of scipy functions wherever possible

Interpolation: interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation. Given the values at n points in a tabulated form, evaluate the value of trigonometric and logarithmic functions at an intermediate point.

Numerical differentiation (Forward and Backward difference formula). Given Position with equidistant time data calculate velocity and acceleration and plot them.

Integration: Integrating a given function (in the form of data or expression)using Newton Cotes Quadrature methods (Trapezoidal and Simpson methods). Given data of acceleration with time, determine velocity and position and plot them. Application to other mathematical and physical problems.

Solution of Ordinary Differential Equations (Initial Value Problems): First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods. Emphasis should be given to the importance of making equations in terms of dimensionless variables,

Programs (First order ODE): Radioactive decay,Current in RC, LC circuits with DC source, Newton’s law of cooling, Classical equations of motion, Solve the coupled differential equations e.g

$$\frac{dx}{dt} = y + x - \frac{x^3}{3}, \frac{dy}{dt} = -x$$

for four initial conditions : x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four initial conditions on the same screen for

$0 \le t \le 15$

Programs :(Second order ODE) :- Harmonic oscillator (no friction), Damped free Harmonic oscillator (Over damped, Critically damped and under damped cases), Forced Harmonic oscillator (Transient and Steady state solution). Corresponding solutions for LCR circuits also. Solve

$x^2\frac{d^2y}{dx^2} - 4x\,(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$ with the conditions $y=\frac{1}{2}e^2$, $\frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$ at $x=1$. Find solution in the range [1,3] of x. Plot y and dy/dx against x in the given range on the same graph.

Solution of Linear system of equations: Solve system of linear equations using Gauss elimination method and Gauss Seidal method. Inverse of a matrix (by Gauss elimination), Application to Solution of mesh equations of electric circuits (3 meshes), Solution of coupled spring mass systems (3 masses)

Generation of Special functions using User defined functions in Python: Generating and plotting Legendre polynomials and Bessel functions using user defined functions as well as by inbuilt functions of scipy. Verification of recursion formulae. Use the data obtained above for Legendre polynomials or Bessel's function at N points and find its value at an intermediate point using Lagrange interpolation.

References

References for Theory:

- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Mathematical methods for Scientists & Engineers, D.A.McQuarrie, 2003, Viva Books
- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematical Physics, A.K. Ghatak, I.C. Goyal and S.J. Chua, Laxmi Publications Private Limited (2017)
- Mathematical Methods for Physicists, Arfken, Weber and Harris, Elsevier
-

References for Practical:

- Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015).
- An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., PHI Learning Pvt. Ltd. (2012).
- Applied numerical analysis, Cutis F. Gerald and P.O. Wheatley, Pearson Education, India (2007).
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

Additional Resources:

- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Mathematical Techniques: An Introduction for the Engineering, Physical, and Mathematical Sciences, Dominic Jordan, Oxford University Press (2008)
- Mathematical Physics with Applications, Problems and Solutions, V. Balakrishnan, Ane Books (2017)
- Fourier Series, Georgi P. Tolstov (Author) and Richard A. Silverman (Translator), Martino Fine Books (2014)
- Fourier Transform and Its Applications, Ronald Newbold Bracewell , McGraw-Hill (1978)
- Partial Differential Equations for Scientists and Engineers: Stanley J. Farlow, Dover Publications
- Numerical Recipes : The Art of Scientific Computing, 3rd edition, W.H. Press et.al.,,Cambridge University Press.
- Numerical Analysis, Timothy Sauer, Pearson (2013).
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Assessment Methods

The students are to be examined entirely on the basis of problems, seen and unseen.

Keywords

Fourier series, Frobenius method, special functions, Legendre polynomials, Bessel Functions, partial differential equations, Laplace, wave and heat equation

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Mechanics
(32221102)
Core Course - (CC) Credit:6

Course Objective(2-3)

This course begins with the review of Newton’s Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. Students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the understanding of the basics of mechanics. By the end this course, students should be able to solve the seen or unseen problems/numericals in mechanics.

Course Learning Outcomes

Upon completion of this course, students are expected to
□ attain a deep understanding of the following concepts involved:
o Inertial reference frames and Galilean transformations
o Variable mass system and dynamics of a system of particles
o Centre of Mass of discrete and continuous objects
o Conservative and non-conservative forces
o Potential Energy diagrams
o Collisions in Centre of Mass and Laboratory frames
o Angular momentum of a system of particles
o Determination of moment of inertia of discrete and continuous objects
o Geosynchronous orbits
o Simple harmonic motion-quality factor of forced oscillations
o Centrifugal force and Coriolis forces
o Special theory of relativity
□ appreciate the application of the fundamental concepts to the analysis of simple, practical situations
□ develop the ability to analyze and solve related numerical problems
□ apply the knowledge obtained to real-world problems

Unit 1

Fundamentals of Dynamics: Reference frames, Inertial frames, Galilean transformations, Galilean invariance, Review of Newton“s Laws of Motion.Momentum of variablemass system: motion of rocket. Dynamics ofa system of particles.Principle of conservation of momentum. Impulse.Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D).
(8 Lectures)

Unit 2

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable, unstable and neutralequilibrium. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.
(5 Lectures)

Collisions: Elastic (1-D and 2-D) and inelastic collisions. Centre of Mass and Laboratory frames.
(4 Lectures)

Unit 3

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of inertia, theorem of parallel and perpendicular axes. Determination of moment of inertia of discrete and continuous objects [1-D, 2-D & 3-D (rectangular, cylindrical and spherical)]. Kinetic energy of rotation. Motion involving both translation and rotation.
(10 Lectures)

Unit 4

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.
(2 Lectures)

Motion of a particle under a central force field: Two-body problem, its reduction to one-body problem and its solution. Reduction of angular momentum, kinetic energy and total energy. The energy equation and energy diagram. Kepler"s Laws. Satellite in circular orbit, Geosynchronous orbits.
(7 Lectures)

Unit 5

Oscillations: Idea of SHM. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values.Compound pendulum. Damped oscillation. Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor.
(6 Lectures)

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications.
(4 Lectures)

Unit 6

Special Theory of Relativity: Outcomes of Michelson-Morley Experiment. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity, Length contraction, Time dilation. Relativistic transformation of velocity, acceleration, frequency and wave number. Mass of relativistic particle. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect (transverse and longitudinal). Relativistic Kinematics (decay problems, inelastic collisions and Compton effect). Transformation of Energy and Momentum.
(14 Lectures)

Practical

60 Periods
At least 06 experiments from the following

1. Measurements of length (or diameter) using Vernier calliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the motion of the spring and calculate (a) Spring constant and, (b) g.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique.
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille"s method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell"s needle.
10. To determine the elastic Constants of a wire by Searle"s method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater"s Pendulum.

References

For Theory:

Reference Books:

- An Introduction to Mechanics, Daniel Kleppner& Robert Kolenkow, 2007, Tata McGrawHill
- Mechanics, DS Mathur, PS Hemne, 2012, S. Chand
- University Physics, FW Sears, MW Zemansky& HD Young 13/e, 1986, AddisonWesley
- Mechanics Berkeley Physics course, v.1: Charles Kittel, et.al. 2007, Tata McGrawHill
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press

- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole

For Practicals:
Reference Books:
- Advanced Practical Physics for students, B. L. Flint and H.T.Worsnop, 1971, Asia Publishing House
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- Engineering Practical Physics, S.Panigrahi& B.Mallick,2015, Cengage Learning India Pvt. Ltd.
- Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
- A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Edn, 2011,Kitab Mahal

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Teaching Learning Process

The teaching methodology may be broadly interactive with combination of the following methods:
- Chalk & board method supplemented with power-point presentations
- Problem solving periods
- Home work/assignments

- Self-study by the students

Assessment Methods

Assessment methods are the strategies, techniques, tools and instruments for collecting information to determin the extent to which students demonstrate desired learning outcomes. Several methods should be used to assess student learning outcomes.Learning outcomes will be assessed using the following: oral and written examination closed-book and open-book tests; problem-solving exercises, practical assignment laboratory reports, observatic of practical skills, individual project reports, seminar presentation; viva voce interviews; computerised adaptive testing, literature surveys and evaluations, outputs from collaborative work etc.

Keywords

Reference frames, Inertial frames, Galilean transformations, Conservation of momentum, Impulse, Centre of Mass, Work and Kinetic Energy Theorem. Conservative forces, non-conservative forces, Law of conservation of energy, Collisions, Centre of mass reference frame, Angular momentum, Moment of inertia, Kepler’s Laws, Inertial mass, Gravitational mass, Simple harmonic motion, Non-Inertial Systems, Non-inertial frames, fictitious forces, Centrifugal force, Coriolis force, Special theory of relativity, Michelson-Morley experiment.

Quantum Mechanics & Applications
(32221501)
Core Course - (CC) Credit:6

Course Objective(2-3)

After learning the elements of modern physics, students would be poised to learn more advanced topics like ho to

solve the Schrodinger equation for spherically symmetric potentials. Then, in this course, eigenvalues and eigen functions of the

Hamiltonian as well as the orbital angular momentum would be studied. Furthermore, application of Schrodinger equation to various

quantum mechanical problems would be taken up. The spin angular momentum of electrons would also be introduced in the

course.

Course Learning Outcomes

Students will learn:

1. States of physical systems are represented by complex, probability amplitudes called the wavefunctions.
2.The time evolution of a wavefunction is governed by the time-dependent Schrodinger equation.
3. The eigenvalues and eigenfunctions associated with time-independent Schrodinger equation.
4. Methods to solve time-dependent and time-independent Schrodinger equation.
5. Angular momentum: Orbital angular momentum and spin angular momentum.
6. Bosons and fermions - symmetric and anti-symmetric wavefunctions.
7. Application to atomic systems

Unit 1

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function: Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. (12 Lectures)

Unit 2

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues;expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle. (12 Lectures)

Unit 3

General discussion of bound states in an arbitrary potential : continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator : energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle. (10 Lectures)

Unit 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m; s, p, d shells. (10 Lectures)

Unit 5

Atoms in Electric and Magnetic Fields: Electron angular momentum. Angular momentum quantization. Electron Spin and Spin Angular Momentum. Larmor’s Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal Zeeman Effect: Electron Magnetic Moment and Magnetic Energy. (8 Lectures)

Unit 6

Many electron atoms: Pauli’s Exclusion Principle. Symmetric and Anti-symmetric Wave Functions. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Spin-orbit coupling in atoms-L-S and J-J couplings. (8 Lectures)

Practical

Use C/C ++ /Scilab for solving the following problems based on Quantum Mechanics like:

1. Solve the s-wave Schrodinger equation for the ground state and the first excited
state of the hydrogen atom, where m is the reduced mass of the electron. Obtain the energy eigenvalues and plot
the corresponding wavefunctions. Remember that the ground state energy of the
hydrogen atom is -13.6 eV. Take e = 3.795 (eVÅ) 1/2 , ħc = 1973 (eVÅ) and m =
0.511x10 6 eV/c 2 .

2. Solve the s-wave radial Schrodinger equation for an atom:

,

where m is the reduced mass of the system (which can be chosen to be the mass of an
electron), for the screened coulomb potential
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 = 0.511x10 6 eV/c 2 , and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The
ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

,
For the anharmonic oscillator potential
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/c 2 , k = 100
MeV fm -2 , b = 0, 10, 30 MeV fm -3 In these units, cħ = 197.3 MeV fm. The ground state
energy I expected to lie between 90 and 110 MeV for all three cases.
4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen
molecule:
,
Where mu 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 = 940x10 6 eV/C 2 , D = 0.755501 eV, ɑ = 1.44, r o = 0.131349 Å
Laboratory based experiments (Optional):
5. Study of Electron spin resonance- determine magnetic field as a function of the
resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. Quantum efficiency of CCDs

References

 Quantum Mechanics, Robert Eisberg and Robert Resnick, 2 nd Edn., 2002, Wiley.

 Introduction to Quantum Mechanics, D.J. Griffith, 2 nd Ed. 2005, Pearson Education

 Basic Quantum Mechanics, A. Ghatak, Macmillan, 2009

- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
- Quantum Mechanics: Theory and Applications, Ajoy Ghatak & S. Lokanathan, Springer Science & Business Media, 2004

Reference books for practicals:

- Schaum's outline of Programming with C++.J.Hubbard, 2000,McGraw-Hill Publication
- An introduction to computational Physics, T.Pang, 2 nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3 rd Edn., Cambridge University Press

Additional Resources:

- Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
- A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2 nd Ed., 2010, McGraw Hill
- Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966
- Quantum Mechanics, Leonard I. Schiff, 3 rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- The Principles of Quantum Mechanics, P. A. M. Dirac, Clarendon Press, 2004

Solid State Physics
(32221502)
Core Course - (CC) Credit:6

Course Objective(2-3)

This syllabus begins with introduction to the basic concepts and principles to understand the various properties exhibited by condensed matter, especially solids. These properties depend on the chemical constituents making the particular solid and their arrangement in the crystal. A semi-classical approach is used to introduce various models, from toy model to a higher level, suitable to explain the particular property exhibited by the solid. The syllabus is specifically designed to guide the students to learn how to create a theoretical model for a particular property and appreciate the beauty that lies in these solids through their properties.

Course Learning Outcomes

On successful completion of the module students should be able to

- *elucidate the concept of lattice, crystals and symmetry operations.*
- *explain the concepts such as the reciprocal lattice and the Brillouin zone and the dynamics of atoms and electrons in solids.*
- *explain diffraction of X-rays by solids to determine the crystal structure.*
- *understand the elementary lattice dynamics and its influence on the properties of materials.*
- *describe the main features of the physics of electrons in solids.*
- *understand the origin of energy bands, and how they influence electronic behaviour.*
- *Explain the origin of dia-, para-, and ferro-magnetic properties of solids.*
- *explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.*
- *understand the basics of phase transitions and the preliminary concept and experiments related to superconductivity in solid.*
- *apply the gained knowledge to solve problems in solid state physics using relevant mathematical tools.*

- *To appreciate how matter exhibits such interesting and wonderful properties and communicate the importance of solid state physics in the modern society.*

Unit 1

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Types of Lattices. Unit Cell, Symmetry and Symmetry Elements. Miller Indices. Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays: single crystal and powder method. Bragg's Law, Laue Condition. Ewalds' construction. Atomic and Geometrical Factor. Simple numerical problem on SC, BCC, FCC.

(14 Lectures)

Unit 2

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

(10 Lectures)

Unit 3

Electrons in Solids: Electrons in metals- Introduction to Drude Model, Density of states (1-D,2-D,3-D) (basic idea), Elementary band theory: Kronig Penney model. Band Gap, direct and indirect bandgap. Effective mass, mobility, Hall Effect (Metal and Semiconductor).

(10 Lectures)

Unit 4

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Para- magnetism. Hunds's rule. Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Curie's law. B-H Curve. soft and hard material and Energy Loss Hysteresis.

(9 Lectures)

Unit 5

Dielectric Properties of Materials: Polarization. Local Electric Field in solids. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mossotti Equation. Classical Theory of Electric Polarizability. AC polarizability, Normal and Anomalous Dispersion. Complex Dielectric Constant. Langevin-Debye equation.

(9 Lectures)

Unit 6

Introduction to basics of phase transitions: Landau theory for ferromagnetic materials (No derivation).

(3 Lectures)

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

(5 Lectures)

Practical

At least 06 experiments from the following

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of solids.
3. To determine the Coupling Coefficient of a piezoelectric crystal.
4. To study the dielectric response of materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
6. To determine the refractive index of a dielectric material using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Iron (Fe) using solenoid & determine the energy loss from Hysteresis loop.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150°C) by four-probe method and determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
12. Measurement of change in resistance of a semiconductor with magnetic field.

References

Reference Books for Theory:

- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
- Elementary Solid State Physics, M.Ali Omar, 2006, Pearson
- Solid State Physics, Rita John, 2014, McGraw Hill
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Reference Books for Practical:

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

A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

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Teaching Learning Process

The teaching learning process needs

- *To promote student-centric learning. The basic concept should be introduced thoroughly and students are motivated to construct new ideas or concepts based upon their current/past knowledge.*
- *Emphasis to be given on logical learning wherein day today examples related to solids can be given to the students so as to avoid rote learning.*
- *Teaching crystallography on a 2D platform is a real challenge. Students need to be stimulated to widen their imagination and work on software (if possible) which can enhance their knowledge in understanding the crystal structures.*
- *Laboratory visits to various research labs may be organized so that students can appreciate and understa the real-time experiments going on in this field which they might have studied theoretically in their course work.*
- *Quizzes may be conducted frequently to assess the understanding of students regarding the basic concep in solid state physics.*
- *Develop problem solving skills among students.*

· *Project-based learning can be another feature of the teaching-learning process. Students may be divided groups and be assigned some topics for which they can work together. Emphasis should be given to the state of art for the respective topic while documentation. Submitted document (in any form) should be original. Students need to taught the proper use of resources and avoid any form of plagiarism.*

· *Laboratories should be setup suitably so that the students can practically learn and understand the concepts learned in theory.*

Assessment Methods

· *Quiz, problem solving exercise, classroom assessment methods, presentations, end-semester examinatio etc. may constitute the different components of the overall assessment.*

· *Assignments on basic concepts may be given to students where they can do a small reading research on the topic and document their understanding.*

· *Continuous evaluation and gathering feedbacks may prove beneficial in improving teaching learning process.*

· *Continuous learning and assessment in laboratory classes will help the students in performing and understanding the experiments in a better manner.*

Keywords

Crystal Structure, Reciprocal Lattice, Brillouin Zones, Phonons, Hall Effect, Ferromagnetic Domains, Hysteresis, Polarizability, Superconductivity

Statistical Mechanics
(32221602)
Core Course - (CC) Credit:6

Course Objective(2-3)

- The Statistical Mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.)
- of a physical system consisting of large number of particles (solid, liquid or gas) from knowledge of the underlying microscopic behavior of atoms and molecules that comprises it. The main objective of this cour work is to introduce the techniques of Statistical Mechanics which has applications in various fields includi Astrophysics, Semiconductors, Plasma Physics, Bio-Physics etc. and in many other directions.

Course Learning Outcomes

By the end of the course, students will be able to understand :

- the use of Thermodynamic probability and Partition function for calculation of thermodynamic variables
- difference between the classical and quantum statistics
- the use of F D and BE statistics in physical systems consisting of Fermions and Bosons respectively.
- the properties and various Laws associated with the Blackbody radiation

Unit 1

Classical Statistics: Macrostate and Microstates, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur-Tetrode equation . Saha's Ionization Formula. Law of Equipartition of Energy (with proof)– Applications to Specific Heat of gas and solids and its Limitations, Thermodynamic Functions of a Two Energy Levels System, Negative Temperature. **(24 Lectures)**

Unit 2

Unit II: **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. **(12 Lectures)**

Unit 3

Unit III: 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**. (12 Lectures)**

Unit 4

Unit IV : Theory of Radiation : Properties of Thermal Radiation and Radiation Pressure . Blackbody Radiation and its spectral distribution. Kirchhoff law. Stefan-Boltzmann law and its Thermodynamic proof. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation Deduction of Wien's Distribution Law, Rayleigh-Jeans Law, Stefan-Boltzmann Law and Wien's Displacement law from Planck's law. **(12 Lectures)**

Practical

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

Statistical Mechanics like

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

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

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

c) Relationship of large N and the arrow of time

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

.

2. Plot the probability of various macrostates in coin-tossing experiment (two level system) versus number of heads with 4, 8 , 16 coins etc.

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

a) Study the behavior of Z(b), average energy , Cv, and entropy and its dependence upon the temperature, total number of particles N and the spectrum of single particle energy states.

b) Plot the probability of occupancy of all the states w.r.t. temperature.

4 . Plot the Maxwell speed distribution function at different temperatures in a 3 dimension system . Calculate the average speed, root mean square and most probable speed

5. Plot Specific Heat of Solids w.r.t temperature

(a) Dulong-Petit law,

(b) Einstein distribution function

(c) Debye distribution function

6. Plot the following functions with energy at different temperatures

a) Maxwell-Boltzmann distribution

b) Fermi-Dirac distribution

c) Bose-Einstein distribution

7. Plot the distribution of particles w.r.t. energy (dN/de versus e) in 3 Dimensions for

a) Relativistic and non-relativistic bosons both at high and low temperature .

b) Relativistic and non-relativistic fermions both at high and low temperature.

8. Plot Planck’s law of Black body radiation w.r.t. wavelength/frequency at different temperatures. Compare it with Rayleigh-Jeans Law and Wien’s distribution law for a given temperature.

References

For Theory:

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996,
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- An Introduction to thermal physics : D. Schroeder, Pearson
- Statistical Physics , F. Mandl, 2nd Edn., 2003, Wiley
- Introductory Statistical Mechanics, R. Bowley and M. Sanchez, 2nd Edn., 2007, Oxford Univ. Press
- A treatise on Heat, M. N. Saha and B.N. Srivastava

For Practical:

- ElementaryNumericalAnalysis, K.E.Atkinson, 3rd Edn. 2007, WileyIndiaEdition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996

- Introduction to Modern Statistical Mechanics, D.Chandler, Oxford University Press, 1987
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.

