PROGRAMME AND COURSE STRUCTURE WITH CREDIT DISTRIBUTION

FOR

UG Degree Programmes with Single Major

IN

PHYSICS

(*w.e.f. 2023-2024*)

BANKURA UNIVERSITY

BANKURA

WEST BENGAL
PIN 722155

STRUCTURE IN PHYSICS
(UG Degree Programmes with Single Major)
SEMESTER –I

Category of Course	Course Code	Course Title	Credit	Marks I.A.	Marks ESE	Marks Total	No. of Hours Lec.	No. of Hours Tu.	No. of Hours Lab.
1. Major (MJ) :: DSC	S/PHS/101/MJC-1	Mechanics and General Properties of Matter	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
2. Minor Stream	S/PHS/102/MN-1	Mechanics and General Properties of Matter	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
3. Multidisciplinary	S/PHS/103/MD-1	Fundamentals of Physics-I	**3**	**10**	**40**	**50**			
4. Skill Enhancement Courses	S/PHS/104/SEC-1	Basics of Computer and Python Programming	**2 (Th) + 1 (Lab) = 3**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
5. Ability Enhancement Course	ACS/105/AEC-1	Compulsory English: Literature and Communication	**2**	**10**	**40**	**50**			
6. Value Added Course	ACS/106/VAC-1	Environmental Studies	**4**	**10**	**40**	**50**			
Total Credit = 4+4+3+3+2+4 = 20				**Total Number of Courses = 6**					

SEMESTER –II

Category of Course	Course Code	Course Title	Credit	Marks I.A.	Marks ESE	Marks Total	No. of Hours Lec.	No. of Hours Tu.	No. of Hours Lab.
1. Major (MJ) :: DSC	S/PHS/201/MJC-2	Electricity and Magnetism	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
2. Minor Stream	S/PHS/202/MN-2	Electricity and Magnetism	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
3. Multidisciplinary	S/PHS/203/MD-2	Fundamentals of Physics-II	**3**	**10**	**40**	**50**			
4. Skill Enhancement Courses	S/PHS/204/SEC-2	Basic Instrumentation Skills	**2 (Th.) + 1 (Lab.) = 3**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
5. Ability Enhancement Course	ACS/205/AEC-2	MIL-1	**2**	**10**	**40**	**50**			
6. Value Added Course	ACS/206/VAC-2	Any one of the followings: 1. Understanding India: Indian Philosophical Traditions and Value Systems 2. Health and Wellness 3. Basics of	**4**	**10**	**40**	**50**			

		Indian Constitution 4. Arts and Crafts of Bengal 5.Historical Tourism in West Bengal							
Total Credit = 4+4+3+3+2+4 = 20				**Total Number of Courses = 6**					

SEMESTER –III

Category of Course	Course Code	Course Title	Credit	Marks			No. of Hours		
				I.A.	ESE	Total	Lec.	Tu.	Lab.
1. Major (MJ) :: DSC	S/PHS/301/MJC-3	Mathematical Physics-I	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
2. Major (MJ) :: DSC	S/PHS/302/MJC-4	Waves and Oscillation	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
3. Minor Stream	S/PHS/303/MN-3	Waves and Oscillation	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
4. Multidisciplinary	S/PHS/304/MD-3	Renewable Energy and Energy harvesting	3	10	40	50			
5. Skill Enhancement Courses	S/PHS/305/SEC-3	Introduction to LASER and Fibre Optics	2 (Th) + 1 (Lab) = 3	10	25 (Th.) 15 (Lab.)	50			
6. Ability Enhancement Course	ACS/306/AEC-3	MIL-II	2	10	40	50			
Total Credit = 4+4+4+3+3+2 = 20				**Total Number of Courses = 6**					

SEMESTER –IV

Category of Course	Course Code	Course Title	Credit	Marks			No. of Hours		
				I.A.	ESE	Total	Lec.	Tu.	Lab.
1. Major (MJ) :: DSC	S/PHS/401/MJC-5	Mathematical Physics-II	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
2. Major (MJ) :: DSC	S/PHS/402/MJC-6	Heat and Thermodynamics	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
3. Major (MJ) :: DSC	S/PHS/403/MJC-7	Classical mechanics	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
4. Major (MJ) :: DSC	S/PHS/404/MJC-8	Analog Electronics systems and Applications	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
3. Minor Stream	S/PHS/405/MN-4	Heat and Thermodynamics	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
6. Ability Enhancement Course	**ACS/406/AEC-4**	Compulsory English: Literature and Communication	2	10	40	50			
Total Credit = 4+4+4+4+4+2 = 22				**Total Number of Courses = 6**					

SEMESTER –V

Category of Course				Marks			Teaching Hours/Week		
	Course Code	Course Title	Credit	I.A.	ESE	Total	Lec.	Tu.	Lab.
1. Major (MJ) :: DSC	S/PHS/501/MJC-9	Mathematical Physics-III	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
2. Major (MJ) :: DSC	S/PHS/502/MJC-10	Quantum Mechanics-I	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
3. Major (MJ) :: DSC	S/PHS/503/MJC-11	Digital system and applications	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
4. Major (MJ) :: DSC	S/PHS/504/MJC-12	Optics and EM Theory	3	10	40	50			
5. Minor stream	S/PHS/505/MN-5	Digital system and applications	2 (Th) + 1 (Lab) = 3	10	25 (Th.) 15 (Lab.)	50			
6. Internship	ACS/506/INT-3	Internship (Mendatory)	2			50			
Total Credit = 4+4+4+4+4+2 = 22				Total Number of Courses = 6					

SEMESTER –VI

Category of Course				Marks			Teaching Hours/Week		
	Course Code	Course Title	Credit	I.A.	ESE	Total	Lec.	Tu.	Lab.
1. Major (MJ) :: DSC	S/PHS/601/MJC-13	Statistical mechanics	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
2. Major (MJ) :: DSC	S/PHS/602/MJC-14	Nuclear Physics	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.); 15 (10+5) (Lab.)	50			
3. Major (MJ) :: DSC	S/PHS/603/MJC-15	Solid state physics	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
4. Major (MJ) :: DSC	S/PHS/604/MJC-16	Quantum Mechanics-II	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
5. Minor Stream	S/PHS/605/MN-6	Classical Physics	2 (Th) + 1 (Lab) = 3	10	25 (Th.) 15 (Lab.)	50			
Total Credit = 4+4+4+4+4 = 20				Total Number of Courses = 5					

N.B. : S = Science, PHS = Physics, MJ = Major, MN = Minor, ACS = Arts Commerce Science, C = Core Course, AEC = Ability Enhancement Course, SEC = Skill Enhancement Course, DSC = Discipline Specific Core, DSE = Discipline Specific Elective, VAC = Value Added Course, MD = Multidisciplinary, I.A. = Internal Assessment, ESE = End-Semester Examination, Lec. = Lecture, Tu.= Tutorial, and Lab. = Laboratory

PROGRAMME OUTCOME

The Undergraduate (UG) programme of Physics is composed of major, minor and interdisciplinary subjects. The syllabus is based on the National education policy which covers almost all the fields of Physics. The students will be enriched with plenty of knowledge after the completion of the course. The complete syllabus is compatible with the competitive examination for higher studies and research. In this programme there are various multidisciplinary courses. The students will acquire multidisciplinary skills which will be of tremendous value to them.

Sem-I

For DSC paper
(Major)
Credit-3+1

MJC-1 (Theory) Mechanics and General Properties of Matter (3 Credits)

1. Vector Calculus

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

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.

Vector Integration: Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems (Elementary idea only)

2. Fundamentals of Dynamics

Reference frames, Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

3. Work and Energy

Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Qualitative study of one-dimensional motion from potential energy curves. Stable and unstable equilibrium. Elastic potential energy/ instantaneous and average power. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

4. 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. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. Condition of pure rolling without sleeping. Ellipsoid of inertia.

5. Fluid Motion

Motion of ideal fluids. Streamlines and streamline flow. The continuity equation. Euler's equation for an incompressible fluid. Steady flow. Bernoulli's theorem and its applications. Toricelli's expression for the velocity of efflux of a liquid. Venturimeter. Kinematics of Moving Fluids, Poiseuille's Equation for flow of a liquid through Capillary, Bernoulli's theorem and the derivation of the Bernouli's equation. Principle of Pitot tube.

6. Elasticity

Stress and strain. Hooke's law. Elastic moduli and their interrelationship. Strain-energy in a stretched wire. Strain-energy associated with a pure strain. Torsion of a wire. Torsional oscillations. Loaded beams. Bending moment. Stresses induced by bending. The cantilever. Beam supported at its two ends and carrying a load at any point of the beam/ reciprocal theorem of light cantilever.

7. 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. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS)/ energy and nature of orbits for particle motion under central force.

Reference Books

► An Introduction to Mechanics, D. Kleppner, R. J. Kolenkov,1973, McGraw-Hill.
► Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al.2007, Tata McGraw-Hill.
► Physics, Resnick, Halliday and Walker 8/e.2008, Wiley.
► Analytical Mechanics, G.R. Fowles and G.L. Cassiday, 2005, Cengage Learning.
► Feynman Lectures, Vol.-I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education.
► Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

► Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000.
► University Physics, F.W. Sears, M.W. Zemansky, H. D. Young13/e,1986, Addison Wesley
► Physics for Scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
► Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Course Outcomes:

1. Develop the concepts of classical mechanics, vector, vector differentiation and integration.
2. Acquire knowledge about the elasticity of the material and the streamline and turbulent motion. Understand the relationship between elastic constants.
3. Understand how major concepts developed and changed over time.
4. Capable of analyzing and solving problems using oral and written reasoning skills based on the concepts of classical mechanics.

Ability to prepare and organize a presentation on the application of fundamental dynamics

MJC-1 (Lab) Mechanics and General Properties of Matter Lab (1 Credit)

List of practical:

1. To study the Motion of Spring and calculate, (a) Spring constant, (b) g and (c) Modulus of rigidity.
2. Determination of the Young's modulus of a material in the form of a bar by the method of flexure.
3. Determination of the coefficient of viscosity of highly viscous liquid by Stoke's method.
4. To determine the value of **g** by using Bar Pendulum.
5. To determine the value of **g** by using Kater's Pendulum.

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, reprinted1985, Heinemann Educational Publishers.
- ► A Text Book of Practical Physics, I. Prakash & Ramakrishna,11th Edn,2011, Kitab Mahal.
- ► Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

Course Outcomes:

1. Students will learn to use the screw gauge, slide callipers, microscope, telescope.
2. They will know how to experimentally measure the Young's modulus, coefficient of viscosity of liquid, acceleration due to gravity, spring constant.

(Minor)
Credit-3+1
MN-1 (Theory): Mechanics and General Properties of Matter (3 Credits)

1. Vector Calculus

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

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

Vector Integration: Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems (Elementary idea only).

2. Fundamentals of Dynamics

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Motion of a projectile in Uniform gravitational field, Principle of conservation of momentum, Impulse.

3. Work and Energy

Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Qualitative study of one-dimensional motion from potential energy curves. Stable and unstable equilibrium. Elastic potential energy/ instantaneous and average power. Force as gradient of potential energy. Work & Potential energy, Law of conservation of Energy.

4. 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. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation.

5. Fluid Motion

Motion of ideal fluids. Streamlines and streamline flow. The continuity equation. Euler's equation for an incompressible fluid. Steady flow. Bernoulli's theorem and its applications. Venturimeter. Kinematics of Moving Fluids, Poiseuille's Equation for Flow of a Liquid through Capillary, Bernoulli's theorem and the derivation of the Bernouli's equation.

6. Elasticity

Stress and strain. Hooke's law. Elastic moduli and their interrelationship. Strain-energy in a stretched wire. Strain energy associated with a pure strain. Torsion of a wire. Torsional oscillations. Loaded beams. Bending moment. Stresses induced by bending. The cantilever. Beam supported at its two ends and carrying a load at any point of the beam/ reciprocal theorem of light cantilever.