Teaching Learning Process

- Chalk and Blackboard approach

- Group discussion in the class
- PPT presentation on special topics.

Assessment Methods

- Assignments
- Class test
- Semester end examination

Keywords

M-B statistics , B-E statistics, F-D Statistics, Black body radiation

Thermal Physics
(32221302)
Core Course - (CC) Credit:6

Course Objective(2-3)

This coursework deal with the relationship between the macroscopic properties of the physical system in equilibrium. The primary goal is to understand the fundamental laws of thermodynamics and it's applications to various thermo dynamical systems and processes. In addition, it will also give exposure to students about the Kinetic theory of gases , transport phenomenon involved in ideal gases, phase transitions and behavior of real gases.

Course Learning Outcomes

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

- Explain the Laws of Thermodynamics and its application to various physical processes
- Understand the concept of entropy, reversible and Irreversible processes.
- Use the Maxwell relations for solving many problems in Thermodynamics
- Understand the concept and behavior of ideal and real gases.
- Apply the Kinetic theory of gases for calculating the transport properties of gases.

Unit 1

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. (8 Lectures)

Unit 2

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines.Carnot‟s Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot‟s Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. (10 lectures)

Unit 3

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas.Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe.Entropy Changes in Reversible and Irreversible Processes.Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot‟s Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. (7 lectures)

Unit 4

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb‟s Free Energy. Their Definitions, Properties and Applications. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations

Maxwell’s Thermodynamic Relations: Derivation of Maxwell‟s thermodynamic Relations and their applications, Maxwell’s Relations:(1) Clausius Clapeyron equation, (2) Value of Cp-Cv, (3) Tds Equations, (4) Energy equations.

(14 lectures)

Unit 5

Kinetic Theory of Gases Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

Molecular Collisions: Mean Free Path. Collision Probability. Estimation of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. (11 lectures)

Unit 6

Real Gases:Behavior of Real Gases:Deviations from the Ideal Gas Equation. Andrew‟s Experiments on CO2 Gas. Virial Equation. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. van der Waal‟s Equation of State for Real Gases. Values of Critical Constants.Law of Corresponding States.Comparison with Experimental Curves.p-V Diagrams. Free Adiabatic Expansion of a Perfect Gas.Joule-Thomson Porous Plug Experiment.Joule-Thomson Effect for Real and van der Waal Gases.Temperature of Inversion. Joule-Thomson Cooling. (10 lectures)

Practical

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne‟s constant flow method.

2. To determine the Coefficient of Thermal Conductivity of Cu by Searle‟s Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom‟s Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton‟s disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions using a null method. And also calibrate the Thermocouple in a specified temperature range.
7. To calibrate a thermocouple to measure temperature in a specified Range using Op-Amp difference amplifier and to determine Neutral Temperature.

References

For Theory:

Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.

□ A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press

□ Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill

 Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.

 Concepts in thermal Physics: Blundell & Blundell , Oxford Univ. press

For Practical:

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

 A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011,Kitab Mahal

 Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

 A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.

Teaching Learning Process

- Chalk and Blackboard approach
- Group discussion in the class
- PPT presentation on special topics.

Assessment Methods

- Assignments
- Class test
- Semester end examination

Keywords

Laws of thermodynamics, entropy, Maxwell relations, Kinetic theory, real gases.

Waves and Optics
(32221202)
Core Course - (CC) Credit:6

Course Objective(2-3)

This is one of the core course in Physics curriculum that begins with explaining ideas of superposition of harmon oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Course Learning Outcomes

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

1. Understand Simple harmonic oscillation and superposition principle.

2. Understand superposition of a range of collinear and mutually perpendicular simple harmonic motions and their applications.

3. Understand the importance of classical wave equation in transverse and longitudinal waves and solving a range of physical systems on its basis.

4. Understand different types of waves and their velocities: Plane, Spherical, Transverse, Longitudinal.

5. Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations

6. Understand the concept of temporal and spatial coherence.

7. Understand Interference as superposition of waves from coherent sources derived from same parent source

8. Demonstrate understanding of Interference experiments: Young’s Double Slit, Fresnel’s biprism, Llyod’s Mirror, Newton’s Rings, Michelson Interferometer and Fabry-Perot Interferometer

9. Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures

10. Understand Fraunhoffer Diffraction from apertures: Rectangular, Slit, Double Slit, Grating, Circular apertures

11. Demonstrate fundamental understanding of Fresnel Diffraction: Half period zones, Zone Plate, Fresnel’s Integrals, Cornu’s Spiral and its applications.

Lab Course is designed to understand the principles of measurement and skills in experimental designs.

Unit 1

Superposition of Collinear Harmonic oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats).Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. **(6 Lectures)**

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies and their uses.

(2 Lectures)

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves.Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. **(4 Lectures)**

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities.Changes with respect to Position and Time.Energy of Vibrating String.Transfer of Energy.Normal Modes of Stretched Strings.Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes.Superposition of N Harmonic Waves. **(8 Lectures)**

Unit 2

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(4 Lectures)**

Interference: Division of amplitude and wavefront. Young’s double slit experiment. Lloyd’s Mirror and Fresnel’s Biprism. Phase change on reflection: Stokes’ treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton’s Rings: Measurement of wavelength and refractive index. **(10 Lectures)**

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes.Fabry-Perot interferometer. **(6 Lectures)**

Unit 3

Diffraction:

Fraunhofer diffraction: Single slit. Rectangular and Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.
(10 Lectures)

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave.Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate.Fresnel's Integral, Cornu`s spiral and its applications. Straight edge, a slit and a wire. **(10 Lectures)**

Practical

At least 6 experiments from the following

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ2–T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

References

- Vibrations and Waves, A.P. French, 1stEdn., 2003, CRC press.

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill

- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.

- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

- Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications

- Optics, Eugene Hecht, 4thEdn., 2014, Pearson Education.

- Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011,Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal,1985, Vani Pub.

Teaching Learning Process

- Chalk and Blackboard approach
- Group discussion in the class
- PPT presentation on special topics.

Assessment Methods

- Assignments
- Class test
- Semester end examination

Advanced Mathematical Physics
(32227502)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

The course is intended to impart the concept of generalized mathematical constructs in terms of Algebraic Structures (mainly Vector Spaces) and Tensors to have in-depth analysis of our physical system.

Course Learning Outcomes

- Demonstration of Algebraic Structures in n-dimension.
- Application of Vector Spaces & Matrices in the quantum world.
- We understand how to express the mathematical equations for the Laws of Physics in their co-variant forms.
- We understand how to express a mathematical equation concerned with an event compatible with the physical system.

Unit 1

Linear Vector Spaces Abstract Systems: Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. (12 Lectures)

Unit 2

Matrices, Addition and Multiplication of Matrices: Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner product of vectors. (8 Lectures)

Unit 3

Eigen-values and Eigenvectors: Finding Eigen – values and Eigen vectors of a Matrix. Diagonalization of Matrices. Properties of Eigen-values and Eigen Vectors of Orthogonal, Hermitian and Unitary Matrices. Cayley-Hamiliton Theorem(Statement only).Finding inverse of a matrix using Cayley-Hamiltion Theorem. Solutions of ordinary second order differential equations and Coupled Linear Ordinary Differential Equations of first order. Functions of a Matrix.(10 Lectures)

Unit 4

Cartesian Tensors: Transformation of Co-ordinates and fundamentals of Tensors. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors : Kronecker and Alternating Tensors. Association of Anti-symmetric Tensor of Order Two and Vectors.(8 lectures)

Unit 5

Applications of Cartesian Tensors: Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Tensor notation of Laplacian operator. Proof of Vector Identities involving scalar and vector products and vector identities involving Del operator under Tensor notation. Isotropic Tensors (Definition only). Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.(12 lectures)

Unit 6

General Tensors: Transformation of Co-ordinates. Minkowski Space - Lorentz Transformation. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor. (10 Lectures)

Practical

PHYSICS PRACTICAL-DSE LAB:

60 Periods

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of lectures(both theory and practical) in the Computer Lab. The recommended group size is not more than 15 students. Evaluation done not only on the basis of programming but also on the basis of formulating the problem. At least six programs must be attempted taking at least one from each programming section.The program list is only suggestive and students should be encouraged to do more problems.

Python based simulations experiments based on Mathematical Physics problems like (at least 06 experiments)

1. Linear algebra:
Eigenvalue and eigenvectors of
(■(2&1&1@1&3&2@3&1&4));(■(1&-i&3+4i@+i&2&4@3-4i&4&3)); (■(2&-i&2i@+i&4&3@-2i&3&5))
Diagonalisation of a non-singular matrix

2. Orthogonal polynomials as eigen functions of Hermitian differential operators.

3. Determination of the principal axes of moment of inertia through diagonalization (Matrix can be generated for a given distribution of discrete masses).

4.Study of geodesics in Euclidean and other spaces (surface of a sphere, etc): Using variational principal find the shortest curve between two points. Suggested Physics problem: problem of refraction.

5. Application to solve differential equations for a bound system – Eigen value problem.

6. Application to computer graphics:
Write operators for shear, strain, two dimensional rotational problems, Reflection, Translation etc. Plot old and new coordinates.

Note: *Students opting for Linear algebra and Tensor analysis as one option in DSE cannot opt Advanced mathematical physics-I course as second option.*

References

References for Theory

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber and F.E.Harris,1970, Elsevier.
- Modern Mathematical methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
- Introduction to Matrices & Linear Transformations, D.T.Finkbeiner,1978, Dover Pub.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole

References for Practicals:

- **Learning Scientific Programming with Python, Christian Hill, Cambridge University Press (2016)**
- An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).

Additional Resources:

- Introduction to Vectors and Tensors, Ray M Bowen, C -C Wang, Dover Publications (2009)
- **An Introduction to Linear Algebra and Tensors, M A Akivis, V V Goldberg, Richard a Silverman, Dover Publications (2012)**
- Computational Problems for Physics: With Guided Solutions Using Python, Rubin H. Landau, Manuel José Páez, CRC Press (2018).
- https://arxiv.org/pdf/1703.09738.pdf

Assessment Methods

- Class Test
- Assignment / Presentation
- Semester end examination

Advanced Mathematical Physics-II
(32227625)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

The course is intended to develop new mathematical tools in terms of Calculus of Variation, Group Theory and Theory of Probability in the repertoire of the students to apply in Theoretical and Experimental Physics.

Course Learning Outcomes

- Demonstration of a new approach while dealing with a dynamical system by using Calculus of Variation.
- Demonstration of symmetries in nature by using Group Theory.
- We understand how to extract information from the experimental data with the help of Theory of Probability.

Unit 1

Variable Calculus: Variational Principle, Euler's Equation and its Application to Simple Problems. Geodesics.
Calculus of Variations:
Concept of Lagrangian. Generalized co-ordinates. Definition of canonical moment, Euler-Lagrange's Equations of Motion and its Applications to Simple Problems (e.g., Simple Pendulum and One dimensional harmonic oscillator). Definition of Canonical Momenta. Canonical Pair of Variables. Definition of Generalized Force: Definition of Hamiltonian (Legendre Transformation). Hamilton's Principle. Poisson Brackets and their properties. Lagrange Brackets and their properties.

(25 Lectures)

Unit 2

Group Theory:
Review of sets, Mapping and Binary Operations, Relation, Types of Relations.
Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel.
Some special groups : SO(2), SO(3), SU(2), SU(3).

(25 Lectures)

Unit 3

Advanced Probability Theory:
Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions: The binomial distribution, The poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares. (25 Lectures)

References

- Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
- Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
- Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.
- Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover
- Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press
- Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill.

Assessment Methods

- Class Test
- Assignment / Presentation
- Semester End Examination

Advanced Quantum Mechanics
(xxx4)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

This course aims to describe quantum phenomena in terms of linear vector space formalism. The students will be able to learn to represent quantum states by ket vectors and physical observables as operators and their time evolution. Commutation relations between observables will be studied since it is fundamental to understanding uncertainty principle as well as deriving the eigen values of angular momenta. The complete set of commuting observables will be introduced. An understanding of identical particles like bosons and fermions will be developed. At the end of the syllabus, students will be able to learn angular momenta algebra and the computation of Clebsch-Gordan coefficients.

Course Learning Outcomes

This course will arm the B.Sc.(Hons.) physics students with modern analytical techniques so that they can easily apply them to research

areas involving lasers interacting with atoms/molecules, manipulate entangled quantum states like qubits, so necessary in the field of

quantum information theory and quantum computation, deal effectively with superconductors and superfluidity, etc.

The world is marching towards attainment of quantum computers, which in turn is likely to revolutionize the field of Artificial Intelligence (AI).

After learning this course properly, our students would be adequately prepared to participate and innovate in the coming AI revolution.

As this course starts with an introduction to linear vector spaces and inner product of two vectors that results in a complex number,

aided by problem solving exercises, students will imbibe a critical understanding of the general mathematical structures of complex

analysis, vector spaces, basis and orthogonality, which form the underlying principles of diverse topics like Fourier transform, matrices

and their diagonalisation, Laurent series and calculus of residues, etc. which in turn constitute the bedrock of signal processing, Wiener-

Khinchin theorem, Match filtering, etc. that are extremely useful in communication, radar techniques, detection of weak signals,

gravitational wave data analysis, operation research, etc.

Intense problem-solving sessions will enable the students to develop analytical and mathematical imagination that are necessary

to be creative in physical sciences as well as engineering research areas.

The quantum dynamics of two-level systems will help the students to understand the principles of NMR, ESR and MRI. Such systems

are also very useful as far as comprehension and implementation of qubit structures that are of paramount importance to future quantum

computers.

Unit 1

Motivation for developing a linear vector space formulation to describe quantum

phenomena. Brief review of linear vector spaces with ket notation: Inner product, norm, Schwarz inequality, linear operators, eigenvalue and eigenvector, adjoint of a linear

operator, Hermitian or self-adjoint operators and their properties. Orthonormal basis –

discrete and continuous. Unitary operators and change of basis. Completeness, closure

relation. The position and momentum representations, Relation between wave functions and kets, given an orthonormal basis.

Bra vectors. (17 lectures)

Unit 2

Representation of quantum states by ket vectors and physical observables by Hermitian

operators. Unitary time-evolution and Schrodinger equation in ket notation. Measurement

of an observable. Expectation value of an observable. Canonical commutation relations -

commutators of position and momentum, commutators for orbital and spin angular

momentum. (14 lectures)

Unit 3

Compatible and incompatible observables: Commutator brackets and their properties, the uncertainty principle.

Ehrenfest's theorem and the classical limit. Correspondence of unitary evolution of ket vectors with Schrodinger wave

mechanics. (6 lectures)

Unit 4

Identical particles: direct product of kets, symmetric and antisymmetric states. Systems of

identical non-interacting particles. Bosons and Fermions; Pauli's exclusion principle.

Dynamics of two-level systems (e.g. electron in an external magnetic field). Entangled states, Qubits;

One dimensional Harmonic oscillator, its energy eigen values and eigen states using ladder operators. (15 lectures)

Unit 5

Addition of orbital and spin angular momenta, J = L+S. Commutators of J x , J y and J z ;

Ladder operators, recursion relations, eigenvalues and eigenstates of total angular momentum operators.

Composite system of two spin-half particles – singlet and triplet states. Clebsch-Gordan

coefficients: formalism, computation (up to 1 x ½) (13 lectures)

Unit 6

Variational Method: Basic idea, application to some simple systems like rigid box problem and one dimensional simple

harmonic oscillator; Estimation of Hydrogen atom

ground state energy using variational method. Helium atom ground state energy. (10 lectures)

References

- Modern Quantum Mechanics, J.J Sakurai, Revised Edition, 1994, Addision-Wesley.
- The Principles of Quantum Mechanics, P. A. M. Dirac, Clarendon Press, 2004
- Introduction to Quantum Mechanics, David J. Griffiths, Second Edition, 2006,

Pearson Education.

- Quantum Mechanic Concepts and Applications, Nouredine Zettili, Second Edition, 2001, John Wiley & Sons, Ltd.
- A Text book of Quantum Mechanics, P.M.Mathews& K.Venkatesan, 2nd Ed., 2010, McGraw Hill.
- Quantum Mechanics, Brian H. Bransden and C. Charles Jean Joachain, 2000, Prentice Hall.

Additional Resources:

- Introduction to Quantum Mechanics, Volume-I, C. Cohen-Tannoudgi, B. Diu, F. Laloe, 1977, Wiley-VCH.
- Quantum Theory, David Bohm, Dover Publications, 1979
- Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
- Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966
- Quantum Mechanics, Leonard I. Schiff, 3 rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, Eugene Merzbacher, 2004, John Wiley and Sons, Inc.

Keywords

Dirac's bra and ket formalism; Commutator brackets; Orthonormal basis; Complete set of commuting observables; Identical particles -

bosons and fermions; Entangled states and Qubits; Ladder operators; Spin and Orbital angular momenta; Variational method to obtain

approximate energy eigen values;

Applied Dynamics
(32227616)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

Most processes encountered in nature are inherently nonlinear. This course introduces the main topics of low-dimensional nonlinear systems, with applications to a wide variety of disciplines, including physics, engineering, mathematics, chemistry, and biology. Specific topics include maps and flows in one and two dimensions, phase portraits, bifurcations, chaos, fractals and elementary fluid dynamics. Students will obtain familiarity with concepts and methods in the field of dynamical systems, apply those concepts and methods to analyze dynamic models analytically and computationally, and will learn how to interpret and critically evaluate the results of those analyses.This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals. The emphasis of this course is to enhance the understanding of the basics of applied dynamics. By the end of this course, students should be able solve the seen or unseen problems/numericals in applied dynamics.

Course Learning Outcomes

Upon successful course completion, a student will be able to:
- Demonstrate understanding of the concepts that underlay the study of dynamical systems.
- Use the analytical and computational methods covered in this course to analyze dynamical systems models.

- Analyze the behavior of dynamical systems (e.g. find periodic orbits and assess their stability, draw phase portraits, etc.)
- Apply the techniques of nonlinear dynamics to physical processes drawn from a variety of scientific and engineering disciplines.

- Analyze uniform and nonuniform oscillators (flows on circle)
- Draw phase portraits and interpret them in several applications from biology, physics, chemistry and engineering.

- Define a fractal and give several examples of fractals in nature
- Understand the basics of different kind of fluid motion.

Unit 1

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Sketching flows and trajectories in phase space. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems. Examples of dynamical systems – Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics. Rate equations for chemical reactions e.g. auto catalysis, bistability (22 Lectures)

Unit 2

Introduction to Chaos and Fractals: Chaos in nonlinear equations - Logistic map and Lorenz equations: Dynamics from time series. Parameter dependence- steady, periodic and chaotic states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period-Doubling route to chaos.

Self-similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure.
(18 Lectures)

Unit 3

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis-concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. Flow visualization - streamlines, pathlines, Streaklines.
(20 Lectures)

Practical

(60 Periods) Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like (at least 06 experiments)

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. To study period doubling route to chaos in logistic map.
8. To study various attractors of Lorenz equations.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streaklines.

References

For theory:

- Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
- Nonlinear Dynamics: Integrability, Chaos and Patterns, M. Lakshmanan and S. Rajasekar, Springer, 2003.
- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
- Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

For Practicals:

- Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer

Teaching Learning Process

Teaching learning process should include appropriate methods to make classroom teaching more effective, encouragement to students for active participation, collaborative learning and effective laboratory practices. Teaching methods should develop interest in the students by choosing appropriate method which cater individuals need, scientific ways of thinking, problem solving ability, student understanding, critical & quantitative thinking and experimental & data analysis skills. Students should Learn to use scientific apparatus, estimate statistical errors & recognize errors and develop reporting skills in laboratory practices.

Assessment Methods

Assessment methods are the strategies, techniques, tools and instruments for collecting information to determin
the extent to which students demonstrate desired learning outcomes. Several methods should be used to assess
student learning outcomes.Learning outcomes will be assessed using the following: oral and written examination
closed-book and open-book tests; problem-solving exercises, practical assignment laboratory reports, observatic
of practical skills, individual project reports, seminar presentation; viva voce interviews; computerised adaptive
testing, literature surveys and evaluations, outputs from collaborative work etc.

Keywords

Phase space, First order dynamical systems, attractors, Chaos, Logistic map, route to chaos, Fractals, Self-similarity, fractal geometry, Autocorrelation, Lyapunov component, Fluid Dynamics, viscosity.

Astronomy and Astrophysics
(32227506)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

This DSE paper for Phsyics Hons students is designed to provide students with the basic knowledge about the theory and techniques of observational astronomy and physics of the astrophysical phenomenon. This course follows the tradition of theoretical rigour and comprehensiveness of Physics Hons course of the University of Delhi. It applies theoretical concepts and mathematical techniques Physics Hons students have learnt in their earlier courses to astronomical and astrophysical phenomenon.

Course Learning Outcomes

After this course students will be familiar with essential features and techniques of astronomy, and will understand how laws of physics are applied to astrophysical phenomenon. Students will also gain an understanding of the latest developments in the field of astronomy and astrophysics. After this course students will be well equipped to take advanced level specialised post graduate level courses in astronomy and astrophysics. They will also will be prepared to do student research level internships at research institutes.

Unit 1

Introduction to Astronomy and Astronomical Scales: Overview of the Night Sky, Diurnal and Yearly motions of the Sun, Stars and Constellations. Size, Mass, Density and Temperature of Astronomical Objects. Basic concepts of Positional Astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Horizon System, Equatorial System, Conversion of Coordinates. Rising and Setting Times, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Astronomical Time Systems (LMT, UT, UTC) (16 Lectures)

Unit 2

Basic Parameters of Stars: Determination of Distance by Parallax Method; Proper Motion, Brightness, Radiant Flux and Luminosity, Apparent and Absolute Magnitude Scales, Distance Modulus, Extinction, Determination of Temperature and Radius of a star; Stellar Spectra, Atomic Spectra Revisited, Introduction to Boltzman and Saha Equations, Balmer Lines of H, H and K lines of Ca, Spectral Types and Their Temperature Dependence, Black Body Approximation, Luminosity Classification, H R Diagram and Relations Between Stellar Parameters (16 Lectures)

Unit 3

Observational Tools and Physical Principles: Observing through the atmosphere (Scintillation, Seeing , Atmospheric Windows and Extinction) Basic Optical Definitions for Telescopes: Magnification, Light Gathering Power, Limiting magnitude, Resolving Power, Diffraction Limit. Optical and Radio Telescopes, Current Indian Observatories.

Virial theorem for N particle systems, applications in astrophysics. Systems in Thermodynamic Equilibrium, Radiative Transfer, Equations for Hydrostatic and Thermal Equilibria, Temperature Gradient in Stars, Mean Molecular Weight of stellar gas, Stellar Energy Sources (16 Lectures)

Unit 4

Sun and the Milky Way: Solar Parameters, Sun’s Internal Structure, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Solar Magneto-Hydrodynamics, Alfven’s Theorem.

Basic Structure and Properties of the Milky Way, Nature of rotation of the Milky Way (Differential rotation of the Galaxy and Oort Constants, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Properties of and Around the Galactic Nucleus. (15 Lectures)

Unit 5

Cosmology: Standard Candles (Cepheids and SNe Type1a), Cosmic Distance Ladder, Olbers Paradox, Hubble Expansion, Cosmological Principle, Newtonian Cosmology and Friedmann Models (12 Lectures)

Unit 6

References

1. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
2. Astrophysics Stars and Galaxies K D Abhyankar, Universities Press
3. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B.

Bhatia, Narosa Publication.

5. The Physical Universe: An Introduction to Astronomy, F H Shu, University Science Books
6. Baidyanath Basu, An introduction to Astrophysics, Second printing, Prentice -

Hall of India Private limited, New Delhi,2001.

7. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.

8. Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, 2014, 7th edition, McGraw Hill

9. Principles of Stellar Dynamics, S Chandrasekhar, Dover Books

Additional Resources:

Teaching Learning Process

1. The main mode of instruction will be class room lectures. Audio visual media involving documentaries, and Web based resour on latest discoveries will also be used.
2. Students will learn problem solving skills in tutorials. A list of problems should be distributed before every tutorial to let student solve them before solutions are discussed.
3. Students will get hands on experience of handling telescopes in coordination with institute's astronomy club. Outdoor excursio can be organised for viewing sky at night.
4. Students will be encouraged to form teams and participate in analysis of observational data available on the net.

Assessment Methods

1. Continuous evaluation of tutorial work.
2. Student Projects
3. Semester end exam.

Atmospheric Physics
(32227507)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

This paper aims to describe the characteristics of earth’s atmosphere and also its dynamics.

Course Learning Outcomes

Atmospheric waves along with the basic concepts of atmospheric Radar and Lidar are discussed in detail.

Unit 1

General features of Earth’s atmosphere: Thermal structure of the Earth’s Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms.
(12 Lectures)

Unit 2

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.
(12 Lectures)

Unit 3

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration
(12 Lectures)

Unit 4

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.(12 Lectures)

Unit 5

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.
(12 Lectures)

Practical

Scilab/C ++ based simulations experiments based on Atmospheric Physics problems like (at least 05 experiments)
1. Numerical Simulation for atmospheric waves using dispersion relations
(a) Atmospheric gravity waves (AGW)
(b) Kelvin waves
(c) Rossby waves, and mountain waves
2. Offline and online processing of radar data
(a) VHF radar,
(b) X-band radar, and
(c) UHF radar
3. Offline and online processing of LIDAR data
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique
6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change
7. PM 2.5 measurement using compact instruments
8. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

References

- Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
- The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3 rd edn. 2002.
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
- Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

Biological physics
(32227508)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

The Biological Physics course introduces the emerging inter-disciplinary field on the interface of Physics and Biology.

Course Learning Outcomes

It makes use of concepts from Physics and discusses their application in Biology. This course helps the students to develop a system level perspective of Biology and equips them with the required mathematical and computational skills.

Unit 1

Overview:
(6 Lectures)
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. Allometric scaling laws.

Unit 2

Molecules of life:
(18 Lectures)
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 to be studied analytically and computationally.

Unit 3

Molecular motion in cells:
(22 Lectures)
Random walks and applications to biology: Diffusion; models of macromolecules.
Entropic forces: Osmotic pressure; polymer elasticity.
Chemical forces: Self assembly of amphiphiles.
Molecular motors: Transport along microtubules.
Flagellar motion: bacterial chemotaxis.

Unit 4

The complexity of life:
(20 Lectures)
At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Metabolic, regulatory and signaling networks in cells. Dynamics of metabolic networks; the stoichiometric matrix. 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. Cellular differentiation and development.
Brain structure: neurons and neural networks. Brain as an information processing system.

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

Unit 5

Evolution:
(9 Lectures)
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.

References

• Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman &Co, NY, 2004)
• Physical Biology of the Cell (2nd Edition); Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
•An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
• Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Classical Dynamics
(32227626)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

This classical dynamics course inculcates and imbibes the problem solving ability and develops understanding of physical problems.This course begins with the review of Newton’s Laws of Motion and ends with the Special Theo of Relativity by 4-vectoer approach and fluids. Students will also appreciate the Lagrangian and Hamiltonian Mechanics. The emphasis of this course is to enhance the understanding of Classical Mechanics (Lagrangian and Hamiltonian Approach). By the end of this course, students should be able to solve the seen or unseenproblems/numericals in classical mechanics.

Course Learning Outcomes

At the end of this course, students will be able to:
 Understand the physical principle behind the derivation of Lagrange and Hamilton's equations, and the advantages of these formulations.
 Translate physical problems into appropriate mathematical language and apply appropriate mathematical tools – particularly, calculus, differential equations, linear algebra, and the calculus of variations – to analyze and solve the resulting equations.
 Apply Lagrangian & Hamiltonian methods to complex motion problems.
 be able to relate symmetries to conservation laws in physical systems, and apply these concepts to practical situations.
 Understand the intricacies of motion of particle in central force field.
 Critical thinking and problem-solving skills
 Have a deep understanding of the theoretical foundations of electromagnetic phenomena, fundamental principles of the special theory of relativity in Minkowski space and space time diagrams.
 Understand the basics of different kind of fluid motion.

Upon taking the classical dynamics course students will be able to integrate competently the knowledge and skills acquired in post-undergraduate studies.

Unit 1

Classical Mechanics of Point Particles: Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Degrees of freedom of a system, Generalized coordinates and velocities. Hamilton's Principle, Lagrangian and Lagrange“s equations of motion of one-dimensional simple harmonic oscillators, falling body in uniform gravity. Cyclic coordinates. Canonical momenta & Hamiltonian. Hamilton“s equations of motion. Comparison of Newtonian, Lagrangian and Hamiltonian mechanics. Applications of Hamiltonian mechanics: Hamiltonian for a simple harmonic oscillator, solution of Hamilton“s equations for simple harmonic oscillations (1-D), particle in a central force field – conservation of angular momentum and energy. (25 Lectures)

Unit 2

Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, small amplitude oscillations about the minimum, normal modes oflongitudinal simple harmonic oscillations (maximum 3 masses connected by 4 springs). Kinetic energy (T) and potential energy (V) in terms of normal co-ordinates. T and V matrices: finding eigen-frequencies and eigen-vectors using these matrices.

(13 Lectures)

Unit 3

Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction, simultaneity Four-vectors: space-like, time-like and light-like. Four-displacement $\left[X^{\mu}=(ct, r)\right]$, 4-velocity $\left[U^{\mu}=\gamma(c, u)\right]$, 4-acceleration (A^{μ}). Metric tensor $(g^{\mu\nu} \text{ or } g_{\mu\nu})$ and alternating tensor $(\in^{abcd} \text{ or } \in_{abcd})$ and their properties. Four-momentum $\left[P^{\mu}=(E/c, p)\right]$ and energy-momentum relation. Concept of four-force (F^{μ}).

(25 Lectures)

Unit 4

Fluid Dynamics: Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille"s equation for flow of a liquid through a pipe. Analogy between liquid flow and current flow, rate of liquid flow through capillaries in series and in parallel combination. Navier Stoke's equation, Reynolds number.

(12 Lectures)

References

- Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rdEdn. 2002,Pearson Education.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
- Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
- Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
- Classical Mechanics, Tai L. Chow, CRC Press.
- An Introduction to Fluid Dynamics, G. K. Batchelor, Cambridge University Press, 2002.

Teaching Learning Process

Teaching learning process should include appropriate methods to make classroom teaching more effective, encouragement to students for active participation, and collaborative learning . Teaching methods should develo interest in the students by choosing appropriate method
which cater individuals need, scientific ways of thinking, problem solving ability, student understanding and critic thinking. Progress of teaching method should be based on students previous knowledge and learning outcomes.

Assessment Methods

Assessment methods are the strategies, techniques, tools and instruments for collecting information to determin the extent to which students demonstrate desired learning outcomes. Several methods should be used to assess student learning outcomes.Learning outcomes will be assessed using the following: oral and written examination closed-book and open-book tests; problem-solving exercises, practical assignment laboratory reports, observatio of practical skills, individual project reports, seminar presentation; viva voce interviews; computerised adaptive testing, literature surveys and evaluations, outputs from collaborative work etc.

Keywords

Newtonian Mechanics, gyroradius, Lagrangian, Hamiltonian, cyclic coordinate, normal modes, Special Theory of Relativity, light cone, time dilation, Four vectors, Fluid Dynamics, Poiseuille's equation.

Communication System
(32227613)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

1. This paper aims to describe the concepts of electronics in communication.
2. Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail.
3. Communication and Navigation systems such as GPS and mobile telephony system are introduced.

Course Learning Outcomes

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

- This paper aims to describe the concepts of electronics in communication. In this course, students will receive an introduction to the principle, performance and applications of communication systems.
- Students will learn the various means and modes of communication. They will gain an understanding of fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- They will gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Students will be able to analyze different parameters of analog communication techniques.
- They will learn the need of sampling and different sampling techniques where they can sample analog signal.
- Students will learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- They will gain an in-depth understanding of different concepts used in a satellite communication system.
- They will study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- Students will understand evolution of mobile communication generations 2G, 3G, and 4G with their characteristics and limitations.
- This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

Unit 1

Electronic communication: Introduction to communication – means and modes. Power measurements (units of power). 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. (4 Lectures)
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, 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. (12 Lectures)

Unit 2

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing). (9 Lectures)

Unit 3

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).(10 Lectures)

Unit 4

Satellite Communication– Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), Uplink and downlink, path loss, Satellite visibility, Ground and earth stations. Simplified block diagram of earthstation. (10 Lectures)

Unit 5

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). (15 Lectures)

Practical

PHYSICS LAB-DSE LAB: COMMUNICATION SYSTEM LAB
60 Periods

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING
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

References

- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- Advanced Electronics Communication Systems- Tomasi, 6thEdn. Prentice Hall.
- Modern Digital and Analog Communication Systems, B.P. Lathi, 4th Edition, 2011, Oxford University Press.
- Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
- Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
- Communication Systems, S. Haykin, 2006, Wiley India
- Electronic Communication system, Blake, Cengage, 5th edition.
- Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press
- Introduction to Communication systems, U. Madhow, 1st Edition, 2018, Cambridge University Press

Keywords

Electronic communication, Modulation, Channels, base band signals, Analog modulation, Amplitude modulation, modulation index, Demodulation, Frequency modulation, Phase modulation, sampling, Analog Pulse modulation, Digital Pulse Modulation, Shift Keying, satellite communication, mobile communication

Digital Signal processing
(32227621)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

1. This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals.
2. This paper also highlights the concept of filters and realization of Digital Filters.
3. At the end of the syllabus, students will develop an understanding of Discrete and fast Fourier Transform.

Course Learning Outcomes

In this course, students will be able to develop a thorough understanding of the central elements of discrete time signal processing theory and correlate this theory with the real-world signal processing applications. 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 analyze the discrete time signals and systems. They will learn to analyze 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 analyze 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 & infinite impulse response filters for various applications.

Unit 1

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. (10 Lectures)

Unit 2

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. (15 Lectures)

Unit 3

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. (5 Lectures)

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. (10 Lectures)

Unit 4

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.(5 Lectures)

Unit 5

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. (15 Lectures)

Practical

PRACTICAL-DSE LAB: DIGITAL SIGNAL PROCESSING LAB
60 Periods

At least 06 experiments from the following using Scilab/Matlab. Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.
1. Write a program to generate and plot the following sequences: (a) Unit sample sequence δ(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≤n≤50.

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5
x(n)=rect(n/2N)=Π(n/2N)={█(1 -N≤n≤N@0 otherwise)┤

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(0.5πn)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 |H(e^jw) | and ∠H(e^jw)

5. Design a digital filter to eliminate the lower frequency sinusoid of x(t)=sin7t+sin200t. The sampling frequency is f_s=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)=({1,1,1,1})¦↑={█(1 0≤n≤3@0 otherwise)┤
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})¦↑
h(n)=({1,-1,-1,1})¦↑
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:
passband edge F_p=2 KHz
stopband edge F_s=5 KHz
Passband attenuation A_p=2 dB
Stopband attenuation A_s=42 dB
Sampling frequency F_s=20 KHz

10. The frequency response of a linear phase digital differentiator is given by
H_d (e^jw)=jwe^(-jτw) |w|≤π
Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

References

- Digital Signal Processing, Tarun Kumar Rawat,2015,Oxford University Press, India
- Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
- Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1st Edn. Oxford University Press.
- Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
- Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
- Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.
- Digital Signal Processing, A. Anand Kumar, 2nd Edition, 2016, PHI learning Private Limited.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.
- Digital Signal Processing, Paulo S.R. Diniz, Eduardo A.B. da Silva, Sergio L .Netto, 2nd Edition, 2017, Cambridge University Press

Keywords

Signals, Periodic signals, Aperiodic signals, Discrete time systems, Impulse response, Convolution, Discrete time fourier transform (DTFT), z-transform, LTI system, Difference equation, Filters, Frequency domain sampling, Discrete fourier transform (DFT), Fast fourier transform, Digital filters, FIR filter, IIR filter, Frequency response, Kaiser window

Dissertation
(32227627)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

It emphasizes the specific skills which the student shall be learning during the course of dissertation, for example, some computational skill or literature survey, etc.

Course Learning Outcomes

The dissertation work should not be a routine experiment or project at the under graduate level. It should involve more than text book knowledge. Referring text books for preparation and making concept, is allowed, however one component of the dissertation must include study of research papers or equivalent research material.

Unit 1

The total number of dissertations in Physics should be limited to 5% of the total strength of the students (Hons. and B.Sc. Programme) in the subject However, students having national scholarships like NTSE, KVPY, INSPIRE, etc. can be considered above this quota. The selection criterion is at the discretion of the college. The student should not have any academic backlog (ER). The sole/single supervisor must have a Ph.D. degree. Not more than two candidates would be enrolled under same supervisor.

Unit 2

At the time of submission of teaching- work load of the teachers by the college to the Department (Department of Physics and Astrophysics, Delhi University), the supervisor shall submit the proposal (200-300 words; not more than full one A4 page) of the proposed dissertation. Along with that four names of the external examiners from any college of Delhi University (other than the own college of the supervisor) or any department of Delhi University can be suggested. The committee of courses of the department may appoint any one teacher as an external examiner from the proposed list of external examiners.

Unit 3

No topic would be repeated from the topics allotted by the supervisor in the previous years, so that the work or dissertation could be distinct every time.

The ‘proposal’ should include the topic, plan of work, and clearly state the expected deliverables. The topic must be well defined. The abstract should clearly explain the significance of the suggested problem. It must emphasize the specific skills which the student shall be learning during the course of dissertation, for example, some computational skill or literature survey, etc. Both Internal (supervisor) and external examiners will assess the student at the end of the semester and award marks jointly, according to the attached scheme.

Unit 4

Other than the time for pursuing dissertation work, there must be at least 2 hours of interaction per week, of the student with the supervisor.

The student has to maintain a “Log Book” to summarize his/ her weekly progress which shall be duly signed by the supervisor.

Experimental work should be carried out in the parent college or any other college or the Department in Delhi University with consent of a faculty member there. Unsupervised work carried out at research institutions / laboratories is to be discouraged.

Unit 5

The dissertation work should not be a routine experiment or project at the under graduate level. It should involve more than text book knowledge. Referring text books for preparation and making concept, is allowed, however one component of the dissertation must include study of research papers or equivalent research material.

The dissertation report should be around 30 pages. It must have minimum three chapters namely Introduction, Main work including derivations / experimentation and Results, Discussion and Conclusion. At the end, adequate references must be included. Plagiarism must be checked.

Unit 6

It is left to the discretion of the college if it can allow relaxation of two teaching periods (at the most two periods per week to the supervisor, irrespective of the number of students enrolled under him / her for dissertation).

The evaluation/presentation of the dissertation must be done within two weeks after the exams are over.

For the interest of the students it is advised that college may organize a workshop for creating awareness amongst students. Any teacher who is not Ph.D. holder can be Co-supervisor with the main supervisor.

Assessment Methods

MARKING SCHEME for Dissertation in B.Sc. (Hons) and Programme courses in Physics

30 marks: **Internal assessment based on performance like sincerity, regularity, etc.** *Checking by: Supervisor*

40 marks: **Written Report (including content and quality of work done)** *Checking by: Supervisor and External Examiner*

30 marks: **Presentation*** *Checking by: Supervisor and External Examiner*

**All Dissertation presentations should be open. Other students / faculty should be encouraged to attend.*

Embedded systems- Introduction to Microcontroller (32227518)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

1. This paper gives a review of microprocessor and introduces microcontroller 8051.
2. Here, students will learn about the 8051 I/O port programming, various addressing modes, Timer and counte programming, Serial port programming with and without interrupt and interfacing 8051 microcontroller to peripherals.

Course Learning Outcomes

This is a course to familiarize/ introduce students to designing and developing embedded systems. It provides the students with an introductory coverage of embedded systems. The learning outcomes of the course are:

- Knowledge of the major components that constitute an embedded system.
- Understand what is a microcontroller, microcomputer embedded system.
- Description of the architecture of a 8051 microcontroller.
- Write simple programs for 8051 microcontroller in C language.
- Understand key concepts of 8051 microcontroller systems like I/O operations, interrupts, programming of timers and counters.
- Interfacing of 8051 microcontroller with peripherals
- Understand and explain concepts and architecture of embedded systems
- Implement small programs to solve well-defined problems on an embedded platform.
- Develop familiarity with tools used to develop an embedded environment
- Learning to use the Arduino Uno (an open source microcontroller board) in simple applications.

Unit 1

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems. (4 Lectures)

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions. (12 Lectures)

Unit 2

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation. (4 Lectures)

Programming: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions. (12 Lectures)

Unit 3

Timer and counter programming: Programming 8051 timers, counter programming. (3 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051. (6 Lectures)

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing. (2 Lectures)

Unit 4

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. (3 Lectures)

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. (8 Lectures)

Unit 5

Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming and applications.(6 Lectures)

Practical

PRACTICALS- DSE LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS
60 Periods
8051 microcontroller based Programs and experiments (at least 06 experiments):
1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED’s. Simulate binary counter (8 bit) on LED’s .
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display ‘HELP’ in the seven segment LED display.
9. To toggle ‘1234’ as ‘1324’ in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

Arduino based programs and experiments:
12. Make a LED flash at different time intervals.
13. To vary the intensity of LED connected to Arduino
14. To control speed of a stepper motor using a potential meter connected to Arduino
15. To display “PHYSICS” on LCD/CRO.

References

- Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008,Tata McGraw Hill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
- Microcontrollers in practice, I.Susnea and M.Mitescu, 2005, Springer.
- Embedded Systems & Robots, Subrata Ghoshal, 2009, Cengage Learning
- Introduction to embedded system, K.V. Shibu, 1st edition, 2009, McGraw Hill
- Embedded Microcomputer systems: Real time interfacing, J.W.Valvano 2011, Cengage Learning
- Microprocessors and Microcontrollers, Krishna Kant, 2nd Edition, 2016. PHI learning Pvt. Ltd.
- Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.

Keywords

Embedded systems, 8051, Microcontroller, Architecture, Memory map, Addressing modes, Timers, Counter Programming, Interrupts, LCD interfacing, Arduino

Experimental Techniques
(32227501)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

1. This paper aims to describe the errors in measurement and statistical analysis of data required while performi an experiment.