7. 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. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications.

Geosynchronous orbits. Weightlessness.

ReferenceBooks

► An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
► Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
► Physics, Resnick, Halliday and Walker8/e.2008, Wiley.
► Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
► Feynman Lectures, Vol.I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
► Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

► Mechanics, D.S. Mathur, S. Chand and Company Limited,2000
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► Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Course Outcomes:

5. Develop the concepts of classical mechanics, vector, vector differentiation and integration.
1. Acquire knowledge about the elasticity of the material and the streamline and turbulent motion. Understand the relationship between elastic constants.
2. Understand how major concepts developed and changed over time.
3. Capable of analyzing and solving problems using oral and written reasoning skills based on the concepts of classical mechanics.

Ability to prepare and organize a presentation on the application of fundamental dynamics

MN-1 (Lab): Mechanics and General Properties of Matter Lab (1 Credit)

List of practical:

1. To study the Motion of Spring and calculate, (a) Spring constant, (b) **g** and(c) Modulus of rigidity.
2. To determination of the Young's modulus of a material in the form of a bar by the method of flexure.
3. Determination of the coefficient of viscosity of highly viscous liquid by Stoke's method.
4. To determine the value of **g by** using Bar Pendulum.
5. To determine the value of **g** by using Kater's Pendulum.

Reference Books

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

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

► Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

Course Outcomes:

1. Students will learn to use the screw gauge, slide callipers, microscope, telescope.
2. They will know how to experimentally measure the Young's modulus, coefficient of viscosity of liquid, acceleration due to gravity, spring constant.

Multidisciplinary
(Credit-3)

MD-1: Fundamentals of Physics-I (3 Credits)

1. Vector Analysis

Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. Review of 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).

2. Laws of Motion

Frames of reference. Newton’s Laws of motion. Dynamics of a system of particles. Centre of Mass.

3. Momentum and Energy

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

4. Rotational Motion

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

5. Gravitation

Newton’s Law of Gravitation. Motion of a particle in a central force field (motion is in aplane, angular momentum is conserved, areal velocity is constant). Kepler’s Laws (statement only). Satellite in circular orbit and applications.

6. Elasticity

Hooke’s law–stress-strain diagram, Elastic moduli-relation between elastic constants, Poisson’s ratio expression for Poisson’s ratio in terms of elastic constants- work done in stretching and work done in twisting a wire – twisting couple on a cylinder –Determination of Rigidity modulus by static torsion- Torsional pendulum- Determination of Rigidity modulus and moment of inertia by Searles method.

7. Special Theory of Relativity

Postulate of special theory of relativity. Lorentz transformations. Simultaneity and order of events. Lorentz contraction. Time dilation, relativistic transformation of velocity, relativistic addition of velocities.

8. Sound

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Linearity & Superposition Principle.

Qualitative discussions on Damped oscillations, Forced vibrations and resonance. Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation; Absorption coefficient; Sabine’s formula; measurement of reverberation time; Acoustic aspects of halls and auditoria.

9. Electrostatics

Electrostatic Field, electric flux, Gauss's law in electrostatics. Applications of Gauss’s law- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet and disc, 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, Polarization, Displacement vector. Parallel-plate capacitor completely filled with dielectric.

Reference Books

► UniversityPhysics. F.W. Sears, M.W. Zemansky and H.D. Young,13/e, 1986. Addison-Wesley

► Mechanics Berkeley Physics, vol-1: Charles Kittel, et.al. 2007, Tata McGraw-Hill.

► 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.

Course Outcomes:

1. Students will learn and develop the concepts of vector and basic knowledge of the vector differential operator Del and understand the operation on the scalar and vector field.
2. Students will Learn and realize about vector theorems like Divergence and Green theorem etc.
3. Students will develop the concepts on classical mechanics and enhance the basic knowledge of the non-inertial and inertial frame of reference, variable mass, rocket motion, special theory of relativity.
4. They will acquire knowledge about the elasticity of the material and the streamline and turbulent motion.
5. Enhance the capability to prepare and organize a presentation on the application of fundamental dynamics.
6. They can understand the relation between electrical charge, electrical field, electrical potential
7. They can understand and realize the superposition of SHM collinearly and perpendicularly and can study the Beat and Lissajous figures.

Skill Enhancement Course (SEC-1)
(3 Credits: 2 Th. + 1 Lab)

SEC-1 (Theory): Basics of Computer and Python Programming (2 credits)

1. Introduction and Overview Computer architecture and organization, memory and Input/output devices.
2. Basics of scientific computing, Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow, emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
3. Errors and error Analysis; Truncation and round off errors, Absolute and relative errors, Floating point computations.
4. Introduction to programming in python: Introduction to programming, constants, variables and data types, dynamical typing, operator sand expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object-oriented programming**.**

4. Introduction to Computer Programming:

Sum & 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, Binary search, Random number generation, Area of circle, area of square, volume of sphere, value of pi (π).

5. Introduction of graph plotting:

Matplotlib as plotting device. Basics of plotting of function (i) x, (ii) x^2, (iii) x^3, (iv) trigonmetric functions, (v) Hyperbolic functions. Plot of 3D, Color map, Bar chart plots, circular plots, Plot from data file, saving the figures, subplots, multiple plot, Curve fitting, Least square fit, Goodness of fit, standard deviation.

SEC-1 (Lab): Basics of Computer and Python Programming Lab (1 credit)

1. Write a program to calculate the multiplication and sum of two numbers.
2. Write a program to print the sum of the current number and the previous number
3. Write a program to add the even numbers from 1-100.
4. Write a program to add the odd numbers from 1-100.
5. Write a program to calculate the area of a circle/square/triangle.
6. Write a program to sort the number in ascending and descending order.
7. Write a program to find the largest of a given list of numbers
8. Write a program to check if the first and last number of a list is the same or not.
9. Write a program to display numbers divisible by 5 from a list.
10. Print the following pattern

    1
    2 2
    3 3 3
    4 4 4 4
    5 5 5 5 5

11. Write a program to print a 3x3 matrix.
12. Plot the graph of a sine, cos, and tan curves.
13. Plot the graph of f(x) vs x or x^2 or x^3
14. Plot the graph of e^x, e^{-x}, and log(x).
15. Plot the graph of $ax + b/x^2$, where a and b are positive constants.
16. Plot the graph from a data file.
17. Calculation of resistance from Ohms law by using least square fitting.

Reference books

►Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.

► Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.

► Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.

► Effective Computation in Physics-Field guide to research with Python, A. Scopatzand K.D. Huff, 2015, O'Rielly

► A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.

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

► Numerical Methods for Scientists &Engineers, R.W. Hamming, 1973, Courier Dover Pub.

► An Introduction to computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press
Computational Physics, DarrenWalker,1st Edn., 2015, Scientific International Pvt. Ltd

Course Outcomes:

1. There is a scope to know the computer architecture.
2. There is a scope to study the Python programming language.
3. The students will be able to learn how can solve any physical problem in Python.
4. There is a scope to learn the graph plotting.

Sem II

For DSC paper
(Major)
Credit: 3 Th. +1 Lab.

MJC-2 (Theory): Electricity and Magnetism (3 Credits)

1. Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss's Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Concept of electrical monopole, dipole, quadrupole, multipole. Potential and Electric Field due to monopole, dipole, quadrupole and multipole expansion. Force and Torque on a dipole. Dipole-dipole interaction energy. Electrostatic energy of a 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, Cylindrical and Spherical capacitors. Capacitance of an isolated conductor. Uniqueness theorem (statement). Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

2. 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.

3. Magnetic Field

Magnetic force between current elements and definition of Magnetic Field B. 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) infinite straight wire, (2) Infinite planar surface current, and (3) Solenoid. Properties of B: curl and divergence. Axial vector property of B and its consequences. 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.

4. Electromagnetic Induction and Magnetic Properties of Matter

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. Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Origin of Dia-magnetism, Para-magnetism and Ferro -Magnetism. B-H curve and hysteresis.

5. 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.

6. Network theorems

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

Reference Books

► Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw Hill.

► Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education

► Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

► FeynmanLecturesVol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education

► Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.

► Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol-I,1991, Oxford Univ. Press.

Course Outcomes:

The course will help the students to understand the basic concepts of electrostatics including electric field, potential, electrostatic energy, electric dipole etc. They should be able to understand Laplace's equation, Poisson's equation, method of images and their application to simple electrostatic problems. The students will also acquire knowledge about dielectric properties of matter and application of laws of electrostatics for dielectric materials. This course will provide the students with basic knowledge of magnetostatics i.e. magnetic effect of current and related laws of physics. On completion of the course students will learn about electromagnetic induction, magnetic properties of matter, operation of different ac electrical circuits, network theorem, etc.

MJC-2 (Lab): Electricity and Magnetism Lab (1 Credit)

List of Practical:

1. To verify the Thevenin, Norton and Maximum power transfer theorems.
2. 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) Bandwidth.
3. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
4. Determination of the boiling point of a suitable liquid using a platinum resistance thermometer.
5. Construction of one Ohm coil.

Reference Books

► 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,11thEd., 2011, Kitab Mahal

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

► Engineering Practical Physics, S. Panigrahi and B.Mallick, 2015,Cengage Learning.

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

Course Outcomes:

On performing the laboratory experiments students should have a rudimentary grasp on how experimental equipment related to electricity and magnetism can be used. They will have a better insight by experimentally verifying some of the laws/theorems of electricity and magnetism.

(Minor)
Credit: 3+1

MN-2 (Theory): –Electricity and Magnetism (3 Credits)

1. Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss's Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem (statement only). Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic field. Parallel-plate capacitor. Capacitance of an isolated conductor.

2. 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.

3. Magnetic Field

Magnetic force between current elements and definition of Magnetic Field B. 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) infinite straight wire and (3) Solenoid. 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.

4. 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. 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.

5. 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.

6. Network theorems

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Maximum Power Transfer theorem. Applications to simple dc circuits.

Reference Books

► Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw Hill.

► Electricity and Magnetism, Edward M. Purcell,1986 McGraw-Hill Education

► Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

► Feynman LecturesVol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson

Education.
► Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
► Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol-I,1991, Oxford Univ. Press.

Course Outcomes:

The course will help the students to understand the basic concepts of electrostatics including electric field, potential, electrostatic energy, electric dipole etc. They should be able to understand Laplace's equation, Poisson's equation, method of images and their application to simple electrostatic problems. The students will also acquire knowledge about dielectric properties of matter and application of laws of electrostatics for dielectric materials. This course will provide the students with basic knowledge of magnetostatics i.e. magnetic effect of current and related laws of physics. On completion of the course students will learn about electromagnetic induction, magnetic properties of matter, operation of different ac electrical circuits, network theorem, etc.

MN-2 (Lab): –Electricity and Magnetism Lab (1 Credit)

List of Practical:

1. To verify the Thevenin, Norton and Maximum power transfer theorems.
2. 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) Bandwidth.
3. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
4. Determination of the boiling point of a suitable liquid using a platinum resistance thermometer.
5. Construction of one Ohm coil.

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► Engineering Practical Physics, S. Panigrahi and B.Mallick, 2015,CengageLearning.

► A Laboratory Manual of Physics forunder graduate classes, D.P. Khandelwal, 1985, Vani Pub.

Course Outcomes:

On performing the laboratory experiments students should have a rudimentary grasp on how experimental equipment related to electricity and magnetism can be used. They will have a better insight by experimentally verifying some of the laws/theorems of electricity and magnetism.

Multidisciplinary

(Credit-3)

MD-2: Fundamentals of Physics-II (3 Credits)

1. Magentic field and Electromagnetic induction

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. Electromagnetic Induction, Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, Mutual inductance of two coils. Energy stored in magnetic field.

2. Magnetic properties of materials

Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.

3.Kinetic Theory of Gases

Mean free path (zeroth order), Law of equipartition of energy (no derivation) and its applications to specific heat of gases, mona-atomic, diatomic and triatomic gases.