2. Also, students will learn the working principle, efficiency and applications of transducers & industrial instrume like digital multimeter, RTD, Thermistor, Thermocouples and Semiconductor type temperature sensors.

Course Learning Outcomes

Upon successful completion of the course, students will be able to:

- Learn the measurement systems, errors in measurements and statistical treatment of data.
- Understand principle of working and industrial applications of various transducers like Electrical, Thermal and Mechanical systems commonly used to measure Temperature and Position in industry.
- Develop an understanding of construction and working of different measuring instruments.
- Develop an understanding of construction, working and use of different AC and DC bridges and its applications.

Unit 1

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. Gaussian distribution. **(7 Lectures)**

Signals and 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 **(3 Lectures)**

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

Unit 2

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. Qualitative difference between Transducers and sensors.Types of sensors (Physical, Chemical and Biological), Characteristics of Transducers.Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector. **(21 Lectures)**

Unit 3

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. **(5 Lectures)**

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

Unit 4

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber with roughing and backing, Mechanical pumps (Rotary and root pumps), Diffusion pump & Turbo Molecular pump, Ion pumps, Pumping speed, throughput, Pressure gauges (Pirani, Penning, ionization, cold cathode). **(16 Lectures)**

Practical

PRACTICAL- DSE LAB: EXPERIMENTAL TECHNIQUES

60 Periods

At least 06 experiments each from the following:

1. Determine output characteristics of a LVDT & measure displacement using LVDT
2. Measurement of

(a) Strain using Strain Gauge,

(b) level using capacitive transducer.

(c) distance using ultrasonic transducer

3. To study the characteristics of a Thermostat and determine its parameters.
4. Calibrate Semiconductor type temperature sensor (AD590, LM35, LM75) and Resistance Temperature Device (RTD).
5. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
6. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2mlength, understanding of importance of grounding using function generator of mV level & an oscilloscope.
7. To design and study the Sample and Hold Circuit.
8. Design and analyze the Clippers and Clampers circuits using junction diode
9. To plot the frequency response of a microphone.
10. To measure Q of a coil and influence of frequency, using a Q-meter.

References

- Experimental Methods for Engineers, J.P. Holman, McGraw Hill
- Introduction to Measurements and Instrumentation, A.K. Ghosh, 4th Edition, 2017, PHI Learning Pvt. Ltd.
- Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
- Instrumentation Devices and Systems, C.S.Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
- Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer
- Basic Electronics:A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1990, Mc-Graw Hill
- Measurement, Instrumentation and Experiment Design in Physics & Engineering, M.Sayer and A. Mansingh, 2005, PHI Learning.

Keywords

Error, Accuracy, precision, Statistical analysis of data, curve fitting, Noise in measurement, Noise figure, Grounding, Shielding, Transducers, sensors, digital multimeter, Impedance bridges, Vacuum systems, Mean free path, Pressure gauges

Linear Algebra and Tensor analysis
(xxx3)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

The course is intended to impart the concept of generalized mathematical constructs in terms of Algebraic Structures (mainly Vector Spaces) and Tensors to have in-depth analysis of our Physical System.

Course Learning Outcomes

- Demonstration of Algebraic Structures in n-dimension.
- Application of Vector Spaces & Matrices in the Quantum World.
- We understand how to express the Laws of Physics in their co-variant form.
- We understand how to express the mathematical equation concerned with an event compatible the system.

Unit 1

Vector Space and Subspace: Binary Operations, Groups, Rings& Fields, Vector Space & Subspace, Examples of Vector Spaces, Euclidean Vector Spaces: Length and Distance in Rn, Matrix notation for vectors in Rn,Four Subspaces associated with a Matrix
(8 Lectures)
Basic and Dimension: Linear Dependence and Independence of vectors, Spanning a Space, Basis and Dimensions, Rank and Nullity of a Matrix, Examples from Real Function Space and Polynomial Space, Orthogonal Vectors and Subspaces, Orthogonal Basis, Gram-Schmidt process of generating an Orthonormal Basis (4 Lectures)

Unit 2

Linear Transformation: Function and Mapping, General Linear Transformations and Examples, Kernel and Range of a Matrix Transformation, Homomorphism and Isomorphism of vector space, Singular and Non-singular Mapping/Transformations, Algebra of Linear operator. (8 Lectures)

Invertible operators: Identity Transformation, Matrices and Linear Operators, Matrix Representation of a Linear transformation and change of basis, Similarity (5 Lectures)

Unit 3

Matrices and Matrix Operations: Addition and Multiplication of Matrices, Null Matrices, Diagonal, Scalar and Unit Matrices, Upper Triangular and Lower-Triangular Matrices, Transpose of a Matrix, Symmetric and Skew-Symmetric Matrices, Matrices for Networks, Matrix Multiplication and System of Linear Equations, Augmented Matrix, Echelon Matrices, Gauss Elimination and Gauss-Jordan Elimination, Inverse of a Matrix, Elementary Matrix, Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices, Determinants, Evaluating Determinants by Row Reduction, Properties of Determinants, Adjoint of a Matrix, Singular and Non-Singular matrices, Orthogonal Matrix, Unitary Matrices, Trace of a Matrix, Inner Product.(12 Lectures)

Unit 4

Eigen-values and Eigenvectors: Finding Eigen-values and Eigen vectors of a Matrice. Diagonalization of Matrices. Properties of Eigen-values and Eigen Vectors of Orthogonal, Hermetian and Unitary Matrices. Cayley- Hamiliton Theorem (Statement only).Finding inverse of a matrix using Cayley-Hamiltion Theorem. Solutions of Coupled Linear Ordinary Differential Equations of first order. Functions of a Matrix. (8 Lectures)

Unit 5

Cartesian Tensor: Transformation of co-ordinates, Einstein's summation convention, Relation between Direction Cosines, Tensors, Algebra of Tensors, Sum, Difference and Product of Two Tensors, Contraction, Quotient Law of Tensors, Symmetric and Anti-symmetric Tensors, Invariant Tensors: Kronecker and Alternating Tensors,

Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation Gradient, Divergence and Curl of Tensor Fields. Vector Identities.Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor.Generalized Hooke's Law.
(16 Lectures)

Unit 6

Geometrical Applications: Equation of a line, Angle between lines. Projection of a line on another line. Condition for two lines to be coplanar. Foot of the Perpendicular from a Point on a Line, Rotation Tensor (No derivation), Isotropic tensors (definition only),Moment of Inertia tensors .(4 Lectures)

General Tensors: Transformation of Co-ordinates, Minkowski Space - Lorentz Transformation, Contravariant & Covariant Vectors, Contravariant, Covariant and Mixed Tensors, Kronecker Delta and Permutation Tensors, Algebra of Tensors, Sum, Difference & Product of Two Tensors, Contraction, Quotient Law of Tensors, Symmetric and Anti-symmetric Tensors, Metric Tensor (10 Lectures)

References

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber and F.E.Harris,1970, Elsevier.
- Theory and Problems of Linear Algebra, Seymour Lipschutz, 1987, McGraco-Hill Inc.
- Theory and Problems of Vector Analysis and an introduction to Tensor Analysis, Murray R. Spiegel, 1974, McGraw Hill, Inc.
- Elementary Linear Algebra, Applications Version, Howard Anton and Chris Rorres, Wiley Student edition.
- Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011,Cambridge University Press.
- Introduction to Matrices & Linear Transformations, D.T.Finkbeiner,1978, Dover Pub.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole

Assessment Methods

- Class Test
- Assignment / Presentation
- Semester end examination

Medical Physics
(32227615)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

This course introduces a student to the basics of Medical Physics.

Course Learning Outcomes

The last few years have witnessed a tremendous growth in the applications of Physics to the field of medicine. Beginning with the use of Imaging in Diagnostics to Radiation therapy for Cancer, everything involves Physics. Hence, there is a big need for being aware of medical physics. This course introduces a student to the basics of Medical Physics. Today with the changing life styles it is also necessary for one to have a better understanding of the human body from the perspective of Physics. This course seeks to fulfil both these needs.

Unit 1

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.
Other Systems in the body: Pressure system of body. Physics of breathing, Physics of cardiovascular system.
(8 Lectures)

Unit 2

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.
(10 Lectures)

Unit 3

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I
X-Rays: 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.
(7 Lectures)

Radiation Physics: Radiation units exposure, absorbed dose, units: rad, gray, 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.
(7 Lectures)

Unit 4

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).
(9 Lectures)
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.
(9 Lectures)

Unit 5

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.
(5 Lectures)

Unit 6

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.
(5 Lectures)

Practical

1. Understanding the working of a manual Hg Blood Pressure monitor, Stethoscope and to 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 & to measure background radiation
7. Familiarization with Radiation meter and to measure background radiation.
8. Familiarization with the Use of a Vascular Doppler.

References

- Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
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- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
- Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I. Publication Pvt Ltd.
- The Physics of Radiology-H E Johns and Cunningham.
- Christensen’s Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
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- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
- Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I.Publications Pvt Ltd.

Nano Materials and Applications
(32227612)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

The syllabus introduces the basic concepts and principles to categories and understand nanomaterial. Various nanomaterial synthesis/growth methods and characterizations techniques are discussed to explore the field in detail. The effect of dimensional confinement of charge carries on the electrical, optical and structural propertie are discussed. Interesting experiments which shape this filed like conductance quantization in 2DEG (Integer Quantum Hall Effect) and coulomb blockade are introduced. The concept of micro- and nano- electro mechanical systems (MEMS and NEMS) and important applications areas of nanomaterials are discussed.

Course Learning Outcomes

On successful completion of the module students should be able to

- *explain the difference between nanomaterials and bulk materials and their properties.*
- *explain various methods for the synthesis/growth of nanomaterials.*
- *explain the role of confinement on the density of state function and so on the various properties exhibited by nanomaterials compared to bulk materials.*
- *explain the various characterization tools required to study the structural, optical and electrical properties of nanomaterials.*
- *analyze the data obtained from the various characterization techniques.*
- *explain the concept of Quasi-particles such as excitons and how they influence the optical properties.*
- *explain the direct and indirect bandgap semiconductors, radiative and non-radiative processes and the concept of luminescence.*
- *explain the structure of 2DEG system and its importance in quantum transport experiments.*
- *explain the Interger Quantum Hall Effect and the concept of Landau Levels, and edge states in conductance quantization.*
- *explain the conductance quantization in 1D structure and its difference from the 2DEG system.*
- *explain the necessary and sufficient conditions required to observe coulomb blockade, single electron transistor and the scope of these devices.*
- *explain how MEMS and NEMS devices are produced and their applications.*
- *explain why nanomaterials exhibit properties which are sometimes very opposite, like magnetic, to their bulk counterparts.*

Unit 1

NANOSCALE SYSTEMS: Density of states (3D, 2D, 1D,0D),Length scales in physics, Nanostructures: 1D, 2D and 3Dconfinednanostructures (thin films, nanowires, nanorods, nanodots), Schrodinger equation- Infinite potential well, potential step, potential box,Band structure and densityof states of materials at nanoscale(Quantitative for 3D, 2D, 1D, 0D), Size Effects in nano systems, Applications of quantum confinement of carriers in 3D, 2D, 1Dnanostructures and itsconsequences on electronic and optical properties. Numerical problems based on above topics.

(14 Lectures)

Unit 2

SYNTHESIS OF NANOSTRUCTURE MATERIALS (Qualitative): Top down and Bottom up approach,Photolithography. Ball milling.Spin coating, Vacuum deposition: Physical vapor deposition (PVD): Thermal evaporation, Sputtering, Pulsed Laser Deposition (PLD), electric arc deposition for CNT, C_{60}, grapheme, Chemical vapor deposition (CVD). Preparation through colloidal methods (Metals, Metal Oxide nanoparticles), Molecular Beam Epitaxy (MBE) growth of quantum dots.

(5 Lectures)

Unit 3

CHARACTERIZATION: Structure and Surface morphology: X-Ray Diffraction (XRD). Scanning Electron Microscopy (SEM).Transmission Electron Microscopy (TEM).Atomic Force Microscopy (AFM).Scanning Tunneling Microscopy (STM).**Spectroscopy:** Working principle of UV-Vis spectroscopy, IR Spectroscopy, Raman and Photoluminescence Spectroscopy and study the size dependent properties using these techniques.

(11 Lectures)

Unit 4

OPTICAL PROPERTIES: Quasi-particles and collective excitations (Qualitative idea).Quantitative treatment of excitons, Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of nanoparticles as a function of size, defects and impurities: deep level and surface defects. Numerical problems based on above topics.

(10 Lectures)

Unit 5

ELECTRON TRANSPORT:time and length scales of electrons in solids, Carrier transport in nanostructures:diffusive and ballistic transport, Charging effect, Coulomb blockade effect. Single electron transfer devices (no derivation).Conductance quantization: 2DEG in GaAs and integer quantum hall effect (Quantitative), conductance quantization in 1D structures using split gate in 2DEG (no derivation).Numerical problems based on above topics.

(14 Lectures)

Unit 6

APPLICATIONS (Qualitative): Applications of nanoparticles, quantum dots, nanowires and thinfilms for photonic devices (LED, solar cells). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructurelasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots-magnetic data storage.Micro Electromechanical Systems (MEMS), NanoElectromechanical Systems (NEMS).

(6 Lectures)

Practical

At least 06 experiments from the following:

1. Synthesis of metal (Au/Ag)nanoparticles by chemical route and study its optical absorption properties.
2. Synthesis of semiconductor (CdS/ZnO/TiO_2/Fe_2O_3etc) nanoparticles and study its XRD and optical absorption properties as a function of time.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. Analysis of XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on the 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 and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) andstudy its XRD and transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function oftemperature or frequency.
11. Fabricate a PN junction diode by diffusing Al over the surface of N-type Si/Geand study itsV-I characteristic.
12. Fabricate thin films (polymer, metal oxide) using electro-deposition
13. To study variation of resistivity or sheet resistance with temperature of the fabricated thin films using four probe method.

References

Reference books for Theory:

- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt.Ltd..
- S.K. Kulkarni, Nanotechnology: Principles & Practices 2ndedition (2011) (Capital Publishing Company)
- K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
- Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
- Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

Introductory Nanoscience by Masaru Kuno, (2012) Garland science Taylor and Francis Group

- Solid State Physics by J. R. Hall and H. E. Hall, 2nd edition (2014) Wiley

- Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.
- Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCASH, 4th edition, McGrawHill.

Reference Books for Practicals:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt.Ltd..
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

Additional Resources:

- Quantum Transport in semiconductor nanostructures by Carla Beenakker and HenK Van Houten (1991) (available at arXiv: cond-mat/0412664) open source
- Sara cronewett Ph.D. thesis (2001).

Teaching Learning Process

Since this is an advanced course and is only for students who specifically opt for it, the teaching learning proces must include

- *That the important concepts be introduced in detail, as per the syllabus, to provide firm support for furthe exploration*
- *That lab visits, to research labs and USIC, DU or others, be organized so that students can see the variou instrumentations/facilities and appreciate the technology that plays a crucial role in shaping this field.*
- *That student should be encouraged to search or they be provided with topics of experiments, outside the syllabus, that shape this field and submit an assignment. Few topics are like: Aharonov-Bohm effect, Bohm Oscillations, classical conductance quantization, fractional quantum hall effect.*
- *That instead of tests, quizzes should be conducted every week to assess the students.*
- *That labs should be setup suitably so that the students learning from theory can be tested, wherever suitable, with practical data.*

Assessment Methods

- *Regular quizzes, one per week, be conducted based on what has been taught in that week instead of lengthy test covering several topics.*
- *Assignment based on experiments which contributed to this field be given to students. The students shou be encouraged to write the assignment in their own words (plagiarism must be avoided) as per their understanding.*
- *The students should present the assigned topic through presentation.*
- *Continuous evaluation and gathering feedbacks may prove beneficial in improving teaching learning process.*

Keywords

Nano,0D, 1D, 2D and 3D nanostructures and confinemnnt, quantum dots, thin films, nanowires, nanorods, two dimensional electron gas (2DEG), Quasi-particles, excitons, radiative and non-radiative process, MEMS, NEMS, heterostructure, coulomb blockade, CNT

Nuclear and Particle Physics
(32227504)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It wil emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem based skills.

Course Learning Outcomes

The acquire knowledge can be applied in the areas of nuclear, medical, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

To be able to understand the basic properties of nuclei as well as knowledge of experimental assessments, the concept of binding energy and n-z curves and their significance

To appreciate the formulations and contrasts between different nuclear models such as Liquid drop and Shell Model and evidences in support.

Radioactivity and decay laws. A detailed analysis, comparison and energy kinematics of alpha, beta and gamma decays.

Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.

To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter. After learning of this unit, students will acquire knowledge about Accelerator facilities in India along with a comparative study of a range of detectors and accelerators which are building blocks of modern day instruments.

It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub-atomic particles with the different conservation laws, concept of quark model

Unit 1

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

(10 Lectures)

Unit 2

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumption of shell model. **(11 Lectures)**

Unit 3

Radioactivity decay: Decay rate and equilibrium (Secular and Transient)(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion. **(10 Lectures)**

Unit 4

Nuclear Reactions: Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8 Lectures)**

Unit 5

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production), neutron interaction with matter. **(9 Lectures)**

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. **(9 Lectures)**

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages). **(7 Lectures)**

Unit 6

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons. **(11 Lectures)**

References

[1] Basic Ideas and concepts in Nuclear Physics : An introductory Approach by K Heyde, Third edition, IOP Publication, 1999.

[2] Nuclear Physics by S. N. Ghoshal, First edition, S. Chand Publication, 2010.

[3] Concepts of Nuclear Physics by Bernard L Cohen, Tata McGraw Hill Publication, 1974.

[4] Introductory Nuclear Physics by Kenneth S, Krane, Wiley-India Publication, 2008

[5] Nuclear Physics : principles and applications by John Lilley, Wiley Publication, 2006.

[6] Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, Academic Press Elsevier, 2007.

[7] Introduction to Modern Physics by Mani & Mehta, Affiliated East-West Press, 1990.

[8]Introduction to elementary particles by David J Griffiths, Wiley, 2008.

[9] Modern Physics by Serway, Moses and Moyer, CENGAGE LEARNING, 2012.

Additional Resources:

[1] Radiation detection and measurement, G.F. Knoll, John Wiley & Sons, 2010.

[2] Technique for Nuclear and Particle Physics experiments by William R Leo, Springer, 1994.

[3] Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.

[4] Nuclear Physics "Problem-based Approach" Including MATLAB by Hari M. Aggarwal, PHI Learning Pvt. Ltd. (2016)

Numerical Books : Schaum's Outline of Modern Physics, McGraw-Hill Education, 1999 and Modern Physics by R. Murugaeshan, S.Chand Publication, 2010.

Teaching Learning Process

Number of lectures required for individual topics of each Unit is shown in the table along with the reference for each topic.

S. No.	Unit and Syllabus	No. of Lectures	Reference Book
	General Properties of Nuclei		
	Constituents of nucleus and their Intrinsic properties.	1	
	Quantitative facts about mass.	1	
1	radii, charge density, matter density (experimental determination of each).	1	
	Binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve and N/Z plot.	4	[1],[2],[3],[9],[1
	Angular momentum, parity.	1	
	Magnetic moment.	1	
	Electric moments.	1	
	Nuclear Models		
	Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons).	7	13th Chapter of [1 (13.3), 7th Chapt of [1]
2	Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas)	2	8th Chapter of [1 (8.1,8.2)
	Evidence for nuclear shell structure and the basic assumption of shell model.	2	9th Chapter of [1 (9.1) and 5th Chapter of [4] (without any derivation) (5.1), 11th Chapter of [1 (11.6)
	Radioactivity decay		
3	Decay rate and equilibrium (Secular and Transient).(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains.	5	2nd Chapter of [1] 3rd Chapter of [2] (3.5,3.6) , 4thChapter of [1], 4rd Chapter of [2] 8th Chapter of [4] 13th Chapter of [1 (13.5)
	(b) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis.	3	5nd Chapter of [1 (5.1,5.4) (page n 157, only introduction), 8ht Chapter of [3] (8. 9th Chapter of [4] (9.1,9.2 (only ma of the neutrino),9
	(c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.	2	10th Chapter of [4 (10.1,10.2,10.6), 12th Chapter of [3 (no derivation)

		10	
	Nuclear Reactions		
4	Types of reactions, units of related physical quantities,. Conservation Laws, kinematics of reactions, Q-value.	5	11th Chapter of [(11.1- 11.6)
	Concept of compound and direct Reaction, resonance reaction.	2	
	Reaction rate, reaction cross section, Coulomb scattering (Rutherford scattering).	1	
	Interaction of Nuclear Radiation with matter		
5	Energy loss due to ionization (Bethe-Block formula).	2	5th chapter of [5 10th Chapter of [Additional books: [7],[8]
	Energy loss of electrons.	1	
	Cerenkov radiation.	1	
	Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production).	4	
	Neutron interaction with matter.	1	
	Detector for Nuclear Radiations		
6	Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter.	3	6th Chapter of [5] (6.1 to 6.6) Additional book : 3rd, 5th and 6th Chapters of [6]
	Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT).	2	
	Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility).	3	
	Neutron detector.	1	
	Particle Accelerators		
7	Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. (Principal, construction, working, advantages and disadvantages).	7	6th Chapter of [5] (6.8), 15th Chapte of [4], Additional book : [9]
	Particle physics		
8	Particle interactions (concept of different types of forces), basic features.	2	1st chapter of[10 up to 1.8, 18th Chapters of [4] u to 18.4, 13th Chapter of [12] Additional Book: [
	Cosmic Rays.	1	
	Types of particles and its families.	2	
	Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness).	3	
	Concept of quark model, color quantum number and gluons.	3	

Reference Book :

[1] Basic Ideas and concepts in Nuclear Physics : An introductory Approach by K Heyde, Third edition, IOP Publication, 1999.

[2] Nuclear Physics by S. N. Ghoshal, First edition, S. Chand Publication, 2010.

[3] Concepts of Nuclear Physics by Bernard L Cohen, Tata McGraw Hill Publication, 1974.

[4] Introductory Nuclear Physics by Kenneth S, Krane, Wiley-India Publication, 2008

[5] Nuclear Physics : principles and applications by John Lilley, Wiley Publication, 2006.

[6] Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, Academic Press Elsevier, 2007.

[7] Radiation detection and measurement, G.F. Knoll, John Wiley & Sons, 2010.

[8] Technique for Nuclear and Particle Physics experiments by William R Leo, Springer, 1994.

[9] Introduction to Modern Physics by Mani & Mehta, Affiliated East-West Press, 1990.

[10]Introduction to elementary particles by David J Griffiths, Wiley, 2008.

[11] Modern Physics by Serway, Moses and Moyer, CENGAGE LEARNING, 2012.

[12] Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.

Numerical Books : Schaum's Outline of Modern Physics, McGraw-Hill Education, 1999 and Modern Physics by Murugaeshan, S.Chand Publication, 2010.

Keywords

Nuclear Physics, Nuclear Structure, Nuclear Decay & Reaction, Accelerators & Detectors, Particle Physics

Physics of Devices and Communication
(32227505)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

1. This paper is based on advanced electronics which covers the devices such as UJT, JFET, MOSFET, CMOS etc.

2. Process of IC fabrication is discussed in detail. Digital Data serial and parallel Communication Standards are described along with the understanding of communication systems.

Course Learning Outcomes

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

· Students will develop the basic knowledge of semiconductor device physics and electronic circuits along with the practical technological considerations and applications.

· They will be able to understand the operation of devices such as UJT, JFET, MOS and the various bias circuits of MOSFET.

· Students will learn to analyze MOSFET circuits and develop an understanding of MOSFET I-V characteristics and the allowed frequency limits.

· Another objective of this paper is to introduce students with the IC fabrication technology involving the process of diffusion, implantation, oxidation and etching with an emphasis on photolithography and electron-lithography.

· Students will learn to apply concepts for the regulation of power supply by developing an understanding of various kinds of RC filters classified on the basis of allowed range of frequencies.

· Students will learn basic principles of phase locked loop (PLL) and understand its operation.

· They will gain an understanding of Digital Data serial and parallel Communication Standards.

· Also, students will understand different blocks in communication system, need of modulation, modulation processes and different modulation schemes.

Unit 1

Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO2-Si based MOS, C-V characteristics of MOS, MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. (17 Lectures)

Unit 2

Processing of Devices: Basic process flow for IC fabrication. Crystal plane and orientation. Diffusion and implantation of dopants. Passivation. Oxidation Technique for Si. Contacts and metallization technique. Wet etching. Dry etching (RIE). Positive and Negative Masks. Photolithography. Electron-lithography, Basic idea of SSI, MSI, LSI, VLSI and USI. (14 Lectures)

Unit 3

RC Filters: Passive-Low pass and High pass filters, Active (1st order butterworth) -Low Pass, High Pass, Band Pass and band Reject Filters. (3 Lectures)

Phase Locked Loop (PLL): Basic Principles, Phase detector (XOR and edge triggered), Voltage Controlled Oscillator (Basics, varactor). Lock and capture. Basic idea of PLL IC (565 or 4046). (6 Lectures)

Digital Data Communication Standards:
Serial Communications: RS232, Handshaking, Implementation of RS232 on PC, Universal Serial Bus (USB), USB standards, Types and elements of USB transfers.
Parallel communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.
(5 Lectures)

Unit 4

Introduction to communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. Frequency modulation and demodulation, basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK. (15 lectures)

Practical

PRACTICAL- DSE LAB: Physics of Devices and Communication

60 Periods

At least 06 experiments each from section-A and section-B:

Section-A:

1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of given specification.
3. To design the active filter (wide band pass and band reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.

6. To study the output characteristics of a MOSFET.
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using transistor.
11. To study a PLL IC (Lock and capture range).
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via USB port of PC.
15. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

Section-B: ***SPICE/MULTISIM simulations for electronic circuits and devices***

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. Design the 1storder active low pass and high pass filters of given cutoff frequency
6. Design a Wein`s Bridge oscillator of given frequency.
7. Design clocked SR and JK Flip-Flop`s using NAND Gates
8. Design 4-bit asynchronous counter using Flip-Flop ICs
9. Design the CE amplifier of a given gain and its frequency response.
10. Design an Astable multivibrator using IC555 of given duty cycle.

References

- Physics of Semiconductor Devices, S.M.Sze and K.K.Ng, 3rd Edition 2008, John Wiley & Sons
- Op-Amps & Linear Integrated Circuits, R.A.Gayakwad,4 Ed. 2000, PHI Learning Pvt. Ltd
- Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
- Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
- Introduction to Measurements & Instrumentation, A.K.Ghosh, 4th Edition, 2017, PHI Learning
- Semiconductor Physics and Devices, D.A. Neamen, 2011, 4th Edition, McGraw Hill
- PC based instrumentation; Concepts and Practice, N. Mathivanan, 2007, Prentice-Hall of India
- Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller,1994, Mc-Graw Hill
- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Introduction to PSPICE using ORCAD for circuits& Electronics, M.H.Rashid,2003, PHI Learning.

Keywords

UJT, JFET, Metal semiconductor junction, MOS device, flat band voltage, MOSFET, CMOS, charge coupled device IC fabrication, Diffusion, Implantation, Passivation, Etching, Filters, Phase locked loop, Voltage controlled oscillator, Serial communication, Parallel communication, Amplitude modulation, modulation index, Demodulatio Frequency modulation, Phase modulation

Physics of the Earth
(32227624)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

This course familiarizes the students with the origin of universe and role of earth in the solar system.

Course Learning Outcomes

It focuses on the structure of the earth as well as various dynamical processes occurring on it. It also aims to develop an understanding of evolution of the earth.

Unit 1

The Earth and the Universe:
(17 Lectures)
(a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography . Introduction to various branches of Earth Sciences.
(b) General characteristics and origin of the Universe.The Big Bang Theory. Age of the universe and Hubble constant. Formation of Galaxies. The Milky Way galaxy,Nebular Theory,solar system, Earth's orbit and spin, the Moon's orbit and spin.The terrestrial and Jovian planets.Titius-Bode law. Asteroid belt. Asteroids: origin types and examples. Meteorites & Asteroids. Earth in the Solar system,origin, size, shape, mass, density, rotational and revolution parameters and its age.
(c) Energy and particle fluxes incident on the Earth.
(d) The Cosmic Microwave Background.

Unit 2

Structure:
(18 Lectures)
(a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?
(b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.
(c) The Atmosphere: layers, variation of temperature with altitude, adiabatic lapse rate, variation of density and pressure with altitude, cloud formation
(d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

Unit 3

Dynamical Processes:
(18 Lectures)
(a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; types of plate movements, hotspots; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Seismic waves, Richter scale, geophones. Volcanoes: types products and distribution.
(b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.
(c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones and anti-cyclones.
Climate:
i.
Earth's temperature and greenhouse effect.
ii.
Paleoclimate and recent climate changes.
iii.
The Indian monsoon system.
(d) Biosphere: Water cycle, Carbon cycle. The role of cycles in maintaining a

steady state.

Unit 4

Evolution:
(18 Lectures)
Stratigraphy: Introduction and types, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Time line of major geological and biological events. Introduction to geochronological methods and their application in geological studies. Radiometric dating: Advantages & disadvantages of various isotopes. History of development of concepts of uniformitarianism, catastrophism and neptunism. Various laws of stratigraphy. Introduction to the geology and geomorphology of Indian subcontinent. Origin of life on Earth
Role of the biosphere in shaping the environment. Future of evolution of the Earth and solar system: Death of the Earth (Probable causes).

Unit 5

Disturbing the Earth – Contemporary dilemmas
(4 Lectures)
(a) Human population growth.
(b) Atmosphere: Green house gas emissions, climate change, air pollution.
(c) Hydrosphere: Fresh water depletion.
(d) Geosphere: Chemical effluents, nuclear waste.
(e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

References

- Planetary Surface Processes, H. Jay Melosh, 2011, Cambridge University Press.
- Consider a Spherical Cow: A course in environmental problem solving, John Harte, University Science Books
- Holme’s Principles of Physical Geology, 1992, Chapman & Hall.
- Planet Earth, Cosmology, Geology and the Evolution of Lifeand Environment, C. Emiliani, 1992, Cambridge University Press.
- The Blue Planet:An Introduction to Earth System Science, Brian J. Skinner, Stephen C. Portere, 1994, John Wiley & Sons.
- Physics of the Earth, Frank D. Stacey, Paul M. Davis, 2008, Cambridge University Press.
- Fundamentals of Geophysics, William Lowrie, 1997, Cambridge University Press.
- The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
- The Earth: A Very Short Introduction, Martin Redfern, 2003, Oxford University Press.
- Galaxies: A Very Short Introduction, John Gribbin, 2008, Oxford University Press.
- Climate Change: A Very Short Introduction, Mark Maslin, 3 rd Edition, 2014, Oxford University Press.
- The Atmosphere: A Very Short Introduction, Paul I. Palmer, 2017, Oxford University Press.
- IGNOU Study material: PHE 15 Astronomy and Astrophysics Block 2

Verilog and FPGA based system design
(32227628)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

1. This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits.

2. Evolution of Programmable logic devices such as PAL, PLA and GAL is explained.
3. At the end of the syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.

Course Learning Outcomes

This paper discusses the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques. At the end of this course, students will be able to develop following learning outcomes:

- Understand the steps and processes for design of logic circuits and systems.
- Be able to differentiate between combinational and sequential circuits.
- Be able to design various types of state machines.
- Be able to partition a complex logic system into elements of data-path and control path.
- Understand various types of programmable logic building blocks such as CPLDs and FPGAs and their tradeoffs.
- Be able to write synthesizable Verilog code.
- Be able to write a Verilog test bench to test various Verilog code modules.
- Be able to design, program and test logic systems on a programmable logic device (CPLD or FPGA) using Verilog.

Unit 1

Digital logic design flow. Review of combinational circuits. Combinational building blocks: multiplexors, demultiplexers, decoders, encoders and adder circuits. Review of sequential circuit elements: flip-flop, latch and register. Finite state machines: Mealy and Moore. Other sequential circuits: shift registers and counters. FSMD (Finite State Machine with Datapath): design and analysis. Microprogrammed control. Memory basics and timing. Programmable Logic devices. (20 lectures)

Unit 2

Evolution of Programmable logic devices. PAL, PLA and GAL. CPLD and FPGA architectures. Placement and routing. Logic cell structure, Programmable interconnects, Logic blocks and I/O Ports. Clock distribution in FPGA. Timing issues in FPGA design. Boundary scan. (20 lectures)

Unit 3

Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog. (20 lectures)

Practical

PRACTICALS-DSE LAB: VERILOG AND FPGA LAB
60 Periods

AT LEAST 08 EXPERIMENTS FROM FOLLOWING.
1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Design and simulation of a 4 bit Adder.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs)
8. 3-bit Ripple counter
9. To design and study switching circuits (LED blink shift)
10. To design traffic light controller.
11. To interface a keyboard
12. To interface a LCD using FPGA
13. To interface multiplexed seven segment display.
14. To interface a stepper motor and DC motor.
15. To interface ADC 0804.

References

- LizyKurien and Charles Roth. Principles of Digital Systems Design and VHDL. Cengage Publishing. ISBN-13: 978-8131505748
- Palnitkar, Samir, Verilog HDL. Pearson Education; Second edition (2003).
- Ming-Bo Lin. Digital System Designs and Practices: Using Verilog HDL and FPGAs. Wiley India Pvt Ltd. ISBN-13: 978-8126536948

- Zainalabedin Navabi. Verilog Digital System Design. TMH; 2ndedition. ISBN-13: 978-0070252219
- Wayne Wolf. FPGA Based System Design. Pearson Education.
- S. K. Mitra, Digital Signal processing, McGraw Hill, 1998
- VLSI design, Debaprasad Das, 2nd Edition, 2015, Oxford University Press.
- D.J. Laja and S. Sapatnekar, Designing Digital Computer Systems with Verilog, Cambridge University Press, 2015.
- U. Meyer Baese, Digital Signal Processing with FPGAs, Springer, 2004
- Verilog HDL primer- J. Bhasker. BSP, 2003 II edition

Keywords

Combinational circuits, Multiplexer, Demultiplexer, Encoder, Decoder, Shift registers, Counters, Programmable logic devices, Verilog HDL

Engineering design and prototyping/Technical Drawing (32223906)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

“How I See is How I Understand”

Course Learning Outcomes

Drawings and pictorial representations are simple but effective tools in engineering crafts and one of the best ways to communicate ideas, learnings, and concepts. The purpose of this SEC is to empower the learners to think computationally and communicate pictorially.

Unit 1

Introduction: Fundamentals of Engineering design, design process and sketching: Scales and dimensioning, Designing to Standards (ISO Norm Elements/ISI), Engineering Curves: Parabola, hyperbola, ellipse and spiral.
(4 Lectures)

Unit 2

Projections: Principles of projections, Orthographic projections: straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids. Intersection and Interpenetration of solids. Isometric and Oblique parallel projections of solids.
(10 Lectures)

Unit 3

CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD specific skills (graphical user interface, create, retrieve, edit, and use symbol libraries). Use of Inquiry commands to extract drawing data. Control entity properties. Demonstrating basic skills to produce 2-D drawings. Annotating in Auto CAD with text and hatching, layers, templates and design centre, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. Basic printing and editing tools, plot/print drawing to appropriate scale.
(10 Lectures)

Unit 4

Computer Aided Design and Prototyping: 3D modeling with AutoCAD (surfaces and solids), 3D modeling with Sketchup, 3D designs, Assembly: Model Editing; Lattice and surface optimization; 2D and 3D packing algorithms, Additive Manufacturing Ready Model Creation (3D printing), Technical drafting and Documentation.
(6 Lectures)

References

- Engineering Drawing, N.S. Parthasarathy and Vele Murali, 1 st Edition, 2015, Oxford University Press
- Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International
- Engineering Drawing, Dhananjay A Jolhe, McGraw-Hill
- AutoCAD 2014 and AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
- Don S. Lemons, Drawing Physics, MIT Press, M A Boston, 2018, ISBN:9780262535199
- Norton, Robert L. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, M A Boston, McGraw-Hill, 2007.
- James A. Leach, AutoCAD 2017 Instructor, SDC publication, Mission, KS 2016. ISBN: 978163057029.
- Architectural Design with Sketchup/Alexander Schreyer/John Wiley & Sons/ISBN: 978-1-118-12309-6

Applied Dynamics
(32225104)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

Most processes encountered in nature are inherently nonlinear. This course introduces the main topics of low-dimensional nonlinear systems, with applications to a wide variety of disciplines, including physics, engineering, mathematics, chemistry, and biology. Specific topics include maps and flows in one and two dimensions, phase portraits, bifurcations, chaos, fractals and elementary fluid dynamics. Students will obtain familiarity with concep and methods in the field of dynamical systems, apply those concepts and methods to analyze dynamic models analytically and computationally, and will learn how to interpret and critically evaluate the results of those analyses.This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals. The emphasis of this course is to enhance the understanding of the basics of applied dynamics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in applied dynamics.

Course Learning Outcomes

Upon successful course completion, a student will be able to:
- Demonstrate understanding of the concepts that underlay the study of dynamical systems.
- Use the analytical and computational methods covered in this course to analyze dynamical systems models.

- Analyze the behavior of dynamical systems (e.g. find periodic orbits and assess their stability, draw phase portraits, etc.)
- Apply the techniques of nonlinear dynamics to physical processes drawn from a variety of scientific and engineering disciplines.

- Analyze uniform and nonuniform oscillators (flows on circle)
- Draw phase portraits and interpret them in several applications from biology, physics, chemistry and engineering.

- Define a fractal and give several examples of fractals in nature
- Understand the basics of different kind of fluid motion.

Unit 1

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems. Examples of dynamical systems – Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics. (22 Lectures)

Unit 2

Introduction to Chaos and Fractals: Chaos in nonlinear equations - Logistic map and Lorenz equations: Dynamics from time series. Parameter dependence- steady, periodic and chaotic states.Cobweb iteration.Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions.

Self-similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs.self-similar fractal structure. (18 Lectures)

Unit 3

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis-concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. (20 Lectures)

Practical

(60 Periods) Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like (at least 06 experiments)
1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. To study period doubling route to chaos in logistic map.
8. To study various attractors of Lorenz equations.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streaklines.

References

For Theory:

- Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007.
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
- Nonlinear Dynamics: Integrability, Chaos and Patterns, M. Lakshmanan and S. Rajasekar, Springer, 2003.
- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002.
- Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

For Practicals:
- Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer

Teaching Learning Process

Teaching learning process should include appropriate methods to make classroom teaching more effective, encouragement to students for active participation, collaborative learning and effective laboratory practices. Teaching methods should develop interest in the students by choosing appropriate method which cater individuals need, scientific ways of thinking, problem solving ability, student understanding, critical & quantitative thinking and experimental & data analysis skills. Students should Learn to use scientific apparatus, estimate statistical errors & recognize errors and develop reporting skills in laboratory practices.

Assessment Methods

Assessment methods are the strategies, techniques, tools and instruments for collecting information to determin the extent to which students demonstrate desired learning outcomes. Several methods should be used to assess student learning outcomes.Learning outcomes will be assessed using the following: oral and written examination closed-book and open-book tests; problem-solving exercises, practical assignment laboratory reports, observatio of practical skills, individual project reports, seminar presentation; viva voce interviews; computerised adaptive testing, literature surveys and evaluations, outputs from collaborative work etc.

Keywords

Phase space, First order dynamical systems, attractors, Chaos, Logistic map, route to chaos, Fractals, Self-similarity, fractal geometry, Autocorrelation, Lyapunov component, Fluid Dynamics, viscosity.

Astronomy and Astrophysics
(32225418)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This General Elective course is meant to introduce undergraduate students of the University of Delhi to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using la of geometry and physics, and more recently chemistry and biology. They will learn about diverse set of astronomical and astrophysical phenomenon, from the daily and yearly motion of stars and planets in the night sky which they can observe themselves, to the expansion of the universe deduced from the latest observations and cosmological models. The course presupposes school level understanding of mathematics and physics.

Course Learning Outcomes

Students completing this course gain

1. an understanding of different types of telescopes, diurnal and yearly motion of astronomical objects, and astronomical coordinate systems and their transformations.

2. Brightness scale for stars, types of stars, their structure and evolution on HR diagram.

3. Components of Solar System and its evolution

4. The large scale structure of the Universe and its history

4. Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life.

Unit 1

Introduction to Astronomy and Astronomical Scales: Wonders of the Universe, Overview of the Night Sky, Diurnal and Yearly motions of the Sun, Stars and Constellations. Size, Mass, Density and Temperature of Astronomical objects, Basic concepts of Positional Astronomy: Celestial Sphere, Astronomical Coordinate Systems, Horizon System, Equatorial System, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar, Astronomical Time Systems (LMT, UT, UTC) (15 Lectures)

Unit 2

Basic Parameters of Stars: Determination of Distance by Parallax

Method; Aberration, Proper Motion, Brightness, Radiant Flux and Luminosity, Apparent and Absolute Magnitude Scales, Distance Modulus; Determination of Temperature and Radius of a Star; Stellar Spectra, Atomic Spectra Revisited, Spectral Types and their Temperature Dependence, Black Body Approximation, Luminosity Classification, H R Diagram and Relations Between Stellar Parameters

(15 Lectures)

Unit 3

Observational Tools and Physical Principles: Observing through the atmosphere (Scintillation, Seeing , Atmospheric Windows and Extinction) Basic Optical Definitions for Telescopes: Magnification, Light Gathering Power, Limiting magnitude, Resolving Power, Diffraction Limit, Optical and Radio Telescopes, Current Indian Observatories.

Virial Theorem for N Particle Systems and Applications, Mean Molecular Weight of Stellar Gas, Stellar Energy Sources, (15 Lectures)

Unit 4

Sun and the Solar Family: Solar Parameters, Sun’s Internal Structure, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity.