4. Laws of Thermodynamics

Thermodynamic description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various thermodynamic processes, Applications of First Law: General relation between C_p and C_v, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law of thermodynamics and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

5. Introduction of Modern Physics

Structure of matter, Concept of molecule, atom, nuclei and quark. Thompson atom model, Rutherford atom model, Bohr's atom model and concept of energy levels, ionization and excitation potentials. X-rays, production (Coolidge tube), continuous and characteristic-X-rays, soft and hard X-rays, and applications. Photo electric effect, Compton scattering and pair production. Elementary of black body radiation and wave particle duality.

Reference Books

- ► Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
- ► Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol-I, 1991, Oxford Univ. Press
- ► Electricity and Magnetism, D. C. Tayal, 1988, Himalaya Publishing House.
- ► University Physics, Ronald LaneReese,2003, Thomson Brooks/Cole.
- ► D.J. Griffiths, IntroductiontoElectrodynamics,3rdEdn,1998, Benjamin Cummings
- ► 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.
- ► Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
- ► Heat and Thermodynamics, M.W. Zemansky and R. Dittman, 1981, McGrawHill
- ► Thermodynamics, Kinetic theory & Statistical Thermodynamics, F.W. Searsand
- ► G.L. Salinger.1988, Narosa

► University Physics, Ronald LaneReese,2003, Thomson Brooks/Cole.
► Thermal Physics, A. Kumar and S.P.Taneja, 2014,R.chand Publications.

Course Outcomes:

After completion of the course the students should understand the basic concepts about magnetic effect of current, basic concepts about different types of magnetic materials and electromagnetic induction. This course further enables the students to acquire knowledge about basic concepts of kinetic theory of gases. They will also gain knowledge about laws of thermodynamics and their application to different thermodynamic processes. This course will further help the students to acquire knowledge on basic modern physics such as structure of matter, atomic model, production of x-rays, theory of photo electric effect, Compton scattering, pair production and black body radiation.

Skill Enhancement Course (SEC-2)

(3 Credits: 2 Th. + 1 Lab)

SEC-2 (Theory): Basic Instrumentation Skills (2 credits)

1. Basic of Measurement, Instruments accuracy, precision, sensitivity, resolution range, etc. Errors in measurements and loading effects. Multi-meter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multi-meter and their significance.

2. Electronic Voltmeter Advantage over conventional multi-meter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multi-meter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.

3. Cathode Ray Oscilloscope, Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

4. Digital Instruments, Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. Digital Multi-meter Block diagram and working of a digital multi-meter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time-base stability, accuracy and resolution.

References:

- Electrical Measurements and Instrumentation: Electrical and Electronic Measuring Instruments, Storage Devices, Transducers by Late Ajay V Bakshi and Uday A Bakshi.
- ELECTRONIC DEVICES AND CIRCUIT THEORY by R BOYLESTAD, SEVENTH EDITION. ELECTRONIC DEVICES. AND CIRCUIT THEORY. ROBERT BOYLESTAD
- ELECTRONICS FUNDAMENTALS AND APPLICATIONS [17 TH EDITION] BY D. CHATTOPADHYAY & P. C. RAKSHIT. by D. CHATTOPADHYAY & P. C. RAKSHIT
- Fundamentals Principles of Electronics : Basudev, Ghosh

SEC-2 (Lab): Basic Instrumentation Skills (1 credit)

List of Practical's:

1. To observe the loading effect of a multi-meter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multi-meter for measuring low/high frequency voltage and currents.
3. Measurement of a low resistance using a Carry-Foster bridge
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of a current through low resistance using a potentiometer.
6. Measurement of rise, fall and delay times using a CRO.
7. Converting the range of a given measuring instrument (voltmeter, ammeter)

Course Outcomes:

Through this course, the students will develop the ideas about the basics of measurements. They learn the uses of various instruments like electronic voltmeter, cathode ray oscilloscope (CRO), Signal Generators and Analysis Instruments, Impedance Bridges & Q-Meters and some digital instruments.

Sem III

For DSC paper
(Major)
Credit: 3+1

MJC-3 (Theory): Mathematical Physics-I (3 Credits)

Orthogonal Curvilinear Coordinates **(8 Lectures)**

Orthogonal Curvilinear Coordinates. Unit vectors in curvilinear coordinate system. Arc length, surface, and volume elements. Derivation of Gradient, Divergence, Curl, and Laplacian in Cartesian, Spherical, and Cylindrical Coordinate Systems. Comparison of velocity and acceleration in cylindrical and spherical coordinate systems.

Differential Equation **(10 Lectures)**

First Order and Second Order Differential Equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Euler's theorem of homogeneous function of degree n. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factors, with a simple illustration. Cyclic and chain rule of partial derivative. Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical, and spherical symmetry. Diffusion Equation.

Fourier Series **(11 Lectures)**

Periodic function, Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Fourier series - Expansion of periodic functions in a series of Sine and Cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions (Fourier Cosine & Fourier Sine series). Application. Summing of Infinite Series. Term-by-term differentiation and integration of Fourier Series. Parseval Identity. Application to triangular, square, and saw tooth waves.

Frobenius Method and its applications **(9 Lectures)**

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel. 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.

Special Functions **(7 Lectures)**

Beta and Gamma Functions and the Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

References

- ► Higher Engineering Mathematics, H.K. Dass, Er. Rajnish Verma, S. Chand Publication.
- ► Higher Engineering Mathematics, B.S. Grewal, Khanna Publishers.
- ► Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
- ► An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- ► Differential Equations, George F. Simmons, 2007, McGraw Hill.
- ► Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- ► Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- ► 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.
- ► Essential Mathematical Methods, K.F. Riley & M.P. Hobson, 2011, Cambridge Univ. Press
- ► Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

LEARNING OUTCOMES

At the end of this course, the following concepts will be learnt.

- Students will develop the concepts of First Order and Second Order Differential equations.
- Acquire knowledge on Particular Integral, Partial derivatives, and Integrating factor.
- Learn about vector integration and related theorems like Divergence and Green theorem etc.
- Acquire Knowledge about the orthogonal curvilinear coordinate systems and their transformation relation with special emphasis on spherical polar system.
- Able to think about the mathematical formulation of Fourier series, half range series,
- Fourier transformation etc.
- Get knowledge about ODE learn to solve series solution of 2nd order ODE, Bessel’s differential equation, Legendre’s differential equation, Partial differential equations,
- Solution of Laplace’s equation in different coordinate systems by the method of separation of variables.

MJC-3 (Lab): Mathematical Physics-I Lab (1 Credit)

List of Practical's:
[N.B: Python language should be used]

1. Write a Python script to convert between Cartesian, cylindrical, and spherical coordinates.
2. Implement and visualize gradient, divergence, and curl for a given vector field in different coordinate systems.
3. Solve a first-order ODE using SciPy's ***odeint*** or ***solve_ivp***.
4. Solution of Ordinary Differential Equations (ODE) First-order Differential equation Euler, modified Euler.
5. Plot Legendre polynomials and Bessel functions.
6. Implement the separation of variables technique to solve Laplace's Equation in different coordinate systems.

Reference books

- Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
- Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
- Effective Computation in Physics- A field guide to research with Python, A. Scopatz, and K.D. Huff, 2015, O'Reilly
- An Introduction to Computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press.
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd

Learning outcomes

- Understand and visualize different coordinate systems.
- Implement basic vector operations in Python.
- Solve first- and second-order differential equations using Python.
- Implement numerical solutions for ordinary and partial differential equations.
- Compute Fourier series for different functions.
- Understand and visualize the impact of harmonics in periodic functions.
- Explore special functions like Legendre and Bessel functions using Python.

MJC-4 (Theory): Waves and Oscillation (3 Credits)

1. Superposition of Collinear Harmonic Oscillations **8 Lectures**

Superposition of collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. Superposition of two perpendicular Harmonic Oscillations. Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

2. Damped and Forced Oscillations **6 Lectures**

Damped oscillations, Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

3. Wave Motion **6 Lectures**

Plane Progressive (Travelling) Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves

4. Vibration of Strings **10 Lectures**

Standing (Stationary) Waves in a String: Velocity of transverse waves along a stretched string. Changes with respect to Position and Time. Energy of vibrating string. Transfer of Energy. Plucked and Struck Strings, Bowed string. Melde's Experiment. Longitudinal Standing Waves and Normal Modes.

5. Doppler Effect **4 Lectures**

Calculation of Doppler shift, Doppler shift due to reflection from reflector, Interconnection between Doppler Effect and Stationary wave.

6. **Acoustics of Buildings** **4 Lectures**

Requirements of a good auditorium, Reverberations, Absorption coefficient and its measurement, Sabine's formula for reverberation time, Dead room reverberation time.

7. Technical Acoustics **7 Lectures**

Generation and detection of Ultrasonic waves, Applications of Ultrasonic waves, Microphones: Carbon, Condenser, moving coil electrodynamic, Crystal and Ribbon Microphone, Loudspeakers, Recording and reproduction of Sound, Accoustic filters.

Reference Books:

1. Principles of Acoustics, B.Ghosh, Sreedhar Publishers.
2. The Physics of Waves and Oscillations, N.K.Bajaj, Tata McGraw-Hill.
3. Modern Acoustics, A.B. Gupta, Books and Allied (P) Limited.
4. A Treatise on Oscillations, Waves and Acoustics, D. Chattopadhyay, Books and Allied (P) Limited.
5. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
6. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
7. A. Hirose and K.E. Lonngren, "Introduction to Wave Phenomena," (Wiley Interscience, New York, 1985). Corrected edition (1995).
8. M. I. Rabinovich and D. I. Trubetskov, Oscillations and Waves in Linear and Nonlinear Systems. Boston, MA: Kluwer, 1989.

Course Outcome:

The course will provide the students with knowledge of various aspects of simple harmonic oscillation including damped and forced oscillations, resonance, superposition under different conditions, Lissajous figures etc. The students will acquire knowledge about wave motion, superposition of waves and formation of waves on strings and pipes. Students also recognize and use a mathematical oscillator equation and wave equation, and derive these equations for certain systems, point out the limitations, and be able to refer to very different solutions of identical oscillator equations due to different initial and boundary conditions.

MJC-4 (Lab): Waves and Oscillation Lab (1 Credit)

List of Practical's:

1. Volume resonator experiment.
2. Simple pendulum-Normal distribution of errors estimation of time period and the error of the mean by statistical analysis
3. Verification of laws of vibrations of stretched string- **Sonometer**
4. Study of a damped oscillation using the torsional pendulum immersed in a liquid – Decay constant and damping correction
5. To study Lissajous Figures.
6. To investigate the Motion of Coupled Oscillators.
7. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\boldsymbol{\lambda^2 - T}$ Law by Melde's Experiment.

Reference Books:

1. Advance Practical Physics,Ghosh and Majumder, Sreedhar Publishers.
2. An Advance Course in Practical Physics, D.Chattopadhyay and P.C. Rakshit, New Central Book Agency(P) Limited.
3. Principles of Acoustics, B.Ghosh, Sreedhar Publishers.
4. The Physics of Waves and Oscillations, N.K.Bajaj, Tata McGraw-Hill.
5. Modern Acoustics, A.B. Gupta, Books and Allied (P) Limited.
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9. M. I. Rabinovich and D. I. Trubetskov, Oscillations and Waves in Linear and Nonlinear Systems. Boston, MA: Kluwer, 1989.