The Solar Family: Facts and Figures, Origin of the Solar System: The

Nebular Model. Tidal Forces and Planetary Rings, Extra-Solar Planets. (8 Lectures)

Unit 5

Milky Way: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constants, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Properties of and around the Galactic Nucleus. Interstellar molecules. (10 lectures)

Unit 6

Cosmology and Astrobiology: Standard Candles (Cepheids and SNe Type1a), Cosmic Distance Ladder, Olber’s Paradox, Hubble’s Expansion, History of the Universe, Chemistry of Life, Origin of Life, Chances of Life in the Solar System, Exoplanets

(12 Lectures)

References

1. Seven Wonders of the Cosmos, Jayant V Narlikar, Cambridge University Press
2. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
3. The Physical Universe: An Introduction to Astronomy, F H Shu, University Science Books
4. Astrophysics Stars and Galaxies K D Abhyankar, Universities Press
5. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
6. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B.

Bhatia, Narosa Publication.

7. Baidyanath Basu, An introduction to Astrophysics, Second printing, Prentice -

Hall of India Private limited, New Delhi,2001.

8. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th
Edition, Saunders College Publishing.

9. Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, 2014, 7th edition, McGraw Hill

10. The Molecular Universe, A.G.G.M. Tielens, Reviews of Modern Physics, Vol 85, July September, 2013

Additional Resources:

Teaching Learning Process

1. The main mode of instruction will be class room lectures. Audio visual media involving documentaries, and Web based resour on latest discoveries will also be used.
2. Students will learn problem solving skills in tutorials. A list of problems should be distributed before every tutorial to let student solve them before solutions are discussed.
3. Students will get hands on experience of handling telescopes in coordination with institute's astronomy club. Outdoor excursio can be organised for viewing the sky at night.

Assessment Methods

1. Continuous evaluation of tutorial work.
2. Student Projects
3. Semester end exam.

Atmospheric Physics
(32225419)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This paper aims to describe the characteristics of earth’s atmosphere and also its dynamics.

Course Learning Outcomes

Atmospheric waves along with the basic concepts of atmospheric Radar and Lidar are discussed in detail.

Unit 1

General features of Earth’s atmosphere: Thermal structure of the Earth’s Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric

Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms.
(12 Lectures)

Unit 2

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.
(12 Lectures)

Unit 3

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration
(12 Lectures)

Unit 4

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.
(12 Lectures)

Unit 5

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.
(12 Lectures)

Practical

Scilab/C ++ based simulations experiments based on Atmospheric Physics problems like (at least 05 experiments)
1. Numerical Simulation for atmospheric waves using dispersion relations
(a) Atmospheric gravity waves (AGW)
(b) Kelvin waves
(c) Rossby waves and mountain waves
2. Offline and online processing of radar data
(a) VHF radar,
(b) X-band radar, and
(c) UHF radar
3. Offline and online processing of LIDAR data
1374. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
5. Handling of satellite data and plotting of atmospheric parameters using different techniques such as radio occultation technique
6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change
7. PM 2.5 measurement using compact instruments
8. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

References

- Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
- The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3 rd edn. 2002.
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

- Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

Biological physics
(32225205)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

The Biological Physics course introduces the emerging inter-disciplinary field on the interface of Physics and Biology.

Course Learning Outcomes

It makes use of concepts from Physics and discusses
their application in Biology. This course helps the students to develop a system level perspective of Biology and equips them with the required mathematical and computational skills.

Unit 1

Overview:
(6 Lectures)
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. Allometric scaling laws.

Unit 2

Molecules of life:
(18 Lectures)
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 to be studied analytically and computationally.

Unit 3

Molecular motion in cells:
(22 Lectures)
Random walks and applications to biology: Diffusion; models of macromolecules.
Entropic forces: Osmotic pressure; polymer elasticity.
Chemical forces: Self assembly of amphiphiles.
Molecular motors: Transport along microtubules.
Flagellar motion: bacterial chemotaxis.

Unit 4

The complexity of life:
(20 Lectures)
At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Metabolic, regulatory and signaling networks in cells. Dynamics of metabolic networks; the stoichiometric matrix. 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. Cellular differentiation and development.

Brain structure: neurons and neural networks. Brain as an information processing system.

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

Unit 5

Evolution:
(9 Lectures)
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.

References

- Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman &Co, NY, 2004)
- Physical Biology of the Cell (2nd Edition); Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
- An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
- Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Communication System
(32225312)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

1. *This paper aims to describe the concepts of electronics in communication.*
2. *Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail.*
3. *Communication and Navigation systems such as GPS and mobile telephony system are introduced.*

Course Learning Outcomes

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

- This paper aims to describe the concepts of electronics in communication. In this course, students will receive an introduction to the principle, performance and applications of communication systems.
- Students will learn the various means and modes of communication. They will gain an understanding of fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- They will gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Students will be able to analyze different parameters of analog communication techniques.
- They will learn the need of sampling and different sampling techniques where they can sample analog signal.
- Students will learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- They will gain an in-depth understanding of different concepts used in a satellite communication system.
- They will study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- Students will understand evolution of mobile communication generations 2G, 3G, and 4G with their characteristics and limitations.

- This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

Unit 1

Electronic communication: Introduction to communication – means and modes. Power measurements (units of power). 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. **(4 Lectures)**

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, 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. **(12 Lectures)**

Unit 2

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing). . **(9 Lectures)**

Unit 3

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). **(10 Lectures)**

Unit 4

Satellite Communication– Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), Uplink and downlink, path loss, Satellite visibility, Ground and earth stations. Simplified block diagram of earthstation. **(10 Lectures)**

Unit 5

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) **(15 Lectures)**

Unit 6

Practical

PHYSICS Lab-GE LAB: COMMUNICATION System LAB

60 Periods

At least 05 experiments from the following

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

References

- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- Advanced Electronics Communication Systems- Tomasi, 6thEdn. Prentice Hall.
- Modern Digital and Analog Communication Systems, B.P. Lathi, 4th Edition, 2011, Oxford University Press.
- Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
- Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
- Communication Systems, S. Haykin, 2006, Wiley India
- Electronic Communication system, Blake, Cengage, 5th edition.
- Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press
- Introduction to Communication systems, U. Madhow, 1st Edition, 2018, Cambridge University Press

Keywords

Electronic communication, Modulation, Channels, base band signals, Analog modulation, Amplitude modulation, modulation index, Demodulation, Frequency modulation, Phase modulation, sampling, Analog Pulse modulation, Digital Pulse Modulation, Shift Keying, satellite communication, mobile communication

Digital Signal processing
(32225416)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

1. This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals.

2. This paper also highlights the concept of filters and realization of Digital Filters.

3. At the end of the syllabus, students will develop the understanding of Discrete and fast Fourier Transform.

Course Learning Outcomes

In this course, students will be able to develop a thorough understanding of the central elements of discrete time signal processing theory and correlate this theory with the real-world signal processing applications. 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 analyze the discrete time signals and systems. They will learn to analyze 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 analyze 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 & infinite impulse response filters for various applications.

Unit 1

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. **(10 Lectures)**

Unit 2

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. **(15 Lectures)**

Unit 3

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. **(5 Lectures)**

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. **(10 Lectures)**

Unit 4

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. **(5 Lectures)**

Unit 5

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.

(15 Lectures)

Practical

PRACTICAL-GE LAB: DIGITAL SIGNAL PROCESSING LAB

60 Periods

At least 06 experiments from the following using Scilab/Matlab. Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence δ(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≤n≤50.

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

x(n)=rect(n/2N)=Π(n/2N)={█(1 -N≤n≤N@0 otherwise)┤

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(0.5πn)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 |H(e^jw)| and ∠H(e^jw)

5. Design a digital filter to eliminate the lower frequency sinusoid of x(t)=sin7t+sin200t. The sampling frequency is f_s=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)=({1,1,1,1})¦↑={█(1 0≤n≤3@0 otherwise)┤

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})¦↑

h(n)=({1,-1,-1,1})¦↑

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:

passband edge F_p=2 KHz

stopband edge F_s=5 KHz

Passband attenuation A_p=2 dB

Stopband attenuation A_s=42 dB

Sampling frequency F_s=20 KHz

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

H_d (e^jw)=jwe^(-jτw) |w|≤π

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

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Keywords

Signals, Periodic signals, Aperiodic signals, Discrete time systems, Impulse response, Convolution, Discrete time fourier transform (DTFT), z-transform, LTI system, Difference equation, Filters, Frequency domain sampling, Discrete fourier transform (DFT), Fast fourier transform, Digital filters, FIR filter, IIR filter, Frequency response, Kaiser window

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Digital, Analog and Instrumentation
(32225103)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

1. This paper aims to cover the basic digital and analog electronic systems. The concept of Boolean algebra is discussed in detail and arithmetic circuits are described.

2. Students will learn the physics of semiconductor devices such as p-n junction, rectifier diodes and bipolar junction transistors.
3. By the end of the syllabus, students will also have an understanding of operational amplifiers and instrumentation including CRO, power supply etc.

Course Learning Outcomes

LEARNING OUTCOMES:

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

- *To differentiate between Analog and Digital circuits, acquire knowledge of the concepts of binary numbers, their addition, subtraction and conversion into decimal numbers.*
- *To explains the concepts of logic states and logic gates AND, OR, NOT, NAND, NOR, XOR and XNOR as fundamental, universal and derived gates with its utility.*
- *To learn how to write logical Boolean statements using the truth table, its simplification using Boolean Algebra, De-Morgan’s Theorem and Karnaugh Maps specially the Sum of Products method and realize the corresponding logic circuit.*
- *To realize addition and subtraction of binary numbers using electronic circuits.*
- *To introduce the structure and operation of PN junction diodes and Bipolar Junction transistors. Also understand characteristics of different configurations, various current components and related parameters.*
- *To learn about the DC load line, quiescentpoint and biasing of voltage divider circuit.*
- *To analyze CE transistor amplifier using h-parameter model of the transistor.*
- *To distinguish ideal and practical op-amps and their electrical parameters.*
- *To understand various operating modes of Op-amps and its linear and non-linear application and acquire skill to design circuits for different OP-amp applications.*
- *To comprehend the criterion for sustained oscillations and its application in frequency determination for RC phase shift oscillator.*
- *To impart understanding of working of CRO and its usage in measurements of voltage, current, frequency and phase measurement.*
- *To describe working of rectifier circuits and quantitatively explain effect of capacitance filter, line and load regulation*
- *To explain the working of timer circuits using IC 555 and use them to develop multivibrators.*

Unit 1

UNIT-1: Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates. NAND and NOR. Gates as Universal Gates. XOR and XNOR Gates. (5 Lectures)

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

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders andFull Adders and Subtractors, 4-bit binary Adder-Subtractor. (4 Lectures)

Unit 2

UNIT-2: Semiconductor Devices and Amplifiers:

Semiconductor Diodes: P and N type semiconductors. PN junction and its characteristics. Static and dynamic Resistance. (2 Lectures)

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff & Saturation regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q-point. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit of transistor. Analysis of single-stage CE amplifier using hybrid Model. Input and output Impedance. Current and Voltage gains. (12 Lectures)

Unit 3

UNIT-3: Operational Amplifiers (Black Box approach):

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed-loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator,(5) Integrator, (6) Zero crossing detector. (14 Lectures)

Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Phase-shift Oscillator. (5 Lectures)

Unit 4

UNIT-4: Instrumentations:

Introduction to CRO: Block diagram of CRO. Applications of CRO: (1) Study of waveform, (2) Measurement of voltage, current, frequency, and phase difference. (3 Lectures)

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation. (6 Lectures)

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator. (3 Lectures)

Practical

GE LAB: DIGITAL, ANALOG CIRCUITS AND INSTRUMENTS

60 Periods

AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO

2. To minimize a given (a) logic circuit and (b) Boolean equation.

3. Half adder, Full adder and 4-bit Binary Adder.

4. To design an astable multivibrator of given specifications using 555 Timer.

5. To design a monostable multivibrator of given specifications using 555 Timer.

6. To study IV characteristics of (a) PN diode, (b) Zener diode and (3) LED.

7. To study the characteristics of a Transistor in CE configuration.

8. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.

9. (a) To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.

(b) To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.

10. To study Differential Amplifier of given I/O specification using Op-amp.

11. To investigate a differentiator made using op-amp.

12. To design a Wien Bridge Oscillator using an op-amp.

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Keywords

Logic gates, Boolean Algebra, Adder, Subtractor, Semiconductor diode, Transistor, Amplifier, Oscillators, CRO, Rectifiers, Zener diode,Voltage regulation, Multivibrator

Electricity and Magnetism
(32225101)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This course begins with elementary vector analysis, an essential mathematical tool for understanding static elect
and magnetic field. By the end of the course student should appreciate Maxwell’s equations.

Course Learning Outcomes

1. Demonstrate the application of Coulomb’s law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.
2. Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution.
3. Apply Gauss’s law of electrostatics to solve a variety of problems.
4. Demonstrate an understanding of the behavior of electric conductors.
5. Demonstrate a working understanding of capacitors.
6. Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot-Savart and Ampere laws)
7. Understand the concepts of induction and self-induction, to solve problems using Faraday’s and Lenz’s laws.

Unit 1

Vector Analysis: Vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).(20 Lectures)

Unit 2

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.(22 Lectures)

Unit 3

Magnetism:
Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials. (10 Lectures)

Unit 4

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. (6 Lectures)

Introduction to Maxwell`s equations (2 Lectures)

Practical

At least 05 experiments from the following:
1. Ballistic Galvanometer:
(i) Measurement of charge and current sensitivity
(ii) Measurement of CDR
(iii) Determine a high resistance by Leakage Method
(iv) To determine Self Inductance of a Coil by Rayleigh’s Method.

2. To compare capacitances using De’Sauty’s bridge.
3. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
4. To study the Characteristics of a Series RC Circuit.
5. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor
6. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
7. To determine a Low Resistance by Carey Foster’s Bridge.
8. To verify the Thevenin and Norton theorems
9. To verify the Superposition, and Maximum Power Transfer Theorems

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Teaching Learning Process

- Chalk and Blackboard approach
- Group discussion in the class
- PPT presentation on special topics.

Assessment Methods

- Assignments
- Class test
- Semester end examination

Elements of Modern Physics
(32225202)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This course introduces modern development in Physics that ushered in relativity and quantum physics which

not only revolutionized mankind's understanding of time, space, atomic and sub-atomic structures that make up the matter

around us, but also led to

fascinating developments in technology that are being witnessed all around us.

Beginning with technological marvels like electronics, spectroscopy, semiconductor based devices,

IC chips, lasers, harnessing of nuclear energy, satellite communication, atomic clocks, GPS, space travel, scanni tunneling

microscope, nano-materials, nano- technology, CCDs, etc. modern physics brought forth useful tools

in our daily lives like laptop computers, mobile phones, laser pointers, LEDs, LCD screens, so on and so forth. Therefore,

the objective of this course is to teach the physical and mathematical foundations necessary for learning variou topics in modern

physics.

Starting from Planck’s law, this course introduces experimental observation of photo-ejection of electrons, idea of wave-particle duality

as well as Bohr model of atoms and, then it develops the formulation of

Schrodinger equation and the idea of probability interpretation associated with wave-functions.

It also introduces basic underlying concepts involved in laser physics as well as that in nuclear physics, so crucia for high energy

physics, nuclear technology and astrophysics.

Course Learning Outcomes

Starting from Planck’s law, this course

develops the idea of probability interpretation and then discusses the formulation of

Schrodinger equation. It also introduces basic concepts of nuclear physics.

Unit 1

Planck’s quantum, Planck’s constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets.Group and Phase velocities and relation between them. Double-slit experiment with electrons. Probability. Wave amplitude and wave functions.

(12 Lectures)

Unit 2

Position measurement : gamma ray microscope thought experiment; Wave-particle duality leading to Heisenberg uncertainty principle; Uncertainty relations involving canonical pair of variables: Derivation from Wave Packets; Impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle: origin of natural width of emission lines as well as estimation of the mass of the virtual particle that mediates a force from the observed range of the force (7 Lectures)

Unit 3

Two-slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. (10 Lectures)

Unit 4

One dimensional infinitely rigid box : energy eigenvalues, eigenfunctions and their normalization; Quantum dot as an example;

Quantum mechanical scattering and tunneling in one dimension : across a step potential & across a rectangular potential barrier.

Lasers: Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. (14 Lectures)

Unit 5

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy. (6 Lectures)

Unit 6

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Fission : nature of fragments and emission of neutrons. Fusion and thermonuclear reactions driving stellar evolution (brief qualitative discussions). (11 Lectures)

Practical

At least 06 experiments from the following:

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 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 H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.

7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine angular spread of He-Ne laser using plane diffraction grating

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Additional Resources:

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 Quantum Theory, David Bohm, Dover Publications, 1979

 Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

Embedded System: Introduction to microcontroller (32225204)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

1. In this course, students will learn about the 8051 I/O port programming, various addressing modes.

2. Students will have a thorough understanding of Timer and counter programming, Serial port programming wi and without interrupt and interfacing 8051 microcontroller to peripherals.

Course Learning Outcomes

This is a course to familiarize/ introduce students to designing and developing embedded systems. It provides the students with an introductory coverage of embedded systems. The learning outcomes of the course are:

- *Knowledge of the major components that constitute an embedded system.*
- *Understand what is a microcontroller, microcomputer embedded system.*
- *Description of the architecture of a 8051 microcontroller.*
- *Write simple programs for 8051 microcontroller in C language.*
- *Understand key concepts of 8051 microcontroller systems like I/O operations, interrupts, programming of timers and counters.*
- *Interfacing of 8051 microcontroller with peripherals*
- *Understand and explain concepts and architecture of embedded systems*
- *Implement small programs to solve well-defined problems on an embedded platform.*
- *Develop familiarity with tools used to develop an embedded environment*
- *Learning to use the Arduino Uno (an open source microcontroller board) in simple applications.*

Unit 1

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges and design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers. (4 Lectures)

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions. (12 Lectures)

Unit 2

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of8051 microcontroller, I/O port pins description and their functions, I/O port programming in 8051, (Using Assembly Language), I/O programming: Bit manipulation. (4 Lectures)

Programming of 8051: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic & logic instructions, 8051 programming in C:- for time delay and I/O operations and manipulation, for arithmetic & logic operations, for ASCII and BCD conversions. (12 Lectures)

Unit 3

Timer & counter programming: Programming 8051 timers, counter programming. (3 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051. (6 Lectures)

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing. (2 Lectures)

Unit 4

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. (3 Lectures)

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. (8 Lectures)

Unit 5

Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming and applications. (6 Lectures)

Practical

PRACTICALS- GE LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

60 Periods

At least 06 experiments based on 8051 microcontroller from the following:

1. To find that the given numbers is prime or not.

2. To find the factorial of a number.

3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.

4. Use one of the four ports of 8051 for O/P interfaced to eight LED’s. Simulate binary counter (8 bit) on LED’s .

5. Program to glow the first four LEDs then next four using TIMER application.

6. Program to rotate the contents of the accumulator first right and then left.

7. Program to run a countdown from 9-0 in the seven segment LED display.

8. To interface seven segment LED display with 8051 microcontroller and display ‘HELP’ in the seven segment LED display.

9. To toggle ‘1234’ as ‘1324’ in the seven segment LED display.

10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.

11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

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- Embedded Systems & Robots, Subrata Ghoshal, 2009, Cengage Learning
- Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.
- Microprocessors and Microcontrollers, Krishna Kant, 2nd Edition, 2016. PHI learning Pvt. Ltd.

Keywords

Embedded systems, 8051, Microcontroller, Architecture, Memory map, Addressing modes, Timers, Counter Programming, Interrupts, LCD interfacing, Arduino

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Mathematical Physics
(32225102)
Generic Elective - (GE) Credit:6

Unit 1

Introduction and Overview:

Computer architecture and organization, memory and Input/output devices.

Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.

Algorithms and Flow charts: Purpose, symbols and description

Unit 2

Introduction to C++ : Introduction to Programming: Algorithms: Sequence, Selection and Repetition, Structured programming, basic idea of Compilers. Data Types, Enumerated Data, Conversion & casting, constants and variables, Mathematical, Relational, Logical and Bitwise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables.
Programs:
- To calculate area of a rectangle
- To check size of variables in bytes (Use of sizeof() Operator)

C++ Control Statements: if-statement, if-else statement, Nested if Structure, Else-if statement, Ternary operator, Goto statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, For loop, nested loops, break and continue statements
Programs:
- To find roots of a quadratic equation if…else And if…else if
- To find largest of three numbers
- To check whether a number is prime or not
- To list Prime numbers up to 1000

Unit 3

Random Number generator:

To find value of pi using Monte Carlo simulations

Arrays and Functions: Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order using Bubble sort and Sequential sort, Binary search.

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods Solution of linear and quadratic equation, solving equations in optics,

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Unit 4

Interpolation by Newton Gregory Forward & Backward difference formula, Error estimation of linear interpolationEvaluation of trigonometric functions e.g. sin□, cos□, tan□ etc

Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method Given Position with equidistant time data calculate velocity and acceleration and vice versa. Find the area of BH Hysteresis loop

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Unit 5

Solution of Ordinary Differential Equations (ODE)
First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods
First order differential equation
Radioactive decay
Current in RC, LC circuits with DC source
Newton's law of cooling
Classical equations of motion
Also attempt the following problems using RK 4 order method
Solve the coupled differential equations
dx/dt=y+x- 〖x^3/3 ; dy/dx〗 ^ = -x
for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four initial conditions on the same screen for 0 □ t □ 15

References

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C++: The Art of Scientific Computing, W.H. Press et.al., 2nd Edn., 2013, Cambridge University Press.
- A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- AnIntroductiontocomputationalPhysics,T.Pang,2nd Edn., 2006,CambridgeUniv. Press

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Mechanics
(32225201)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This course begins with the review of Vectors and Differential equations and ends with the Special Theory of Relativity. Students will also appreciate the Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the basics of mechanics. By the end of this course, students should be able to solve the see or unseen problems/numericals in vectors, differential equations and mechanics.

Course Learning Outcomes

- In this course students will gain knowledge about the theoretical concept behind physical phenomena.
- This course will provide a deep understanding on the following topics
- Vectors and Ordinary Differential equations.
- Centre of mass of objects with different symmetries.
- Kepler’s laws Geosynchronous orbits
- Variable mass system and dynamics of a system of particles
- Conservative and non-conservative forces
- Determination of moment of inertia of discrete and continuous objects
- Simple harmonic motion
- Inertial reference frames and Galilean transformations
- Concept of space- time, mass variation of a relativistic particle.
- Mass- Energy equivalence.

Upon completion of this course, students are expected to

- appreciate the fundamental concepts which frames the basis of our universe
- attain a deep understanding on how to analyze practical situations
- develop the ability to analyze and explain different applications.
- Use a mathematical approach for solving problems.

Unit 1

Vectors: Vector algebra.Derivatives of a vector with respect to a parameter. Scalar and vector products of two, three and four vectors. Gradient, divergence and curl of vectors fields. Polar and Axial vectors. (5 Lectures)

Ordinary Differential Equations:1st order homogeneous differential equations, exact and non-exact differential equations, 2nd order homogeneous and non-homogenous differential equations with constant coefficients (Operator Method Only). (8 Lectures)

Unit 2

Laws of Motion: Review of Newton“s Laws of motion. Dynamics of a system of particles. Concept of Centre of Mass, determination of center of mass for discrete and continuous systems having cylindrical and spherical symmetry (1-D, 2-D, 3-D objects). (6 Lectures)

Work and Energy: Motion of rocket.Work-Energy theorem for conservative forces. Force as a gradient of Potential Energy. Conservation of momentum and energy. Elastic and in-elastic Collisions. (5 Lectures)

Unit 3

Rotational Dynamics: Angular velocity, Angular momentum, Torque, Conservation of angular momentum, Moment of Inertia. Theorem of parallel and perpendicular axes. Calculation of Moment of Inertia of discrete and continuous objects (1-D, 2-D and 3-D). Kinetic energy of rotation. Motion involving both translation and rotation. (10 Lectures)

Unit 4

Gravitation: Newton"s Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler"s Laws (statements only). Satellite in circular orbit and applications. Geosynchronous orbits. (5 Lectures)

Unit 5

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions.Kinetic and Potential Energy, Total Energy and their time averages. Compound pendulum. Differential equations of damped oscillations and its solution. (7 Lectures)

Unit 6

Special Theory of Relativity: Frames of reference. Gallilean Transformations. Inertial and Non-inertial frames. Outcomes of Michelson Morley"s Experiment. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic transformation of velocity. Relativistic variation of mass. Mass-energy equivalence. Transformation of Energy and Momentum. (14 Lectures)

Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate.

Practical

(60 Periods) At least 05 experiments from the following:
1. Measurements of length (or diameter) using Vernier calliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the motion of the spring and calculate (a) Spring constant and, (b) g.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique.
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille"s method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell"s needle.
10. To determine the elastic constants of a wire by Searle"s method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater"s Pendulum.

References

For theory:

- University Physics.FW Sears, MW Zemansky & HD Young13/e, 1986.Addison-Wesley
- Mechanics Berkeley Physics course,v.1:Charles Kittel,et.al. 2007, Tata McGraw-Hill
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
- Engineering Mechanics, Basudeb Bhattacharya, 2ndedn., 2015, Oxford University Press
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

For Practicals:

- Advanced Practical Physics for students, B.L.Flintand H.T.Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Engineering Practical Physics, S. Panigrahi and B.Mallick, 2015, Cengage Learning India Pvt. Ltd.

Teaching Learning Process

- Class room teaching complemented with power-point presentations to provide physical pictures.
- Use of short videos for visual capture.
- Student teacher interaction in tutorial classes.
- Home work/assignments

Assessment Methods

Assessment methods are the strategies, techniques, tools and instruments for collecting information to determin the extent to which students demonstrate desired learning outcomes. Several methods should be used to assess student learning outcomes.Learning outcomes will be assessed using the following: oral and written examination closed-book and open-book tests; problem-solving exercises, practical assignment laboratory reports, observati of practical skills, individual project reports, seminar presentation; viva voce interviews; computerised adaptive testing, literature surveys and evaluations, outputs from collaborative work etc.

Keywords

Gradient, divergence, curl, ordinary differential equations, Newton’s laws of motion, Centre of Mass, Moment of inertia, central forces, Kepler’s Laws, Geosynchronous orbits, Simple Harmonic oscillator, Inertial frames, Special theory of relativity, Galilean transformation, Mass-Energy equivalence.

Medical Physics
(32225105)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This course introduces a student to the basics of Medical Physics.

Course Learning Outcomes

The last few years have witnessed a tremendous growth in the applications of Physics to the field of medicine. Beginning with the use of Imaging in Diagnostics to Radiation therapy for Cancer, everything involves Physics. Hence, there is a big need for medical physicists. This course introduces a student to the basics of Medical Physics. Today with the changing life styles it is also necessary for one to have a better understanding of the human body from the perspective of Physics. This course seeks to fulfil both these needs.

Unit 1

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. Basics of CPR.
(8 Lectures)

Unit 2

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.
(10 Lectures)

Unit 3

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I
X-RAYS: 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, types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables, HT generation.
(7 Lectures)

RADIATION PHYSICS: Radiation units exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, Rem & Sievert, linear attenuation coefficient. Radiation Detectors: Thimble chamber, condenser chambers, Geiger Muller counter, Scintillation counters and Solid State detectors, ionization chamber, Dosimeters, survey methods, area monitors, TLD,Semiconductor detectors.
(7 Lectures)

Unit 4

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 & function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display).
(9 Lectures)

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, medical linear accelerator, 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.
(9 Lectures)

Unit 5

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.
(5 Lectures)

Unit 6

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.
(5 Lectures)

Practical

1. Understanding the working of a manual Hg Blood Pressure monitor, Stethoscope and to measure the Blood Pressure.
2. Basic Process of doing CPR
3. Understanding the working of a manual optical eye-testing machine and to learn eye-testing procedure.
4. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.
5. Correction of Hypermetropia/Hyperopia (long sightedness) combination of lenses on an optical bench/breadboard.
using
a
6. To learn working of Thermoluminescent dosimeter (TLD) badges and measure the background radiation.
7. Familiarization with Geiger-Muller (GM) Counter & to measure background radiation
8. Familiarization with Radiation meter and to measure background radiation.
9. Familiarization with the Use of a Vascular Doppler.

References

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

Nano Materials and Applications
(32225314)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This course introduces briefly the basic concepts of Quantum Mechanics, essential for this course. Schrodinger wave equation and its applications to simple problems are discussed. The concepts were then used to understan the idea of quantum confinement which is central to the understanding of the optical properties and electron transport phenomenon in nanostructures. Synthesis, characterization and applications of nanomaterials are discussed.

The main prerequisite is an introductory course in Solid State Physics and Quantum Mechanics

Course Learning Outcomes

On successful completion of the module students should be able to

- *explain the difference between nanomaterials and bulk materials and their properties.*
- *explain various methods for the synthesis/growth of nanomaterials.*
- *explain the role of confinement on the density of state function and so on the various properties exhibited by nanomaterials compared to bulk materials.*
- *explain the various characterization tools required to study the structural, optical and electrical properties of nanomaterials.*
- *analyze the data obtained from the various characterization techniques.*
- *explain the concept of Quasi-particles such as excitons and how they influence the optical properties.*
- *explain the direct and indirect bandgap semiconductors, radiative and non-radiative processes and the concept of luminescence.*
- *explain the structure of 2DEG system and its importance in quantum transport experiments.*
- *explain the Interger Quantum Hall Effect and the concept of Landau Levels, and edge states in conductance quantization.*
- *explain the conductance quantization in 1D structure and its difference from the 2DEG system.*
- *explain the necessary and sufficient conditions required to observe coulomb blockade, single electron transistor and the scope of these devices.*
- *explain how MEMS and NEMS devices are produced and their applications.*
- *explain why nanomaterials exhibit properties which are sometimes very opposite, like magnetic, to their bulk counterparts.*

Unit 1

Brief Historical achievements: Use of nanoparticle by artisans or craftsman's in glass wares, pottery etc. Introduction to naturally occurring nanoparticles/nanostructures (explore the surroundings). Discussion on Michael Faraday's experiment with the gold films. Discussion on the visionary articles: (1) There's Plenty of Room at the Bottom: An Invitation to Enter a New Field of Physics by Prof. Richard P. Feynman, (2) Room at the Bottom, Plenty of Tyranny at the Top by Prof. Karl Hess.

(8 Lectures)

Unit 2

Basic Quantum Mechanics: Idea about particles as wave, electron interference experiment, superposition principle, position (or amplitude), and momentum. Wave-particle duality, uncertainty principle, energy quantization, Schrodinger equation. Applications of Schrodinger equation (**qualitative**): The free particle, potential step, rectangular potential barrier and the tunnel effect, free and bound states of a particle in square well potential, particle in a box (3D) problem.

(10 Lectures)

Unit 3

Basic Introduction to solids and Nanoscale Systems: Classification of solids into crystalline and amorphous materials, classification based on conductivity (range of values) as metals, semiconductors and insulators, idea of bandgap and its consequences on optical and electrical properties, electrons as free particles for current conduction (I = nevA), introduce bulk (3D) and nanomaterials {thin films (2D), nanowires (1D) nanodots or quantum dots (0D)} with an example of the colour of say Gold metals and its nanoparticles.Bulk materials Density of states function and its implication on electrical properties, Band structure and density of states function for nanoscale materials (Quantitative for 2D, 1D, 0D), Applications of quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences on electronic and optical properties.

(DOS function can be introduced through the population census survey, the plot of no. of persons (in millions) vs age)

(17 Lectures)

Unit 4

Synthesis and Characterization(Qualitative): Top down and Bottom up approach, Photolithography. Ball milling. Spin coating, Vacuum deposition: Physical vapor deposition (PVD): Thermal evaporation, Sputtering, Pulsed Laser Deposition (PLD), electric arc deposition for CNT, C_{60}, grapheme, Chemical vapor deposition (CVD). Preparation through colloidal methods (Metals, Metal Oxide nanoparticles), MBE growth of quantum dots.**Structure and Surface morphology:**X-Ray Diffraction (XRD). Scanning Electron Microscopy (SEM), Scanning Tunnel Microscopy (STM) (must discuss Quantum Corral). Transmission Electron Microscopy (TEM).**Spectroscopy:** UV-Vis spectroscopy. (Emphasis should be on to discuss data and plots gathered from these techniques)

(10 Lectures)

Unit 5

Optical and Electron TransportProperties: Bandgap tuning as a function of particle size (discuss results of oxide and metal nanoparticles) Radiative processes: General formalization-absorption, emission and luminescence. Defects and impurities.Idea about time and length scale,diffusive and ballistic transport of electrons in nanostrcutures, Discuss interesting experiments (no derivations) (1) Charging effect, Coulomb blockade effect (2) Single electron device.

(10 Lectures)

Unit 6

Applications (Qualitative): based on optical, electrical and magnetic properties of nanoparticles, nanowires and thin films in electronicindustry, medical industry, beauty products, Micro Electromechanical Systems (MEMS).

(5 Lectures)

Practical

At least 06 experiments from the following:

1. Synthesis of metal (Au/Ag) nanoparticles by chemical route and study/observe its optical absorption properties.
2. Synthesis of semiconductor (CdS/ZnO/TiO2/Fe2O3etc) nanoparticles and study/observe its optical absorption properties.
3. Study the XRD pattern of nanoparticles and estimation the particle size.
4. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
5. To study/observe 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 and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study its XRD and UV-Visible spectra.
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/Ge and study its V-I characteristic.

References

Reference books for Theory:

Solid State Physics, M. A. Wahab, 2011, Narosa Publications

- Solid State Physics by J. R. Hall and H. E. Hall, 2nd edition (2014) Wiley
- Quantum Mechanics by S. P. Singh, M. K. Bagde and K. Singh, S. Chand and Company Ltd.
- Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt. Ltd.
- S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)

- K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
- Electronic transport in mesoscopic systems by SupriyoDatta (1997) Cambridge University Press.
- Electronic transport in mesoscopic systems by SupriyoDatta (1997) Cambridge University Press.
- Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCASH, 4th edition, McGrawHill.

Reference Books for Practicals:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt.Ltd..
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

Additional Resources:

- Quantum Transport in semiconductor nanostructures by Carla Beenakker and HenK Van Houten (1991) (available at arXiv: cond-mat/0412664) open source
- Sara cronewett Ph.D. thesis (2001).

Teaching Learning Process

Since this is an advanced course and is only for students who specifically opt for it, the teaching learning proces must include

- *That the important concepts be introduced in detail, as per the syllabus, to provide firm support for furthe exploration*
- *That lab visits, to research labs and USIC, DU or others, be organized so that students can see the variou instrumentations/facilities and appreciate the technology that plays a crucial role in shaping this field.*
- *That student should be encouraged to search or they be provided with topics of experiments, outside the syllabus, that shape this field and submit an assignment. Few topics are like: Aharonov-Bohm effect, Bohm Oscillations, classical conductance quantization, fractional quantum hall effect.*
- *That instead of tests, quizzes should be conducted every week to assess the students.*
- *That labs should be setup suitably so that the students learning from theory can be tested, wherever suitable, with practical data.*

Assessment Methods

- *Regular quizzes, one per week, be conducted based on what has been taught in that week instead of lengthy test covering several topics.*
- *Assignment based on experiments which contributed to this field be given to students. The students shou be encouraged to write the assignment in their own words (plagiarism must be avoided) as per their understanding.*
- *The students should present the assigned topic through presentation.*
- *Continuous evaluation and gathering feedbacks may prove beneficial in improving teaching learning process.*

Keywords

Nano,0D, 1D, 2D and 3D nanostructures and confinemnnt, quantum dots, thin films, nanowires, nanorods, two dimensional electron gas (2DEG), Quasi-particles, excitons, radiative and non-radiative process, MEMS, NEMS, heterostructure, coulomb blockade, CNT

No content added

Nuclear and Particle Physics
(32225417)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It wil emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem based skills.

Course Learning Outcomes

The acquire knowledge can be applied in the areas of nuclear, medical, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

To be able to understand the basic properties of nuclei as well as knowledge of experimental assessments, the concept of binding energy and n-z curves and their significance

To appreciate the formulations and contrasts between different nuclear models such as Liquid drop and Shell Model and evidences in support.

Radioactivity and decay laws. A detailed analysis, comparison and energy kinematics of alpha, beta and gamma decays.

Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.

To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter. After learning of this unit, students will acquire knowledge about Accelerator facilities in India along with a comparative study of a range of detectors and accelerators which are building blocks of modern day instruments.

It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub-atomic particles with the different conservation laws, concept of quark model

Unit 1

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

(10 Lectures)

Unit 2

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumption of shell model. **(11 Lectures)**

Unit 3

Radioactivity decay: Decay rate and equilibrium (Secular and Transient)(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c)

Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion. **(10 Lectures)**

Unit 4

Nuclear Reactions: Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8 Lectures)**

Unit 5

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production), neutron interaction with matter. **(9 Lectures)**

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. **(9 Lectures)**

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages). **(7 Lectures)**

Unit 6

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons. **(11 Lectures)**

References

[1] Basic Ideas and concepts in Nuclear Physics : An introductory Approach by K Heyde, Third edition, IOP Publication, 1999.

[2] Nuclear Physics by S. N. Ghoshal, First edition, S. Chand Publication, 2010.

[3] Concepts of Nuclear Physics by Bernard L Cohen, Tata McGraw Hill Publication, 1974.

[4] Introductory Nuclear Physics by Kenneth S, Krane, Wiley-India Publication, 2008

[5] Nuclear Physics : principles and applications by John Lilley, Wiley Publication, 2006.

[6] Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, Academic Press Elsevier, 2007.

[7] Introduction to Modern Physics by Mani & Mehta, Affiliated East-West Press, 1990.

[8]Introduction to elementary particles by David J Griffiths, Wiley, 2008.

[9] Modern Physics by Serway, Moses and Moyer, CENGAGE LEARNING, 2012.

Additional Resources:

[1] Radiation detection and measurement, G.F. Knoll, John Wiley & Sons, 2010.

[2] Technique for Nuclear and Particle Physics experiments by William R Leo, Springer, 1994.

[3] Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.

[4] Nuclear Physics "Problem-based Approach" Including MATLAB by Hari M. Aggarwal, PHI Learning Pvt. Ltd. (2016)

Numerical Books : Schaum's Outline of Modern Physics, McGraw-Hill Education, 1999 and Modern Physics by R. Murugaeshan, S.Chand Publication, 2010.

Teaching Learning Process

Number of lectures required for individual topics of each Unit is shown in the table along with the reference for each topic.

S. No.	Unit and Syllabus	No. of Lectures	Reference Book
1	**General Properties of Nuclei**		[1],[2],[3],[9],[1
	Constituents of nucleus and their Intrinsic properties.	1	
	Quantitative facts about mass.	1	
	radii, charge density, matter density (experimental determination of each).	1	
	Binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve and N/Z plot.	4	
	Angular momentum, parity.	1	
	Magnetic moment.	1	
	Electric moments.	1	
2	**Nuclear Models**		
	Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons).	7	13th Chapter of [1 (13.3), 7th Chapt of [1]
	Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas)	2	8th Chapter of [1 (8.1,8.2)
	Evidence for nuclear shell structure and the basic assumption of shell model.	2	9th Chapter of [1 (9.1) and 5th Chapter of [4] (without any derivation) (5.1), 11th Chapter of [1 (11.6)
3	**Radioactivity decay**		
	Decay rate and equilibrium (Secular and Transient).(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains.	5	2nd Chapter of [1] 3rd Chapter of [2] (3.5,3.6) , 4thChapter of [1], 4rd Chapter of [2] 8th Chapter of [4] 13th Chapter of [1 (13.5)
	(b) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis.	3	5nd Chapter of [1 (5.1,5.4) (page n 157, only introduction), 8ht Chapter of [3] (8. 9th Chapter of [4] (9.1,9.2 (only ma of the neutrino),9
	(c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.	2	10th Chapter of [4 (10.1,10.2,10.6), 12th Chapter of [3 (no derivation)

		10	
	Nuclear Reactions		
	Types of reactions, units of related physical quantities,. Conservation Laws, kinematics of reactions, Q-value.	5	
4	Concept of compound and direct Reaction, resonance reaction.	2	11th Chapter of [(11.1- 11.6)
	Reaction rate, reaction cross section, Coulomb scattering (Rutherford scattering).	1	
	Interaction of Nuclear Radiation with matter		
	Energy loss due to ionization (Bethe-Block formula).	2	
5	Energy loss of electrons.	1	5th chapter of [5 10th Chapter of [Additional books: [7],[8]
	Cerenkov radiation.	1	
	Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production).	4	
	Neutron interaction with matter.	1	
	Detector for Nuclear Radiations		
	Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter.	3	
6	Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT).	2	6th Chapter of [5] (6.1 to 6.6) Additional book : 3rd, 5th and 6th Chapters of [6]
	Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility).	3	
	Neutron detector.	1	
	Particle Accelerators		
7	Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. (Principal, construction, working, advantages and disadvantages).	7	6th Chapter of [5] (6.8), 15th Chapte of [4], Additional book : [9]
	Particle physics		
	Particle interactions (concept of different types of forces), basic features.	2	1st chapter of[10 up to 1.8, 18th Chapters of [4] u to 18.4, 13th Chapter of [12] Additional Book: [
8	Cosmic Rays.	1	
	Types of particles and its families.	2	
	Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness).	3	
	Concept of quark model, color quantum number and gluons.	3	

Reference Book :

[1] Basic Ideas and concepts in Nuclear Physics : An introductory Approach by K Heyde, Third edition, IOP Publication, 1999.

[2] Nuclear Physics by S. N. Ghoshal, First edition, S. Chand Publication, 2010.

[3] Concepts of Nuclear Physics by Bernard L Cohen, Tata McGraw Hill Publication, 1974.

[4] Introductory Nuclear Physics by Kenneth S, Krane, Wiley-India Publication, 2008

[5] Nuclear Physics : principles and applications by John Lilley, Wiley Publication, 2006.

[6] Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, Academic Press Elsevier, 2007.

[7] Radiation detection and measurement, G.F. Knoll, John Wiley & Sons, 2010.

[8] Technique for Nuclear and Particle Physics experiments by William R Leo, Springer, 1994.