Course Outcome:

This course will help the students to know how to determine the acceleration due to gravity at a place using Compound pendulum and Simple pendulum. Notice the difference between flat resonance and sharp resonance in case of volume resonator and sonometer experiments respectively. Verify the laws of transverse vibrations in a stretched string using sonometer and comment on the relation between frequency, length and tension of a stretched string under vibration. Demonstrate the formation of stationary waves on a string in Melde's string experiment. Observe the motion of coupled oscillators and normal modes. Examine phenomena of simple harmonic motion and the distinction between undamped, damped and forced oscillations and the concepts of resonance and quality factor with reference to damped harmonic oscillator

(Minor)
Credit-3+1

MN-3 (Theory): Waves and Oscillation (3 Credits)

1. Superposition of Collinear Harmonic oscillations 10 Lectures

Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. Superposition of two perpendicular Harmonic Oscillations. Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

2. Damped and Forced Oscillations 9 Lectures

Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

3. Wave Motion 10 Lectures

Plane Progressive (Travelling) Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Rippleand Gravity Waves

4. Superposition of Two Harmonic Waves 12 Lectures

Standing (Stationary) Waves in a String: Velocity of transverse waves along a stretched string. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes.

5. Acoustics of Buildings 4 Lectures

Requirements of a good auditorium, Reverbation, Absorption coefficient and its measurement, Sabine's formula for reverbation time.

Reference Books:

1. Principles of Acoustics, B.Ghosh, Sreedhar Publishers.
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5. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
6. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
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Course Outcome:

The course will provide the students with knowledge of various aspects of simple harmonic oscillation including damped and forced oscillations, resonance, superposition under different conditions, Lissajous figures etc. The students will acquire knowledge about wave motion, superposition of waves and formation of waves on strings and pipes. Students also recognize and use a mathematical oscillator equation and wave equation, and derive these equations for certain systems, point out the limitations, and be able to refer to very different solutions of identical oscillator equations due to different initial and boundary conditions.

MN-3 (Lab): Waves and Oscillation Lab (1 Credit)

List of Practical's:

1. Volume resonator experiment.
2. Simple pendulum-Normal distribution of errors estimation of time period and the error of the mean by statistical analysis
3. Verification of laws of vibrations of stretched string- **Sonometer**
4. Study of a damped oscillation using the torsional pendulum immersed in a liquid – Decay constant and damping correction
5. To study Lissajous Figures.
6. To investigate the Motion of Coupled Oscillators.
7. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\boldsymbol{\lambda^2} - \mathbf{T}$ Law by Melde's Experiment.

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5. Modern Acoustics, A.B. Gupta, Books and Allied (P) Limited.
6. A Treatise on Oscillations, Waves and Acoustics, D. Chattopadhyay, Books and Allied (P) Limited.
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9. M. I. Rabinovich and D. I. Trubetskov, Oscillations and Waves in Linear and Nonlinear Systems. Boston, MA: Kluwer, 1989.

Course Outcome:

This course will help the students to know how to determine the acceleration due to gravity at a place using Compound pendulum and Simple pendulum. Notice the difference between flat resonance and sharp resonance in case of volume resonator and sonometer experiments respectively. Verify the laws of transverse vibrations in a stretched string using sonometer and comment on the relation between frequency, length and tension of a stretched string under vibration. Demonstrate the formation of stationary waves on a string in Melde's string experiment. Observe the motion of coupled oscillators and normal modes. Examine phenomena of simple harmonic motion and the distinction between undamped, damped and forced oscillations and the concepts of resonance and quality factor with reference to damped harmonic oscillator

Multidisciplinary
(Credit-3)

MD-3: Renewable Energy and Energy harvesting (3 Credits)

1. Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitations, need of renewable energy, non-conventional energy sources. An overview of developments in offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy, tidal energy, Hydroelectricity. [Mathematical details not required]
(10 lectures)

2. Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell (basic idea), absorption air conditioning. Need and characteristics of photovoltaic (PV) systems (elementary idea only), PV models and equivalent circuits (elementary idea only), and sun tracking systems. Basic ideas on Solar Panels. **(10 lectures)**

3. Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. [Mathematical deductions not required] **(4 lectures)**

4. Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices (elementary idea only). Tide characteristics and Statistics, Tide Energy Technologies (elementary idea only), Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. **(4 lectures)**

5. Geothermal Energy: Elementary idea of Geothermal Resources and Geothermal Technologies. **(3 lectures)**

6. Hydro Energy: Elementary idea of Hydropower resources, hydropower technologies and environmental impact of hydro power sources. **(3 lectures)**

7. Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect (basic concepts), materials and mathematical description of piezoelectricity (detailed deductions not required), Piezoelectric parameters and modeling piezoelectric generators (elementary idea only), Piezoelectric energy harvesting applications, Human power. **(4 lectures)**

8. Electromagnetic Energy Harvesting: a. Basic idea of Linear generators, recent applications. b. Basic idea of Carbon captured technologies, cell, batteries, power consumption. c. Environmental issues and Renewable sources of energy, sustainability. The impact of Green-House effect and use of Nanotechnology in Energy Harvesting. **(5 lectures)**

Reference Books

- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
- Solar energy - M P Agarwal - S Chand and Co. Ltd.
- Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
- Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford

University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assessment Handbook, 2009
- J. Balfour, M. Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
- http://en.wikipedia.org/wiki/Renewable_energy

Course Outcomes:

After completion of this course,

1. The students will have sufficient knowledge about the non-conventional and conventional energy sources.
2. They will learn about the need of renewable energy sources in modern times.
3. They should acquire the knowledge about the importance of solar energy and methods of utilization of solar energy.
4. They will develop the basic idea about tidal energy, wind energy, geothermal energy, bio- mass energy, hydropower and applications of these energy sources.
5. They will also understand how to utilize the piezoelectric effect as a source of non conventional energy.
6. The students will gain basic knowledge of electromagnetic energy harvesting.

Skill Enhancement Course (SEC-3)
(3 Credits: 2 Th. + 1 Lab)

SEC-3 (Theory): Introduction to LASER and Fibre Optics (2 Credits)

1. Historical background of laser; Properties of LASER: Directionality, Intensity, Monochromaticity, Coherence; Einstein's A and B coefficients; Metastable states; Spontaneous and Stimulated emissions; Optical Pumping and Population Inversion; Creation of population inversion in three level & four level lasers. Laser modes, Resonator configuration, Q-switching and mode locking. **(10 lectures)**

2. LASER Structure, Different Types of LASERS: Gas lasers, solid-state lasers, liquid lasers, semiconductor lasers, Ruby LASER– principle, construction, working and application. He-Ne LASER– principle, construction, working and application. CO_2 laser - principle, construction, working and application; P-N Junction Semiconductor Laser. **(10 lectures)**

3. Applications of LASERS, Holography: Importance of coherence, Principle of holography, Recording and reconstruction, Types of Holography, Intensity distribution, Applications. Photo Detector. **(5 lectures)**

4. Optical Fiber: Basic Characteristics of optical fiber, Total internal reflection, Numerical Aperture, Coherent Bundle, Attenuation in optical fiber, Absorptive and radiative loss; Step and Graded index; Single and Multiple Mode Fiber (Concept and Definition Only), Intermodal dispersion; Application of fiber optics; Power Budget Equation in Fiber Optics. **(5 lectures)**

SEC-3 (Lab): Introduction to LASER and Fibre Optics Lab (1 Credit)

List of Practical:

1. Measurement of wavelength of LASER beam using diffraction grating.
2. Measurement of wavelength of LASER beam by forming a diffraction pattern due to a thin wire.
3. Measurement of the divergence of LASER Beam
4. To determine acceptance angle and numerical aperture of an optical fiber
5. Measurement of transmission loss and bending loss in optical fiber
6. To determine the size of lycopodium powder using LASER.
7. To determine number of rulling per meter in a diffraction grating using LASER source.
8. Measurement of wavelength of LASER beam using single or double slit.

Reference Books

- Lasers- B.A.Lengyel
- Principles of lasers- O. Svelto
- Introduction to Fiber Optics– A. Ghatak and K. Thyagarajan
- Lasers:Principles, Types and Applications- K. R. Nambiar

Course Outcomes:

On completion of this course a student should be able to demonstrate understanding of and be able to solve problems on:

1) absorption and spontaneous and stimulated emission in two level, three level, four level systems, and the conditions for laser amplification.

2) the four-level laser system, the simple homogeneous laser and its output behavior and optimal operating conditions.

3) spectral properties of a single longitudinal mode, mode locked laser operation, schemes for active and passive mode locking in real laser system.

4) operations and basic properties of the most common laser types- He-Ne, ruby

Sem IV

For DSC paper
(Major)
Credit: 3+1

MJC-5 (Theory): Mathematical Physics-II (3 Credits)

1. Complex numbers **(4 Lectures)**
Review on Complex Numbers and their Graphical Representation. Euler's formula, Roots of Complex Numbers Functions of a complex variable. Single- and multivalued functions. Analyticity and Cauchy-Riemann equations.

2. Complex line integrals **(20 Lectures)**
Cauchy's integral theorem (statement only) for simply connected regions. Simple consequences of Cauchy's theorem. Cauchy's integral formula. The Taylor and Laurent expansions (statement only). Singular points, Removable singularity, Poles, Essential singularity, Concept of branch cut, Residue at a pole of order m. Cauchy's residue theorem. Evaluation of simple integrals with the help of residue theorem.

3. Matrix algebra **(12 Lectures)**
Transpose of a matrix, Hermitian, orthogonal and unitary matrices. Matrix for rotation in two and three dimensions. The inverse of a matrix. Solution of a system of linear equations by matrix method. Eigenvalues and eigenvectors of a matrix. Properties of eigenvectors and eigenvalues of Hermitian and unitary matrices. Matrix representations of Linear operators. Similarity transformation. Cayley-Hamilton's theorem.

4. Introduction to Probability **(5 Lectures)**
Independent random variables, Probability distribution functions: binomial, Gaussian, and Poisson with examples. Study of Mean, standard deviation and variance. Central limit theorem.

5. Delta functions **(4 Lectures)**
Dirac delta function. Properties of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Kronecker delta function,

Reference Books
► Complex Variables, Schuam's Outline Series, 2nd ed, M.R. Spiegel, S. Lipschutz, J.J. Schiller, D. Spellman, McGraw Hill Private Ltd.
► Complex analysis, D.G. Zill and P.D. Shanahan, 2015 Jones and Bartlett
► Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
► Complex Variables, A. S. Fokas and M. J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
► Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
► Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.
► Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
► Mathematical Physics, H.K. Dass and R. verma, 8th ed., 2019, S Chand & Co Ltd.

Course Outcomes:

1. Students will develop the concept about Argand diagram and know the algebraic operation on complex number
2. Know about different types of singularity and able to know simplest way of integration over a closed contour.
3. Able to solve simultaneous equations using matrix method and learn the properties of matrix.
4. Develop the idea about probability, probability distribution and central limit theorem.
5. Gain knowledge about Dirac-delta function and Kronecker delta functions.

MJC-5 (Lab): Mathematical Physics-II Lab (1 Credit)

Introduction to Scilab:

Constants, variables, pre-defined mathematical variables and functions, integer, operators, and constant, matrix in Scilab, I/O statements, loop, branching, plotting, changing the appearance of a graph, solution of differential equation, solution of definite integral.

List of Practical (Scilab language should be used):

1. Computation the nth roots of unity for n = 2, 3, and 4.
2. Determination the two square roots of (−5+12j).
3. Plotting of 2D and 3D graph using functions and data files.
4. Solution of the differential equation with given initial conditions: $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$; with y(0)=0 and y'(0)=3; Find y(6) and y'(6) ; plot a graph of y(t) and y'(t) vs. t.
5. Solution of definite integral of the following type:

$$\int_a^b f(x)dx$$

8. From the following data points make a graph. Using least square linear fitting, make a fitting curve. Evaluate standard deviation of the fitting.

X	0.0	0.1	0.2	0.3	0.4	0.5
Y	5.05	5.07	5.10	5.15	5.29	5.22

Reference Books

► Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
► Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
► Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
► A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Course Outcomes:

1. Students will be familiar with Scilab language and be able to install and/or use the programming language.
2. They will be able to write the program to determine the roots of complex number and unity.

3. Students will gain sufficient knowledge to plot 2D/3D graph and able to plot data and functions.
4. Students will be able to solve differential equations and can determine the value of a definite integral.
5. They gain knowledge about least square fitting and may be apply this concepts to plot best graph in their laboratory work.

MJC-6 (Theory): Heat and Thermodynamics (3 Credits)

Kinetic Theory of Gases **(8 lectures)**

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. Estimates of Mean Free Path. Qualitative discussion (no derivation) on transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance (No derivation).

Real Gases **(10 lectures)**

Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapor 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. Joule's Experiment. 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.

Introduction to Thermodynamics **(15 lectures)**

Recapitulation: Zeroth Law of Thermodynamics (Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium), First Law of Thermodynamics and its Differential Form (Concept of Temperature, Heat, Work, Internal Energy), Applications of First Law: General Relation between Cp and Cv, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and vice-versa. 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. Examples of Heat engines (qualitative). Heat engines running backward – the refrigerator, the heat pump.

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. The entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature–Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

Thermodynamic Potentials and Maxwell's equations (12 lectures)

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy - their Definitions, properties, and applications. Derivation and application of Maxwell's relations, Clausius Clapeyron equations, Thermal expansion, Thermodynamic relation with heat capacities, T-dS equation, Energy equations.

Phase transition: First order phase transition, Clapeyron equation, Clausius equation (Second latent heat equation), Examples. Second order phase transition, Ehrenfest equation, Examples. Tripple point (qualitative).

References

- Thermal Physics, A.B. Gupta, H.P. Roy, Fifth edition – 2020, Books & Allied (P) Ltd.
- Heat and Thermodynamics, M. W. Zemansky and R. Dittman, 1981, Tata McGraw-Hill.
- Heat and Thermodynamics by D.S. Mathur, 5th revised edition, S. Chand Publications.
- Thermal Physics, S. C. Garg, R. M. Bansal and C. K. Ghosh, 2nd edition, Tata McGraw-Hill.
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Sears and Salinger, 1988, Narosa.
- Concepts in Thermal Physics, Blundell and Blundell, 2nd edition, 2009, Oxford University Press.
- Thermal Physics, A. Kumar and S. P. Taneja, 2014, R. Chand Publications.
- 6) A Text Book of Heat and Thermodynamics for Degree Students, J. B Rajam, 1981, S. Chand Publications.
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications

LEARNING OUTCOMES:

1. Know about the kinetic of gases, the zeroth law of thermodynamics, 1st and 2nd law of
1. thermodynamics.
2. Gather knowledge about isothermal and adiabatic processes and learn how to solve thermodynamic problems.
3. Able to understand the working principle of Heat engines – Carnot's engine and its applications.
4. Learn about entropy and how the entropy of the universe is changing.
5. Understand the interrelationship between thermodynamic functions and the ability to use such relationships to solve practical problems.
6. Understand how statistics of the microscopic world can be used to explain the thermal features of the macroscopic world.
7. Be able to use thermal and statistical principles in a wide range of applications

MJC-6 (Lab): Heat and Thermodynamics Lab (1 Credit)

List of Practical's:

1. To determine the 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 determine the Stefan's constant.
7. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions.
8. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature
9. To determine **J** by Calorimeter.
10. To determine the specific heat of liquid by the method of cooling.

Reference Books

- An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 1990, New Central Book Agency.
- 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, KitabMahal
- 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.
- B.Sc. Practical Physics, C. L. Arora, 2001, S. Chand and Co.
- B.Sc. Practical Physics, G. Sanon, R. Chand, and Co.

Learning Outcomes:

- Able to learn how to experimentally measure the thermal conductivity in different methods.
- Also learn about the platinum resistance thermometer, thermocouple, etc.

MJC-7 (Theory): Classical Mechanics (3 Credits)

1.Constrained motion: Historical background, Constraints and their classification (Scleronomic or Rheonomic, Holonomic or Nonholonomic, Conservative or Dissipative, Bilateral or Unilateral), Properties of constraints, Examples of constraints, The basic problem with the constraint force, Virtual displacement, Virtual work, Principle of virtual work, Conditions of vanishing virtual work due to constraint forces alone, D'Alembert's principle, Application of D'Alembert's principle (5 Lectures)

2.Lagrangian formulation: Introduction, Degrees of freedom, Generalized coordinates, Lagrange' s equation of motion, Lagrangian of a system, Linear generalized potential, Generalized momentum and energy, Cyclic or ignorable coordinates, Integral s of motion, Simple applications of Lagrange's equation Linear harmonic oscillator, Simple pendulum, Central force problem. (10 Lectures)

3.Hamiltonian Mechanics: Introduction, Legendre's dual transformation, Hamiltonian of a system and Hamilton's equation of motion, Properties of Hamiltonian, Applications in simple cases, The Routhian, Configuration space, phase space and state space, Comparison between Lagrangian and Hamiltonian Mechanics. (10 Lectures)

4.Special Theory of Relativity: Introduction, Concept of space, time and mass, Frame of reference Inertial and non-inertial frames, Newtonian relativity, Galilean transformation equations, Electrodynamics and inconsistency with Galilean relativity, The Ether hypothesis, Michel son-Morley experiment, Explanation of the negative results. (5 Lectures)

Postulates of special theory of relativity, Derivation of Lorentz transformation equations, Length contraction, Time Dilation-Twin paradox, Meson decay, Longitudinal and transverse Doppler shift, Relativity of simultaneity, Geometrical representation of contraction, dilation and simultaneity. (8 Lectures)

Addition of velocities, Variation of mass with velocity, Mass energy equivalence, Relationship between the total energy, the rest mass energy and the momentum, Transformation of momentum and energy, Transformation equations for force, Relativistic invariants and four vectors, Minkowski's four-dimensional space time continuum, Space-time diagrams, Causality relationship, Introduction to the key concepts of general relativity (Basic qualitative discussion only). (7 Lectures).

Course outcome:

Upon successful completion of this course it is intended that a student will be able to:
1.Know how to impose constraints on a system in order to simplify the methods in solving physics problems. They will also understand the important of concepts such as generalized coordinates and constrained motion.
2.Learn about Lagrangian and Hamiltonian formulation of classical mechanics and get familiar with their applications to solve simple physics problems.
3. Distinguish between inertial and non-inertial frames.
4. They will also get acquainted to the various aspects of Theory and application in the field of special theory of relativity

References:

1.Course on theoretical physics Vol.1-L.D. Landauand E. M. Lifschitz: Mechanics (Butterworth-Heinemann, London).
2.Lectures in Analytical Mechanics-F. Gantmacher, translated by G.Yankovsky (Mir Publishers, Moscow).
3.Classical dynamics: a contemporary approach- J.V.Jose and E.J.Saletan (Cambridge University Press, Cambridge).
4.Classical Mechanics–J. Goldstein (Narosa Publishing House).
5.Theoretical Mechanics-M. R. Spiegel, (Schaum's Outline Series) (McGraw-Hil
6.Mechanics-K.R. Symon (Addison-Wesley).
7.Introduction to Classical Mechanics- R. G. Takwale and P.S. Puranik (Tata McGraw Hil).
8.Classical Mechanics–N.C.Rana and P.S.Joag (Tata McGraw-Hil).
9.The Feynman Lectures on Physics–VolI (Addison-Wesley).
10.Mechanics–H. S. Hans and S.P. Puri (Tata McGraw-Hil).
11.Berkeley Physics Course, Vol–I (Mechanics) (McGrawHil)

MJC-7 (Lab): Classical Mechanics Lab (1 Credit)

List of practical:

1. To determine the moment of inertia of fly-wheel.
2. To determine the modulus of rigidity of material of a given wire by dynamical method using Maxwell needle.
3. To determine the Moment of Inertia of a metallic cylinder/rectangular bar about an axis passing through the C.G.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine g and velocity for a freely falling body using Digital Timing Technique.

References:

1. Practical Physics, G.L. Squires, Cambridge University
2. B.Sc. Practical Physics, C.L.Arora, S Chand and Company Limited.
3. Physics in Laboratory, Mandal, Chowdhury, Das, Das, Santra Publication.
4. Advanced Practical Physics Vol1, B. Ghosh, K. G. Majumder, Sreedhar Publisher.
5. Practical Physics, P.R.Sasi Kumar, PHI Learning Private Limited.
6. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited.

Course outcome:

Upon successful completion of this course, it is intended that a student will be able to:

1. Determine moment of inertia and elastic constants of different materials.
2. Estimate the value of acceleration due to gravity and get familiar with the digital timing technique.

MJC-8 (Theory): Analog Electronics systems and Applications (3 Credits)

1. Semiconductor Diodes and Applications (8 Lectures)
(a) Qualitative idea of band structure in semiconductor, Formation of PN junction (Simple Idea). Idea of homo and hetero junction, Electric field and potential barrier profile of step graded and linearly graded PN junction (diagrammatic approach). Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. (b) Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation. Circuit and operation of clipping and clamping circuit, Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. Avalanche Photo Detector (APD).

2. Bipolar Junction transistors and Biasing (7 Lectures)
n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. 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. Active, Cut off and Saturation Regions. Transistor Biasing and Stabilization Circuits; Fixed Bias, collector to base bias, emitter or self-bias, voltage Divider Bias.

3. Field Effect transistors (4 Lectures)
Field effect transistor – JEET and its IV characteristics, pinch-off voltage, applications. MOSFET – structure, classification of MOSFETs, enhancement and depletion types, typical applications; structure, I-V characteristics.

4. BJT Amplifiers (8 Lectures)
h-parameter Equivalent Circuit, Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Frequency response of a CE amplifier. Coupled Amplifier: Two stage RC-coupled amplifier, Classification of Class A, B & C Amplifiers.

5. Feedback in Amplifiers (4 Lectures)
Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

6. Operational Amplifiers (9 Lectures)
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. Applications of Op-Amp. as (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) comparators, (9) Schmidt triggers. Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)

7. Oscillators (5 Lectures)
Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. Wein bridge oscillator. Monostable, Astable and Bistable Multivibrators.

Reference Books

► Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
► Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
► Solid State Electronic Devices, B. G. Streetman &S. K. Banerjee, 6th Edn.,2009, PHI Learning
► Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
► OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
► Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
► Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk, 2008, Springer
► Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
► Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
► Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
► Electronic Devices and Circuit Theory, R.L. Boylestad, L. Nashelsky, PHI Private Ltd.

Course Outcomes:

1. This course will help the students to get familiar with different topics of semiconductor physics.
2. Acquire knowledge about three terminal devices, voltage-controlled devices and current controlled devices.
3. They will able to know about different amplifier circuits. Gain Understand how major concepts developed and changed over time.
4. The students will come to know about the operational amplifier and its uses in different aspects
5. Overall, they will gain sufficient knowledge on the theories of electronic circuits.

MJC-8 (Lab): Analog Electronics systems and Applications Lab (1 Credit)

List of practical:

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
3. To design and study the frequency response of the BJT amplifier in CE mode.
4. To investigate the use of an Op-Amp. (741) as (i) inverting amplifier (ii) non inverting amplifier (iii) two input adder (iv) subtractor for dc voltage of given gain.
5. To investigate the use of an Op-Amp. (741) as an Integrator / Differentiator.
6. To study a Wien bridge oscillator for given frequency using an op-amp.
7. To study the reverse characteristics of Zener diode and voltage regulation.

Reference Books

► Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc Graw Hill
► Advanced Practical Physics (volume II), B. Ghosh, Shreedhar Publication
► An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd.
► Laboratory Manual for Operational Amplifiers and Linear ICs, David A. Bell, Prentice Hall of India Pvt Ltd.

Course Outcomes:

1. This course will help the students to get familiar electronic circuits, uses of bread board and discreate components.
2. Students will learn experimentally the I-V characteristics of PN diode, LED and BJT.
3. They will be able to design an amplifier using transistor.
4. They will be able to investigate the uses of Op. Amp. as inverting, non-inverting, adder and subtractor.
5. The students will be able to design Wien bridge oscillator, integrator, and differentiator by employing Op. Amp.

(Minor)
Credit: 3 (Th.) +1 (Lab.)