[9] Introduction to Modern Physics by Mani & Mehta, Affiliated East-West Press, 1990.

[10]Introduction to elementary particles by David J Griffiths, Wiley, 2008.

[11] Modern Physics by Serway, Moses and Moyer, CENGAGE LEARNING, 2012.

[12] Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.

Numerical Books : Schaum's Outline of Modern Physics, McGraw-Hill Education, 1999 and Modern Physics by Murugaeshan, S.Chand Publication, 2010.

Keywords

Nuclear Physics, Nuclear Structure, Nuclear Decay & Reaction, Accelerators & Detectors, Particle Physics

Physics of the Earth
(32225420)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This course familiarizes the students with the origin of universe and role of earth in the solar system.

Course Learning Outcomes

It focuses on the structure of the earth as well as various dynamical processes occurring on it. It also aims to develop an understanding of evolution of the earth.

Unit 1

The Earth and the Universe:
(17 Lectures)
(a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography . Introduction to various branches of Earth Sciences.
(b) General characteristics and origin of the Universe.The Big Bang Theory. Age of the universe and Hubble constant. Formation of Galaxies. The Milky Way

galaxy,Nebular Theory,solar system, Earth's orbit and spin, the Moon's orbit and spin.The terrestrial and Jovian planets.Titius-Bode law. Asteroid belt. Asteroids: origin types and examples. Meteorites & Asteroids. Earth in the Solar system,origin, size, shape, mass, density, rotational and revolution parameters and its age.
(c) Energy and particle fluxes incident on the Earth.
(d) The Cosmic Microwave Background.

Unit 2

Structure:
(18 Lectures)
(a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?
(b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.
(c) The Atmosphere: layers, variation of temperature with altitude, adiabatic lapse rate, variation of density and pressure with altitude, cloud formation
(d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

Unit 3

Dynamical Processes:
(18 Lectures)
(a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; types of plate movements, hotspots;sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and riftvalleys. Earthquake and earthquake belts. Seismic waves, Richter scale, geophones. Volcanoes: types products and distribution.
(b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.
(c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones and anti-cyclones.
Climate:
i.
Earth's temperature and greenhouse effect.
ii.
Paleoclimate and recent climate changes.
iii.
The Indian monsoon system.
(d) Biosphere: Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.

Unit 4

Evolution:
(18 Lectures)
Stratigraphy: Introduction and types, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Time line of major geological and biological events. Introduction to geochronological methods and their application in geological studies. Radiometric dating: Advantages & disadvantages of various isotopes. History of development of concepts of uniformitarianism, catastrophism and neptunism. Various laws of stratigraphy. Introduction to the geology and geomorphology of Indian subcontinent. Origin of life on Earth
Role of the biosphere in shaping the environment. Future of evolution of the Earth and solar system: Death of the Earth (Probable causes).

Unit 5

Disturbing the Earth – Contemporary dilemmas
(4 Lectures)
a. Human population growth.
b. Atmosphere: Green house gas emissions, climate change, air pollution.
c. Hydrosphere: Fresh water depletion.
d. Geosphere: Chemical effluents, nuclear waste.
e. Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

References

- Planetary Surface Processes, H. Jay Melosh, 2011, Cambridge University Press.
- Consider a Spherical Cow: A course in environmental problem solving, John Harte, University Science Books
- Holme's Principles of Physical Geology, 1992, Chapman & Hall.
- Planet Earth, Cosmology, Geology and the Evolution of Lifeand Environment, C. Emiliani, 1992, Cambridge University Press.
- The Blue Planet:An Introduction to Earth System Science, Brian J. Skinner, Stephen C. Portere, 1994, John Wiley & Sons.
- Physics of the Earth, Frank D. Stacey, Paul M. Davis, 2008, Cambridge University Press.
- Fundamentals of Geophysics, William Lowrie, 1997, Cambridge University Press.
- The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
- The Earth: A Very Short Introduction, Martin Redfern, 2003, Oxford University Press.
- Galaxies: A Very Short Introduction, John Gribbin, 2008, Oxford University Press.
- Climate Change: A Very Short Introduction, Mark Maslin, 3 rd Edition, 2014, Oxford University Press.
- The Atmosphere: A Very Short Introduction, Paul I. Palmer, 2017, Oxford University Press.
- IGNOU Study material: PHE 15 Astronomy and Astrophysics Block 2

Quantum Mechanics
(32225311)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

After learning the elements of modern physics, students would be poised to learn more advanced topics like ho to

solve the Schrodinger equation for spherically symmetric potentials. Then, in this course, eigenvalues and eigen functions of the

Hamiltonian as well as the orbital angular momentum would be studied. Furthermore, application of Schrodinger equation to various

quantum mechanical problems would be taken up. The spin angular momentum of electrons would also be introduced in the

course.

It is recommended that students crediting this

course should taken have taken

earlier the courses - (1)"Mathematical Physics" and (2) "Elements of Modern Physics" , in order to perform

well in this course.

Course Learning Outcomes

After studying this course, students would be equipped with the conceptual as well as technical aspects of the following topics:

- Concept of wave function and its properties.

- Probability and probability current density and its significance.

- Application of Time Dependent Schrodinger Equation to get an insight into time evolution

and the dynamical evolution of a quantum state.

- Idea of operators – position, momentum and energy and their commutation relations.
- Meaning of expectation values physical quantities – position & momentum.
- Notion of Hamiltonian, Eigenvalues, Eigenvectors, stationary states and linear combination of stationary states. Time independent Schrodinger equation
- Wave packets for a free particle in 1-D, Fourier transforms & wavefunction.
- Boundary conditions in physical systems, application to a 1-D square well potential.
- Quantum Mechanics of simple harmonic oscillator, its energy levels and eigenfunctions through Frobenious method; Exact solutions of one particle system – Hydrogen & Hydrogen like atoms and associated quantum numbers.
- Physics of atomic interactions with electric and magnetic field - Space quantization, electron spin, spin angular momentum, Larmor’s theorem, Zeeman effect etc.
- Concept on spectral notations, LS-, JJ- coupling, symmetric & antisymmetric wave functions and Pauli’s exclusion principle in in many electron atomic systems

Unit 1

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function: Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. (12 Lectures)

Unit 2

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues;expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle. (12 Lectures)

Unit 3

General discussion of bound states in an arbitrary potential : continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator : energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle. (10 Lectures)

Unit 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m; s, p, d shells. (10 Lectures)

Unit 5

Atoms in Electric and Magnetic Fields: Electron angular momentum. Angular momentum quantization. Electron Spin and Spin Angular Momentum. Larmor’s Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal Zeeman Effect: Electron Magnetic Moment and Magnetic Energy. (8 Lectures)

Unit 6

Many electron atoms: Pauli's Exclusion Principle. Symmetric and Anti-symmetric Wave Functions. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Spin-orbit coupling in atoms-L-S and J-J couplings. (8 Lectures)

Practical

Use C/C ++ /Scilab for solving the following problems based on Quantum Mechanics like:

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

, where

m is the reduced mass of electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Note that the ground state energy of hydrogen atom is □ -13.6 eV. Take e = 3.795 (eVÅ) 1/2 , ħc = 1973 (eVÅ) and m = 0.511x10 6 eV/c 2 .
2. Solve the s-wave radial Schrodinger equation for an atom:

,

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential
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 = 0.511x10 6 eV/c 2 , and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.
3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

,
For the anharmonic oscillator potential
for the ground state energy (in MeV) of the particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c 2 , k = 100 MeV fm -2 , b = 0, 10, 30 MeV fm -3 In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.
4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

,

where □ 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 = 940x10 6 eV/C 2 , D = 0.755501 eV, α = 1.44, r o = 0.131349 Å
Some laboratory based experiments: (optional)
5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting

References

□ Modern Quantum Mechanics, J.J Sakurai, Revised Edition, 1994, Addision-Wesley.

□ Introduction to Quantum Mechanics, David J. Griffiths, Second Edition, 2006,

Pearson Education.

□ Quantum Mechanic Concepts and Applications, Nouredine Zettili, Second Edition,

2001, John Wiley & Sons, Ltd.

□ Introduction to Quantum Mechanics, Volume-I, C. Cohen-Tannoudgi, B. Diu, F. Laloe, 1977,

Wiley-VCH.

Reference Books for the practicals:

□ Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Pub.

□ Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et.al., 3 rd

Edn., 2007, Cambridge University Press.

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

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Cambridge University Press

 Elementary Numerical Analysis, K.E. Atkinson, 3 rd Ed. 2007,WileyIndia Edition

 Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific &

Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández.2014 Springer

 Quantum Mechanics, Leonard I. Schiff, 3 rd Edn. 2010, Tata McGraw Hill.

 A Text book of Quantum Mechanics, P.M.Mathews& K.Venkatesan, 2nd Ed., 2010,

McGraw Hill.

 Quantum Mechanics, Brian H. Bransden and C. Charles Jean Joachain, 2000, Prentice

Hall.

Additional Resources:

 Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019

 Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966

Solid State Physics
(32225203)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This syllabus begins with an introduction of the basic concepts and principles to understand the various propertie exhibited by condensed matter, especially solids. These properties depend on the chemical constituents making the particular solid and their arrangement in the crystal. A semi-classical approach is used to introduce various models, from toy model to a higher level, suitable to explain the particular property exhibited by the solid. The syllabus is specifically designed to guide the students to learn how to create a theoretical model for a particular property and appreciate the beauty that lies in these solids through their properties.

Course Learning Outcomes

On successful completion of the module students should be able to

- *elucidate the concept of lattice, crystals and symmetry operations.*
- *explain the concepts such as the reciprocal lattice and the dynamics of atoms and electrons in solids.*
- *explain the diffraction of X-rays by solidsto determine the crystal structure.*
- *understand the elementary lattice dynamics and its influence on the properties of materials.*
- *describe the main features of the physics of electrons in solids.*
- *understand the origin of energy bands, and how they influence electronic behaviour.*
- *Explainthe origin of dia-, para-, and ferro-magnetic properties of solids.*
- *explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.*
- *apply the gained knowledge to solve problems in solid state physics using relevant mathematical tools.*
- *To appreciate how matter exhibits such interesting and wonderful properties and communicate the importance of solid state physics in the modern society.*

Unit 1

Crystal Structure and Elementary Lattice Dynamics: State of matter: Gas, Liquid, Solid. Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors.Lattice with a Basis.Unit Cell.Types of Lattices.Miller Indices.Reciprocal Lattice.Diffraction of X-rays by Crystals.Bragg’s Law. Lattice Vibrations: Linear Monoatomic and Diatomic Chains.

(12 Lectures)

Unit 2

Elementary band theory: Band Gap. Conductors, Semiconductors and insulators. P-and N- type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient.

(10 Lectures)

Unit 3

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferro- magnetic materials. Classical Langevin Theory of dia– and Para- magnetic Domains.Curie’s law, Weiss’s Theory of Ferromagnetism and Ferromagnetic Domains.Discussion of B-H Curve.Hysteresis and Energy Loss.

(12 Lectures)

Unit 4

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom.Depolarization Field.Electric Susceptibility.Polarizability.Clausius Mossotti Equation.Classical Theory of Electric Polarizability

(8 Lectures)

Unit 5

Applications: Piezoelectric, Pyroelectric, Ferroelectric, Ferromagnetic materials

(3 Lectures)

Unit 6

Superconductivity: Experimental Results. Critical Temperature.Critical magnetic field.Meissner effect. Type I and type II Superconductors.

(5 Lectures)

Practical

At least 06 experiments from the following

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a piezoelectric crystal.
4. To study the dielectric response of materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR

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

8. To study the BH curve of iron using a Solenoid and determine the energy loss.

9. To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150°C) by four-probe method and to determine its band gap.

10. To determine the Hall coefficient of a semiconductor sample.

11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.

12. Measurement of change in resistance of a semiconductor with magnetic field.

References

Reference Books for Theory:

- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Elementary Solid State Physics, M.Ali Omar, 2006, Pearson
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Reference Books for Practical:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

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Teaching Learning Process

The teaching learning process needs

- *To promote student-centric learning. The basic concept should be introduced thoroughly and students are motivated to construct new ideas or concepts based upon their current/past knowledge.*
- *Emphasis to be given on logical learning wherein day today examples related to solids can be given to the students so as to avoid rote learning.*
- *Teaching crystallography on a 2D platform is a real challenge. Students need to be stimulated to widen their imagination and work on software (if possible) which can enhance their knowledge in understanding the crystal structures.*
- *Laboratory visits to various research labs may be organized so that students can appreciate and understa the real-time experiments going on in this field which they might have studied theoretically in their course work.*
- *Quizzes may be conducted frequently to assess the understanding of students regarding the basic concep in solid state physics.*
- *Develop problem solving skills among students.*
- *Project-based learning can be another feature of the teaching-learning process. Students may be divided groups and be assigned some topics for which they can work together. Emphasis should be given to the state of art for the respective topic while documentation. Submitted document (in any form) should be original. Students need to taught the proper use of resources and avoid any form of plagiarism.*
- *Laboratories should be setup suitably so that the students can practically learn and understand the concepts learned in theory.*

Assessment Methods

- *Quiz, problem solving exercise, classroom assessment methods, presentations, end-semester examinatio etc. may constitute the different components of the overall assessment.*
- *Assignments on basic concepts may be given to students where they can do a small reading research on the topic and document their understanding.*
- *Continuous evaluation and gathering feedbacks may prove beneficial in improving teaching learning process.*
- *Continuous learning and assessment in laboratory classes will help the students in performing and understanding the experiments in a better manner.*

Keywords

Crystal Structure, Reciprocal Lattice, Hall Effect, Ferromagnetic Domains, Hysteresis, Polarizability, Superconductivity

Thermal Physics and Statistical Mechanics
(32225415)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

This course will introduce Thermodynamics, Kinetic theory of gases and Statistical Mechanics to the students. Th primary goal is to understand the fundamental laws of thermodynamics and it's applications to various thermo dynamical systems and processes . This coursework will also enable the students to understand the connectio between the macroscopic observations of physical systems and microscopic behavior of atoms and molecul through statistical mechanics.

Course Learning Outcomes

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

- Explain the Laws of Thermodynamics and its application to various physical processes
- Understand the concept of entropy, reversible and Irreversible processes.
- Understand the Blackbody radiation
- Apply the Kinetic theory of gases for calculating the transport properties of gases.
- the concept of classical and quantum statistics

Unit 1

Laws of Thermodynamics: Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CPand CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law, Entropy, Carnot"s cycle & theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. (22 lectures)

Unit 2

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell"s relations and applications - Joule-Thomson Effect, Clausius Clapeyron Equation, Expression for (C_p – C_v), C_p/C_v, TdS equations. (10 lectures)

Unit 3

Kinetic Theory of Gases:Derivation of Maxwell“s law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases (10 lectures)

Unit 4

Theory of Radiation: Blackbody radiation, Spectral distribution, Derivation of Planck's law, Deduction of Wien“s law, Rayleigh-Jeans Law, Stefan Boltzmann Law & Wien“s displacement law from Planck“s law. (6 lectures)

Unit 5

Statistical Mechanics:–Macrostate and Microstate , phase space , Entropy and Thermodynamic Probability - –

Maxwell-Boltzmann law , Fermi-Dirac distribution law - Bose-Einstein distribution law - comparison of three statistics. (12 lectures)

Practical

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne’s constant flow method.
2. Measurement of Planck’s constant using black body radiation.
3. To determine Stefan’s Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle’s Apparatus.
5. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton’s disc method.
6. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
7. To study the variation of thermo emf across two junctions of a thermocouple with temperature.

References

For Theory:

Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.

☐ A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.

☐ Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill

☐ Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L.Salinger. 1988, Narosa

Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

☐ For Practicals:

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

A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

☐ A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.

Teaching Learning Process

- Chalk and Blackboard approach
- Group discussion in the class
- PPT presentation on special topics.

Assessment Methods

- Assignments
- Class test
- Semester end examination

Keywords

Laws of Thermodynamics, entropy, Maxwell relations, Kinetic theory of gases, Black body radiation, M-B, B-E an FD distribution

Verilog and FPGA based system design (32225313)

Generic Elective - (GE) Credit:6

Course Objective(2-3)

1. This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits.

2. Evolution of Programmable logic devices such as PAL, PLA and GAL is explained.

3. At the end of the syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.

Course Learning Outcomes

This paper discusses the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques. At the end of this course, students will be able to develop following learning outcomes:

- Understand the steps and processes for design of logic circuits and systems.
- Be able to differentiate between combinational and sequential circuits.
- Be able to design various types of state machines.
- Be able to partition a complex logic system into elements of data-path and control path.
- Understand various types of programmable logic building blocks such as CPLDs and FPGAs and their tradeoffs.
- Be able to write synthesizable Verilog code.
- Be able to write a Verilog test bench to test various Verilog code modules.
- Be able to design, program and test logic systems on a programmable logic device (CPLD or FPGA) using Verilog.

Unit 1

Digital logic design flow. Review of combinational circuits. Combinational building blocks: multiplexors, demultiplexers, decoders, encoders and adder circuits. Review of sequential circuit elements: flip-flop, latch and register. Finite state machines: Mealy and Moore. Other sequential circuits: shift registers and counters. FSMD (Finite State Machine with Datapath): design and analysis. Microprogrammed control. Memory basics and timing. Programmable Logic devices. (**20 Lectures**)

Unit 2

Evolution of Programmable logic devices. PAL, PLA and GAL. CPLD and FPGA architectures. Placement and routing. Logic cell structure, Programmable interconnects, Logic blocks and I/O Ports. Clock distribution in FPGA. Timing issues in FPGA design. Boundary scan. (**20 Lectures**)

Unit 3

Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog. (**20 lectures**)

Practical

PRACTICALS-GE LAB: VERILOG AND FPGA LAB

60 Periods

At least 08 experiments from following.

1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Design and simulation of a 4 bit Adder.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs)
8. 3-bit Ripple counter
9. To design and study switching circuits (LED blink shift)
10. To design traffic light controller.
11. To interface a keyboard
12. To interface a LCD using FPGA

13. To interface multiplexed seven segment display.
14. To interface a stepper motor and DC motor.
15. To interface ADC 0804.

References

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- Wayne Wolf. *FPGA Based System Design.* Pearson Education.
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- VLSI design, Debaprasad Das, 2nd Edition, 2015, Oxford University Press.
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Keywords

Combinational circuits, Multiplexer, Demultiplexer, Encoder, Decoder, Shift registers, Counters, Programmable logic devices, Verilog HDL

Waves and Optics
(32225310)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

The physics and mathematics of wave motion underlie many important phenomena. The water wave on the sea, the vibration of a violin string, etc. can all be described in a similar way. Light too, often displays properties that are wave-like.
The course is aimed at equipping the students with the general treatment of waves. This begins with explaining ideas of oscillations and simple harmonic motion and go on to look at the physics of travelling and standing wav
This understanding applies to have a more elaborate analysis for sound waves and this further considers a numb
of phenomena in which the wave properties of light are important such as interference, diffraction, and polarization with emphasis of examples as seen in daily life.

Course Learning Outcomes

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

1. Understand Simple harmonic oscillation and superposition principle.

2. Understand superposition of a range of collinear and mutually perpendicular simple harmonic motions and their applications.

3. Understand the importance of classical wave equation in transverse and longitudinal waves and solving a range of physical systems on its basis.

4. Understand different types of waves and their velocities: Plane, Spherical, Transverse, Longitudinal.

5. Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations

6. Understand the concept of temporal and spatial coherence.

7. Understand Interference as superposition of waves from coherent sources derived from same parent source

8. Demonstrate understanding of Interference experiments: Young's Double Slit, Fresnel's biprism, Llyod's Mirror, Newton's Rings.

9. Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures

10. Understand Fraunhoffer Diffraction from a slit.

Lab Course is designed to understand the principles of measurement and skills in experimental designs.

Unit 1

Superposition of Two Collinear Harmonic oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). (6 Lectures)

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses. (2 Lectures)

Unit 2

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.(8 Lectures)

Unit 3

Sound: Sound waves, production and properties. Intensity and loudness of sound. Decibels. Intensity levels. General idea of musical notes and musical scale. Acoustics of buildings (General idea). (6 Lectures)

Unit 4

Wave Optics: Electromagnetic nature of light.Definition and Properties of wave front. Huygens Principle. (3 Lectures)

Interference: Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: measurement of wavelength and refractive index.
(14 Lectures)

Unit 5

Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.
(14 Lectures)

Unit 6

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization (General idea).(7 Lectures)

Practical

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING
1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde'sExperiment and to verify λ2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Refractive Index of the Material of a Prism using Sodium Light.
6. To determine Dispersive Power of the Material of a Prism using Mercury Light
7. To determine the value of Cauchy Constants.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
10. To determine wavelength of sodium light using Newton's Rings.
11. To determine the wavelength of Laser light using Diffraction of Single Slit.
12. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
13. To determine the Resolving Power of a Plane Diffraction Grating.
To determine the wavelength of laser light using diffraction grating

References

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• Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
• A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Teaching Learning Process

- Chalk and Blackboard approach
- Group discussion in the class
- PPT presentation on special topics.

Assessment Methods

- Assignments
- Class test
- Semester end examination