MN-4 (Theory): Heat and Thermodynamics (3 Credits)

Kinetic Theory of Gases **(8 lectures)**

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 (qualitative). Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases (qualitative), Brownian Motion and its Significance.

Real Gases **(10 lectures)**

Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation, Critical Constants. Continuity of Liquid and Gaseous State. Vapor 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 Effect for Real and Van der Waal Gases (qualitative). Temperature of Inversion.

Introduction to Thermodynamics **(15 lectures)**

Recapitulation: Zeroth Law of Thermodynamics (Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium), First Law of Thermodynamics and its Differential Form (Concept of Temperature, Heat, Work, Internal Energy), Applications of First Law: General Relation between Cp and Cv, Work Done during Isothermal and Adiabatic Processes,

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and vice-versa. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Examples of Heat engines (qualitative). Working principles Air Conditioner and Refrigerators.

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. The entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature–Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

Thermodynamic Potentials and Maxwell's equations **(12 lectures)**

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy - their Definitions, properties, and applications. Derivation and application of Maxwell's relations, Clausius Clapeyron equations (qualitative), Thermodynamic relation with heat capacities, T-dS equation.

Phase transition: First order phase transition, Clapeyron equation (qualitative), Clausius equation (qualitative), Examples & significance. Second order phase transition, Ehrenfest equation (qualitative), Examples & significance.

References

- Thermal Physics, A.B. Gupta, H.P. Roy, Fifth edition – 2020, Books & Allied (P) Ltd.
- Heat and Thermodynamics, M. W. Zemansky and R. Dittman, 1981, Tata McGraw-Hill.
- Heat and Thermodynamics by D.S. Mathur, 5th revised edition, S. Chand Publications.
- Thermal Physics, S. C. Garg, R. M. Bansal and C. K. Ghosh, 2nd edition, Tata McGraw-Hill.
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Sears and Salinger, 1988, Narosa.
- Concepts in Thermal Physics, Blundell and Blundell, 2nd edition, 2009, Oxford University Press.
- Thermal Physics, A. Kumar and S. P. Taneja, 2014, R. Chand Publications.
- 6) A Text Book of Heat and Thermodynamics for Degree Students, J. B Rajam, 1981, S. Chand Publications.
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications

LEARNING OUTCOMES:

1. Know about the kinetic of gases, the zeroth law of thermodynamics, 1st and 2nd law of thermodynamics.
2. Gather knowledge about isothermal and adiabatic processes and learn how to solve thermodynamic problems.
3. Able to understand the working principle of Heat engines – Carnot's engine and its applications.
4. Learn about entropy and how the entropy of the universe is changing.
5. Understand the interrelationship between thermodynamic functions and the ability to use such relationships to solve practical problems.
6. Understand how statistics of the microscopic world can be used to explain the thermal features of the macroscopic world.
7. Be able to use thermal and statistical principles in a wide range of applications

MN-4 (Lab): Heat and Thermodynamics Lab (1 Credit)

List of Practicals:

11. To determine the Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
12. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
13. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
14. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
15. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
16. To determine the Stefan's constant.
17. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions.
18. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature
19. To determine **J** by Calorimeter.
20. To determine the specific heat of liquid by the method of cooling.

Reference Books

► An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 1990, New Central Book Agency.
► 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, KitabMahal
► 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.
► B.Sc. Practical Physics, C. L. Arora, 2001, S. Chand and Co.
► B.Sc. Practical Physics, G. Sanon, R. Chand, and Co.

Learning Outcomes:

- Able to learn how to experimentally measure the thermal conductivity in different methods.
- Also learn about the platinum resistance thermometer, thermocouple, etc.

-------------------Up to 4th Semester---------------------

Sem V

For DSC paper
(Major)
Credit: 3+1

MJC-9 (Theory): Mathematical Physics-III (3 Credits)

1. Integrals Transforms **(30 Lectures)**

Introduction to Integral Transforms, Kernel of Integral Transforms, Necessity of Integral Transforms.

Laplace Transform: Definition, Laplace Transforms of Some Elementary Functions, Properties of Laplace Transforms: Linearity Property, Change of Scale Property, Shifting Property. Laplace Transforms of Derivatives, Laplace Transforms of Integrals, Differentiation and Integration of Laplace Transforms. Laplace Transform of: Unit Step function, Dirac Delta function, Periodic Functions. Laplace Transforms of $\{t^n f(t)\}$ and $\left\{\frac{1}{t} f(t)\right\}$.Convolution Theorem. Inverse Laplace Transforms. Properties of Inverse Laplace Transforms. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits. Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Fourier Transform: Definition, Fourier Sine and Cosine Transform. Fourier Transform of Trigonometric, Gaussian, Finite Wave Train & Other Functions. Properties of Fourier transforms. Convolution theorem. Parseval's Identity. Fourier transform of Derivatives, Inverse Fourier Transform. Fourier Transforms in 3D with examples. Relation between Fourier and Laplace Transforms. Applications of Fourier Transform in single slit, double slit and *N*-slit grating. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

2. Linear Vector Spaces **(15 Lectures)**

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. Inner products, Gram-Schmidt orthogonalization, Hilbert Space and Linear Vector Space, Dimension and Basis of a Vector Space, Square Integrable Functions; Dirac Notation; Operators – Hermitian, Adjoint, Projection Operator, Commutator Algebra, Inverse and Unitary Operators, Eigenvalues and Eigenvectors of an Operator, Expectation value of an operator; Unitary Transformation; Matrix Representation of Kets, Bras, and Operators in Different Bases;

Reference Books

- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.
- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
- Mathematical Physics, H.K. Dass and R. Verma, 8th ed., 2019, S Chand & Co Ltd.
- Introduction to Mathematical Physics, Charlie Harper, 1978, PHI Learning Pvt. Ltd.
- Schaum's Outline of Linear Algebra, Seymour Lipschutz and Marc Lipson , 2017, 3rd Edition, Tata McGraw-Hill India.

Course Outcomes:

1. Understand the essential concepts of the Fourier transform for both periodic and non-periodic functions.
2. Utilise Fourier transforms to address boundary value concerns and do signal analysis.
3. Understand the principles and characteristics of Laplace transforms and inverse Laplace transforms.
4. Employ Laplace transforms to resolve ordinary differential equations and integral equations.
5. Develop Fourier and Laplace transform methodologies to address practical issues in engineering, physics, and other disciplines.
6. Understand the essential principles of vector spaces, subspaces, linear combinations, and linear dependence/independence.
7. Examine and formulate linear transformations and investigate their matrix representations.

MJC-9 (Lab): Mathematical Physics-III lab (1 Credit)

List of Practicals (Scilab language should be used)

1. Solution of ODE First order Differential equation Euler, modified Euler method: Radioactive decay, Current in RC, LC circuits with DC source
2. Evaluate the Fourier coefficients of a given periodic function (e.g. square wave, triangle wave, half wave and full wave rectifier etc.)
3. Curve fitting, Least square fit, Goodness of fit, standard deviation: Ohms law to calculate R, Hooke's law to calculate spring Constant.
4. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.
5. Perform circuit analysis of a general LCR circuit using Laplace's transform.
6. Discrete and Fast Fourier Transform of given function in tabulated or mathematical form e.g function $\boldsymbol{exp}(-\boldsymbol{x}^2)$.

Reference Books

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
- Scilab (A free software to Matlab): H. Ramchandran, A. S. Nair. 2011 S. Chand and Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Beta script Publishing
- Mathematical methods for physics, George B. Arfken

Course Outcomes:

1. Students will be familiar with the Scilab language and be able to install and/or use the programming language.
2. They will be able to write the program to determine the roots of complex numbers and unity.

3. Students will gain sufficient knowledge to plot 2D/3D graphs and be able to plot data and functions.
4. Students will be able to solve differential equations and can determine the value of a definite integral.
5. They gain knowledge about the least square fitting and may be apply this concept to plot the best graph in their laboratory work.

MJC-10 (Theory): Quantum Mechanics-I (3 Credits)

Unit – I (20 Lectures)

Origin of Quantum Theory: Limitation of Classical Physics; Black body radiation; Planck's hypothesis, Planck's constant, light as a collection of photons; Photo-electric effect; Compton scattering; Pair production.

Foundation of Quantum Mechanics: Wave aspect of Particles: de-Broglie hypothesis – matter waves, Davisson-Germer experiment; Particle vs waves – Classical and Quantum view of particles, Double Slit experiment; Phase and group velocity, wave packet and its motion, Heisenberg's uncertainty principle, consequences of uncertainty principle. Impossibility of an electron being in the nucleus because of the uncertainty principle, Energy-time uncertainty relation; Postulates of Quantum Mechanics, State of a system and wavefunction, Probability density, Superposition Principle, Expectation values; Statistical interpretation of wave function – Meaning of probability density, probability current density and conservation of probability, Normalization conditions and examples, conditions for physical acceptability of wave functions with examples, Position and momentum operators and their expectation values, Commutation relation.

Unit – II (25 Lectures)

The Schrodinger Equation: Time evolution of the System's state – time evolution operator, Stationary states, Schrodinger equation in one-dimension. Time Independent Schrodinger Equation: Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function.

Application: Energy eigen values and stationary states for a particle inside an infinite well – symmetric and asymmetric case. One-Dimensional problem – Potential Step, Potential Barrier – (i) $E < V_0$, (ii) $E > V_0$: Tunnelling effect; Finite Square well potential – Scattering solution ($E > V_0$), Bound state solution ($0 < E < V_0$);

Simple harmonic oscillator - Energy Levels and Eigen functions using Frobenius Method; Hermite Polynomials; Ground State, Zero Point Energy and Uncertainty Principle; Comparison of classical and quantum harmonic oscillator.

Reference Books

- David J. Griffiths, Introduction to Quantum Mechanics
- N. Zettili, Quantum Mechanics: Concepts and Applications
- Eisberg and Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles
- Richard L. Liboff, Introductory Quantum Mechanics
- H. C. Verma, Concepts of Modern Physic
- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

- Quantum Mechanics: Theory & Applications, A. K. Ghatak & S. Lokanathan, 2004, Macmillan

Additional Books for Reference

- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
- Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
- Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
- Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

LEARNING OUTCOMES

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

- Explain the failure of classical physics and the need for quantum theory.
- Analyze experimental evidence supporting quantum theory (photoelectric effect, Compton effect, Davisson-Germer experiment).
- Solve the Schrödinger equation for one-dimensional systems like free particles, particle in a box, and quantum wells.
- Evaluate the physical meaning of wavefunctions and their statistical interpretation.
- Predict atomic energy levels and spectral lines using the Bohr model and vector atom model.
- Identify the role of quantum numbers, spin-orbit coupling, and Pauli's exclusion principle in atomic structure.
- Interpret atomic spectra and selection rules using quantum mechanical principles.
- Demonstrate the application of quantum mechanics to atomic systems.
- Describe the quantum mechanical model of atoms, including the Bohr model, Sommerfeld's theory, quantum numbers, and atomic spectra.

MJC-10 (Lab): Quantum Mechanics-I lab (1 Credit)

List of Practical's:

1) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
2) To determine the work function of material of filament of directly/indirectly heated vacuum diode.
3) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
4) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
5) To determine the Boltzmann constant using I-V characteristics of PN junction diode

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

- A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Edn, 2011, Kitab Mahal
- Engineering Applications: A. Vande Wouwer, P. Saucez, C.V. Fernández 2014 Springer.

MJC-11 (Theory): Digital Systems and Applications (3 Credits)

1. Number System **7 Lectures**

Basic idea of a base of a number system, Number system of a base up to 10, and Hexadecimal numbers. Conversion from Decimal number to a number of base 2, 3, 4, 5, 6, 7, 8, 9 and Hexadecimal and vice versa. Binary Numbers. BCD, Octal and Hexadecimal numbers. Signed and unsigned number representation of binary system. Representation of negative number. Binary addition , binary subtraction, (a-1)'s Complement and a's Complement method of subtraction, where a is base up to 10 of a number system.

2. Digital Circuits **12 Lectures**

(a) Difference between Analog and Digital Circuits. Boolean algebra, Combinational logic, Truth table. Introduction of basic logic functions AND, OR and NOT. Implementation of OR, AND, NOT Gates (realization using Diodes and Transistor). De Morgan's Theorems. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. Circuit representation of gates (both Usual and IEEE symbols).

(b) Product term and sum term in logical expression. Sum of Product and Product of Sum and mixed expression. Minterm and Maxterm in the expressions. Conversion between truth table and logical expression. Simplification of logical expression using Karnaugh Map.

3. Implementation of different circuits **6 Lectures**

Half and Full Adders. Subtractors, 4-bit binary adder/Subtractor. Combinational logic circuits using PAL/PLA, use of IC 7483 as adder and subtractor.

4. Data processing circuits **5 Lectures**

Basic idea of Multiplexers, De-multiplexers, Decoders, and Encoders.

5. Sequential Circuits: **6 Lectures**

Introduction to Next state present state table, excitation table and truth table for Sequential circuits. SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race condition in SR and Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop, T type FF.

6. Registers and Counters **6 Lectures**

(a) 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). (b) Counters (4 bits): Asynchronous counters: ripple counter, Decade Counter. Synchronous Counter, Ring counter.

7. Data Conversion **3 Lectures**

A/D (Ladder and weighted resistance) and D/A conversion circuit

Reference Books

1. Digital Circuits, Part I & II, D. Raychaudhuri, Eureka Publisher
2. Digital Logic and Computer Design, M. Morris Mano, Pearson Education

3. Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill 4. Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
5. Fundamental of Digital Circuits, A. Anand Kumar, Prentice Hall India Learning Pvt. Ltd.
6. Digital Systems, Principles and Applications, R. Tocci, N. S. Widemer, Prentice Hall India Learning Pvt. Ltd.
7. Modern Digital Electronics, R. P. Jain, Tata McGrow Hill Publishing Company
8. Digital Electronics An Introduction to Theory and Practice, Prentice Hall India Learning Pvt. Ltd.
9. Digital Computer Electronics, A. Malvino & Jerald Brown, Tata McGrow Hill Publishing Company. HONOURS: SEMESTER 6. CC 13, CC 14, DSE A2, DSE B2 59 6.1.2 Digital Systems and Applications (Practical) Paper: PHS-A-CC-6-14-P Credits: 2

MJC-11 (Lab): Digital Systems and Applications Lab (1 Credit)

List of Practicals:

1. To design basic logic gates with diode and resistor.
2. To design basic logic gates with Transistors.
3. To verify the logics by any type of universal gate NAND/NOR.
4. Construction of half adder and full adder
5. Construction of half subtractor and full subtractor
6. Construction of SR, D, JK FF circuits using NAND gates.
7. Construction of 4 bit shift registers (serial & parallel) using D type FF IC 7476.
8. Construction of 4 × 1 Multiplexer using basic gates and IC 74151.

Reference Books

1. Advanced Practical Physics, B. Ghosh, K. G. Majumder, Sreedhar Publication
2. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd

MJC-12 (Theory): Optics and Electromagnetic theory (3 Credits)

Interference:
Basic idea of interference: Two beam and multiple beam interference; Interference in thin films. Haidinger and Brewster fringes. Localization of fringes. Newton’s rings. Michelson’s interferometer, Circular and straight fringes. Visibility of fringes. Multiple-beam interference. Fabry-Perot interferometer. Intensity formula. Coefficient of fineness. Resolving power. Fabry-Perot etalon and its applications. (5 lecture)
Diffraction:
Fresnel diffraction. Division of wave-front into half-period zones. Zone plate. Rectilinear propagation. Fraunhoffer diffraction. Diffraction at a single and at two parallel slits. Plane diffraction grating. Resolving power. Rayleigh’s criterion. Resolving powers of prism. (5 lecture)
Polarization:
Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Elementary idea of 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. (10 lecture)

Maxwell Equations:

Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. (5 lecture)

Propagation of EM Wave 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. (4 lecture)

Propagation of 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 at normal Incidence. Basic concept of mode formation in rectangular waveguide (no derivation). (5 lecture)

Recommended Books:

1. D. J. Griffiths – Introduction to Electrodynamics (PHI)
2. J. D. Jackson – Classical Electrodynamics (Wiley Eastern)
3. Optics - Ajoy Ghatak, 2008, Tata McGraw Hill
4. Fundamental of Optics - A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
5. E. Hecht and Zajac – Optics (Addison-Wesley)

MJC-12 (Lab): Optics and Electromagnetic theory Lab (1 Credit)

List of Practical's:

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 verify the Stefan`s law of radiation and to determine Stefan's constant.
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 determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
7. Resolving power of grating.
8. Dispersive power of Prism.

(Minor)
Credit: 3 (Th.) +1 (Lab.)

MN-5 (Theory): Digital Systems and Applications (3 Credits)

Number System **9 Lectures**
Basic idea of a base of a number system, Number system of a base up to 10, and Hexadecimal numbers. Conversion from Decimal number to a number of base 2, 8 and Hexadecimal and vice versa. Binary Numbers. BCD, Octal and Hexadecimal numbers. Signed and unsigned number representation of binary system. Representation of negative number. Binary addition, binary subtraction, 1's Complement and 2's Complement method of subtraction.
Digital Circuits **20 Lectures**
(a) Difference between Analog and Digital Circuits. Boolean algebra, Combinational logic, Truth table. Introduction of basic logic functions AND, OR and NOT. Implementation of OR, AND, NOT Gates (realization using Diodes and Transistor). De Morgan's Theorems. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.
(b) Product term and sum term in logical expression. Sum of Product and Product of Sum and mixed expression. Minterm and Maxterm in the expressions. Conversion between truth table and logical expression. Simplification of logical expression using Karnaugh Map.

Half and Full Adders. Subtractors, Basic idea of Multiplexers, De-multiplexers.

Sequential Circuits: **16 Lectures**
Introduction to Next state present state table, excitation table and truth table for Sequential circuits. SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race condition in SR and Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop, T type FF. Basic concept of Registers.

Reference Books

1. Digital Circuits, Part I & II, D. Raychaudhuri, Eureka Publisher
2. Digital Logic and Computer Design, M. Morris Mano, Pearson Education
3. Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill 4. Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
5. Fundamental of Digital Circuits, A. Anand Kumar, Prentice Hall India Learning Pvt. Ltd.
6. Digital Systems, Principles and Applications, R. Tocci, N. S. Widemer, Prentice Hall India Learning Pvt. Ltd.
7. Modern Digital Electronics, R. P. Jain, Tata McGrow Hill Publishing Company
8. Digital Electronics and Introduction to Theory and Practice, Prentice Hall India Learning Pvt. Ltd.
9. Digital Computer Electronics, A. Malvino & Jerald Brown, Tata McGrow Hill Publishing Company. HONOURS: SEMESTER 6. CC 13, CC 14, DSE A2, DSE B2 59 6.1.2 Digital Systems and Applications (Practical) Paper: PHS-A-CC-6-14-P Credits: 2

MN-5 (Lab): Digital Systems and Applications Lab (1 Credit)

List of Practicals:

1. To design basic logic gates with diode and resistor.
2. To design basic logic gates with Transistors.
3. To verify the logics by any type of universal gate NAND/NOR.
4. Construction of half adder and full adder
5. Construction of SR, D, JK FF circuits using NAND gates.
6. Construction of 4 × 1 Multiplexer using basic gates and IC 74151.

Reference Books

1. Advanced Practical Physics, B. Ghosh, K. G. Majumder, Sreedhar Publication
2. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd

Sem VI

For DSC paper
(Major)
Credit: 3+1

MJC-13 (Theory): Statistical Mechanics (3 Credits)

1. Classical Statistical Mechanics **Lectures-14**

Macrostate & Microstate, Phase space, density of states, Elementary Concept of Ensemble (Microcanonical, Canonical and grand canonical ensemble), chemical potential, Thermodynamic Probability, Maxwell-Boltzmann distribution law, Partition Function, Entropy, Thermodynamic Functions of an Ideal Gas, Gibbs Paradox, Sackur-Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

2. Classical Theory of Radiation **Lectures-8**

Properties of Thermal Radiation. Blackbody Radiation and its temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law. Ultraviolet Catastrophe.

3. Quantum Theory of Radiation **Lectures-8**

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

4. Bose-Einstein Statistics: **Lectures-8**

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, Radiation as a photongas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.

5. Fermi-Dirac Statistics: **Lectures-7**

Fermi-Dirac Distribution Law, Thermodynamic functions of a strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas.

Reference Books

► Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press
- Statistical Mechanics – an elementary outline, A. Lahiri, 2008, Universities Press

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

MJC-13 (Lab): Statistical Mechanics lab (1 Credit)

List of Practical's (Using Scilab language):

1. Single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interactingparticles N under Maxwell-Boltzmann, Fermi-Dirac and Bose- Einstein statistics:

a) Cv, depend upon the temperature, total number of particles N and the spectrum of single particle states.

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

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

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

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

4. Plot the following functions with energy at different temperatures

a) Maxwell-Boltzmann distribution

b) Fermi-Dirac distribution

c) Bose-Einstein distribution

Reference Books

➢ Elementary Numerical Analysis, K.E.Atkinson, 3 rdEdn . 20 07 , Wiley India Edition

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

➢ 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.

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

MJC-14 (Theory): Nuclear and Particle Physics (3 Credits)

Nuclear Properties:

General properties of nuclei, Size of nuclei, Rutherford's α particle scattering experiment, Mass and charge of nuclei, Mass defect and packing fraction, Binding energy, Nuclear quantum numbers, Nuclear spin and angular momentum, Nuclear magnetic moment, Electric quadrupole moment, Nuclear parity, Systematics of stable nuclei, Properties of nuclear force (**6 lectures**)

Radioactivity:

Alpha decay, Range of α particles, Geiger's empirical relation, Straggling, Geiger-Nuttal law, Disintegration energy of spontaneous α decay, The α ray spectrum and fine structure, Long range α particles, A short description on barrier penetration and Gamow's theory of α decay (calculations are not required) (**6 lectures**)

Beta (β) decay, Three forms of β decay, Continuous β ray spectrum and apparent non-conservation of energy, linear and angular momentum, Pauli's neutrino hypothesis, Fermi's theory of β decay (qualitative discussion). (**6 lectures**)

Gamma (γ) decay, Origin of the γ rays, Internal conversion, Absorption of γ rays in matter, Interaction of γ rays with matter, Pair production and annihilation, Nuclear isomerism, Mössbauer effect. (**2 lectures**)

Nuclear reactions:

Introduction, Types of nuclear reactions, Conservation laws in nuclear reactions, Energies of nuclear reactions, Kinematics of nuclear reactions: The Q value, Threshold energy and separation energy, Cross section of nuclear reaction, Nuclear fission and fusion (**5 lectures**)

Detection of nuclear radiations:

Interaction of radiation with matter, Radiation detectors, variation of ionization current with applied voltage in gas-filled detectors, Ionization chamber, Proportional counter, Geiger-Müller counter, Scintillation counter. (**5 lectures**)

Particle accelerators:

Introduction, Components of an accelerator, Types of accelerator, Linear accelerator, The cyclotron, betatron. (**4 lectures**)

Nuclear models:

Introduction, Liquid drop model, Resemblance of an atomic nucleus with a liquid drop, Bethe-Wiezsäcker semi empirical mass formula and its applications: Mass parabola, Stability of nuclei against β decay, Success and limitations of the liquid drop model, Nuclear shell model, Evidences in favour of shell model, The single particle shell model with square well potential, Spin-orbit coupling, Predictions of the shell model, Success and limitations of the shell model (**6 lectures**)

Particle Physics:

Fundamental interactions in nature, Classification of elementary particles and their families, Exact conservation laws, Approximate conservation laws, Symmetry classification of elementary particles, Quark model, Concept of color charge and gluons. (**5 lectures**)

Reference Books:

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd.)
- Introduction to Nuclear and Particle Physics (Undergraduate Lecture Notes in Physics) by Saverio D'Auria (Springer)
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill)
- Fundamentals of Nuclear Physics by Jahan Singh (Pragati Prakashan)
- Introduction to the physics of nuclei & particles by R. A. Dunlap. (Thomson Asia)
- Introduction to nuclear and particle physics by A. Das and T. Ferbel (Pidgin English)
- Introduction to Elementary Particles, D. Griffith, (John Wiley & Sons)
- Nuclear Physics by S. N. Ghoshal (S. Chand)

Course Outcomes:

Upon successful completion of this course, it is intended that a student will be able to:

1. Acquire general idea about the structure and general properties of atomic nuclei.
2. Cultivate knowledge regarding different aspects of radioactive radiations and different kinds of nuclear reactions.
3. Get familiar to the construction and working principles of the instruments used for detection of nuclear radiations and accelerate sub-atomic particles.
4. Gather acquaintance about different nuclear models.
5. Obtain preliminary knowledge about cosmic rays and elementary particles.

MJC-14 (Lab): Nuclear Physics lab/Project work/Literature Review (1 Credit)

Students have to execute the following responsibilities:

To prepare a project-work/literature-review on any one of the following topics and present their project-work/literature-review in the form of an oral presentation.

1. Interaction of radiation with matter.
2. Nuclear detectors (gamma, neutron and charge particle detector)
3. Geiger Muller counter
4. How Rutherford modify the Thompson model of atomic picture based on Geiger and Marsden experimental results.
5. High energy electron scattering experiment to measure the size of the nucleus and also to get the idea of charge and mass distribution of the nucleus.
6. Measurement of mass of nuclei by using the atomic mass spectrometer (AMS).
7. Large Hadron Collider experiment.
8. A review work of different laboratory standards radioactive sources (gamma source, charge particle source, neutron source)
9. Effect of radiation on our physical body.
10. Applications of nuclear physics in medical science, industry, security, etc.
11. Positron emission therapy for the cancer patient.
12. Nuclear fuels

13. Any others related to nuclear physics

Course Outcomes:

The students will develop the habit of through reading and literature survey. They will able to explain and elaborate a given topic in their own way. They will learn to prepare oral presentation materials and will able to improve their oratory skill, which will consequently boost up their confidence and help them for research work in future.

MJC-15 (Theory): Solid state physics (3 Credits)

1. **Crystal Structure**
Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell & Primitive cell, packing fraction; Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **7 lectures**

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^3 law. **7 lectures**

3. **Magnetic Properties of Matter**
Origin of magnetism, Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia-magnetism and para-magnetism; Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **7 lectures**

4. **Dielectric Properties of Materials**
Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius-Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. **6 lectures**

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

6. **Elementary band theory**
Bloch Theorem, Kronig-Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Determination of Hall coefficient for conductor and semiconductor. **7 lectures**

7. **Superconductivity**
Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Some application of superconductivity. Idea of BCS theory (No derivation). **5 lectures**

Reference Books

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

Course Outcomes: After completion of the course, the students will have basic idea of Unit Cell, Primitive Cell, symmetry then Brillouin Zone etc. Understanding of quantization of acoustical energy in addition to quantization of optical energy is reflected along a comparative avenue with experimental observations. The infusion of quantization in magnetism leads the molecular magnetic theory from classical to quantum. The students will be exposed to dielectric as well as ferroelectric properties of materials. The Elementary Band theory part is also ornamented with some more words for initiation of 'Band theory with generation-based application' along a mathematical passage after 10+2 level. They will also gain elementary knowledge of superconductivity.

MJC-15 (Lab): Solid state physics Lab (1 Credit)

List of Practical's:

1. To measure the Magnetic susceptibility of Solids.
2. To measure the Dielectric Constant of a dielectric Materials.
3. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
4. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150^{o}C) and to determine its band gap.
5. To determine the Hall coefficient of a semiconductor sample.

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.
- A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Course Outcomes:

Theoretical study will remain as literature unless experimental observation. The Experiments for Lab are mostly selected in such a manner so that evolution of curiosity in theoretical classes may be normalized to a certain extent considering overall situation (mainly maintenance scope in some areas) of HEIs.

MJC-16 (Theory): Quantum Mechanics-II (3 Credits)

Unit – I **(14 Lectures)**

Mathematical Foundation: Position and Momentum Representation; Uncertainty Relation between Two Operators, Parity Operator; Symmetry and Conservation Laws (Translational, Rotational, and Time-Reversal Symmetry), Schrodinger vs. Heisenberg Picture - Time evolution of quantum states, Heisenberg equation of motion, Relation between Schrödinger and Heisenberg pictures, Ehrenfest's Theorem (qualitative).

Angular Momentum: Orbital Angular momentum operators and their components, Commutation relations of L_x, L_y and L_z; Eigenvalues and eigenvectors of L^2 and L_z; Raising and Lowering operators and their commutation relations: Spherical Harmonics as Eigenfunctions of L^2 and L_z; Integral and half-integral values of l. Spin Angular momentum – General theory of Spin, Spin Operators and Commutation Relations, Spin Eigenvalues and Eigenfunctions (S^2 and S_z) Experimental evidence of Spin, Spin-half particles and Pauli matrices; Addition of Angular Momenta.

Unit – II **(15 Lectures)**

Discrete, Continuous, and Mixed Spectrum; Symmetric Potential and Parity; Continuity of Wave Function, Boundary Conditions, and Emergence of Discrete Energy Levels;

Applications in One dimensional problem: Simple harmonic oscillator by using Operator Method for Energy Levels and Solutions.

Applications in Three-Dimensional problem (Cartesian coordinate): – Infinite square well potential, Isotropic Harmonic Oscillator problem, Degeneracy. Idea of 3D Quantum well and Quantum Dot.

Hydrogen Atom: Time independent Schrodinger equation in spherical polar coordinates; Separation of variables; Quantum Numbers – Principal, Orbital, Magnetic; Radial wave functions from Frobenius method; Electron probability densities for ground & first excited states;

Unit – III **(16 Lectures)**

Vector Atom Model: *Recapitulation: Electron angular momentum. Space quantization, Electron Spin and Spin Angular Momentum*, Limitations of Bohr-Sommerfeld Theory, Spatial Quantization, Electron Spin, Stern-Gerlach experiment; Quantum Numbers and Electron Configuration - Principal, orbital, magnetic, and spin quantum numbers, Pauli's exclusion principle, Aufbau principle and Hund's rule; Total Angular Momentum (J=L+S), Spin-Orbit coupling – L-S and j-j coupling; Spectral terms and notations, selection rules, intensity rules, correspondence principle. Sodium D-Line Splitting; Fine Structure of Spectral Lines; Magnetic dipole moment due to orbital motion of electron; Magnetic dipole moment due to spin motion of electron; Larmor's theorem.

Atoms in External Fields: Basic idea of time-independent perturbation theory (No derivation). Zeeman Effect - Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr

Magneton, Normal Zeeman Effect, Anomalous Zeeman Effect; Paschen-Back Effect, Stark Effect (Qualitative Discussion), Pauli's Exclusion Principle – Statement and Application; Symmetric & Anti-symmetric Wave Functions; Periodic Table.

Reference Books

- A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer
- Introductory Quantum Mechanics by S. Gasiorowicz, John Wiley & Sons. Inc.
- Quantum Mechanics; Volume 1, Cohen-Tannoudji.

LEARNING OUTCOMES

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

- Explain the concepts of Hilbert space, linear vector spaces, and their applications in quantum mechanics.
- Use Dirac notation and matrix representation of kets, bras, and operators in different bases.
- Apply commutator algebra, Hermitian and unitary operators, and symmetry principles in quantum mechanics.
- Differentiate between Schrödinger and Heisenberg pictures.
- Solve one-dimensional quantum problems such as the simple harmonic oscillator using the Frobenius method and operator methods.
- Understand the concept of energy quantization, wave function continuity, and emergence of discrete energy levels.
- Solve three-dimensional quantum systems, including the isotropic harmonic oscillator and infinite well potential.
- Analyze the hydrogen atom using Schrodinger's equation in spherical coordinates and interpret quantum numbers and radial wave functions.
- Explain the fundamental properties of orbital and spin angular momentum, including commutation relations.
- Solve for eigenvalues and eigenfunctions of Orbital angular momentum, and work with spherical harmonics.
- Describe the limitations of the Bohr-Sommerfeld model and the role of space quantization in atomic physics.

- Explain the total angular momentum concept (J=L+S) and spin-orbit coupling, including L-S and j-j coupling schemes.
- Analyze fine structure and spectral splitting in atomic energy levels, such as sodium D-line splitting.
- Understand the role of magnetic dipole moments due to orbital and spin motion of electrons.
- Explain the Zeeman effect (normal and anomalous), Paschen-Back effect, and Stark effect qualitatively.
- Apply Pauli's exclusion principle to atomic structure and understand symmetric and anti-symmetric wave functions.
- Interpret atomic spectral notations, periodic table organization, and multi-electron atom configurations.

MJC-16 (Lab): Quantum Mechanics Lab (1 Credit)

List of Practicals:

1) Measurement of Planck's constant using black body radiation and photo-detector
2) To determine the Planck's constant using LEDs of at least 4 different colours.
6) To measure wavelengths in the Balmer series using a diffraction grating
3) To determine the ionization potential of mercury.
4) Study of Spectra of Hydrogen to calculate Rydberg Constant.
5) To show the tunnelling effect in tunnel diode using I-V characteristics.
6) To determine the absorption lines in the rotational spectrum of Iodine vapour.

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

(Minor)
Credit: 3 (Th.) +1 (Lab.)

MN-6 (Theory): Classical mechanics (3 Credits)

1. Constrained motion:

Historical background, Limitation of Newtonian mechanics, Constraints and their classification (Scleronomic or Rheonomic, Holonomic or Nonholonomic, Conservative or Dissipative, Bilateral or Unilateral), Properties of constraints, Examples of constraints. Virtual displacement, Virtual work, Principle of virtual work, D'Alembert's principle, Application of D'Alembert's principle. **(15 Lectures)**

2. Lagrangian formulation:

Introduction, Degrees of freedom, Generalized coordinates, Lagrange' s equation of motion, Lagrangian of a system, Linear generalized potential, Generalized momentum and energy, Cyclic or ignorable coordinates, Integrals of motion, Simple applications of Lagrange's equation Linear harmonic oscillator, Simple pendulum, Central force problem. **(15 Lectures)**

3.Hamiltonian-Mechanics:
Introduction, Configuration space, phase space and state space, Legendre's dual transformation, Hamiltonian of a system and Hamilton's equation of motion, Properties of Hamiltonian, Applications in simple cases, Comparison between Lagrangian and Hamiltonian Mechanics. **(15 Lecture)**

Reference Books:

1. Classical Mechanics–J. Goldstein (Narosa Publishing House).
2. Theoretical Mechanics-M. R. Spiegel, (Schaum's Outline Series) (McGraw-Hil
3. Mechanics-K.R. Symon (Addison-Wesley).
4. Introduction to Classical Mechanics- R. G. Takwale and P.S. Puranik (Tata McGraw Hil).
5. Classical Mechanics–N.C.Rana and P.S.Joag (Tata McGraw-Hil).

MN-6 (Lab): Classical mechanics Lab (1 Credit)

List of practical's:

1. To determine the moment of inertia of fly-wheel
2. To determine the Moment of Inertia of a metallic cylinder/rectangular bar about an axis passing through the C.G.
3. To determine the modulus of rigidity of material of a given wire by dynamical method using Maxwell needle.
4. To determine the Young's Modulus of a Wire by Searle's Method.
5. To determine the rigidity modulas of given wire by dynamical method.

-------------------Up to 6th Semester--------------------