ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

Subject Code Format:

A1	A2	B3	C4	C5	C6
School/ Dept. (Offering)		**Level**	**0:** AC	**Serial Number (01 to 99)**	
BH: Basic Sciences and Humanities		**1:** UG/ Int. Msc. **(**1st Year**)**	**1:** PC	01/ 03/…/ 19: Odd Sem. **(**CHEM**)**	
CS: Computer Sciences		**2:** UG/ Int. Msc. **(**2nd Year**)**	**2:** PE	21/ 23/…/ 39: Odd Sem. **(**HUM**)**	
EE: Electrical Sciences		**3:** UG/ Int. Msc. **(**3rd Year**)**	**3:** OE	41/ 43/…/ 59: Odd Sem. **(**MATH**)**	
EI: Electronic Sciences		**4:** UG/ Int. Msc. **(**4th Year**)**	**4:** MC	61/ 63/…/ 79: Odd Sem. **(**PHY**)**	
IP: Infrastructure and Planning		**5:** UG/ Int. Msc. **(**5th Year**)**	**5:** LC	81/ 83/…/ 99: Odd Sem. **()**	
MS: Mechanical Sciences		**6:** PG **(**1st Year**)**	**6:** PR		
BT: Biotechnology		**7:** PG **(**2nd Year**)**	**7:** SE	02/ 04/…/ 20: Even Sem. **(**CHEM**)**	
TE: Textile Engineering		**8:** Ph.D.	**8:**	22/ 24/…/ 40: Even Sem. **(**HUM**)**	
			9:	42/ 44/…/ 60: Even Sem. **(**MATH**)**	
				62/ 64/…/ 80: Even Sem. **(**PHY**)**	
				82/ 84/…/ 98: Even Sem. **()**	

Abbreviation used:

I:	Integrated Program	PC:	Professional Core	SE:	Seminar
P:	Postgraduate Program	PE:	Professional Elective	L:	Lecture
GE:	Generic Elective/ Interdisciplinary	CC:	Core Course	T:	Tutorial
AECC:	Ability Enhancement Compulsory Course	CE:	Core Elective	P:	Practical
SEC:	Skill Enhancement Course	OE:	Open Elective	PH:	Physics
DSE:	Discipline Specific Elective	MC:	Mandatory Course	CY:	Chemistry
IA*:	Internal Assessment	LC:	Lab Course	MH:	Mathematics
EA:	End-Semester Assessment	AC:	Audit course	HS:	Humanities
PA:	Practical Assessment	PR:	Project	CS:	Computer Science

1st SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
AECC-1	BH1431	English For Communication	2	0	0	2	40	60	-	100
AECC-1 Lab	BH1531	English For Communication Laboratory	0	0	2	1	-	-	100	100
SEC-1	CS1481	Fundamentals Of Computers And Programming In C	3	0	0	3	40	60	-	100
SEC Lab-1	CS1581	Programming In C Laboratory	0	0	2	1	-	-	100	100
GE-1	BH1311	Chemistry-I	3	0	0	3	40	60	-	100
GE Lab-1	BH1511	Chemistry Laboratory-I	0	0	3	1	-	-	100	100
GE-2	BH1341	Mathematics-I	2	1	0	3	40	60	-	100
PC-1	BH1161	Classical Mechanics And Special Theory Of Relativity	4	0	0	4	40	60	-	100
PC Lab-1	BH1565	Mechanics Laboratory-I	0	0	3	2	-	-	100	100
PC-2	BH1163	Mathematical Physics-I	4	0	0	4	40	60	-	100
PC Lab-2	BH1563	Mathematical Physics Laboratory-I	0	0	3	2	-	-	100	100
		Total credit	**18**	**1**	**13**	**26**	**240**	**360**	**500**	**1100**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

2nd SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
AECC-2	BH1432	Communication In Practice	2	0	0	2	40	60	-	100
AECC Lab-2	BH1532	Communication In Practice Laboratory	0	0	2	1	-	-	100	100
SEC-2	CS1482	Oops Using C++	3	0	0	3	40	60	-	100
SEC Lab-2	CS1582	Oops Using C++ Laboratory	0	0	2	1	-	-	100	100
GE-3	BH1312	Chemistry-II	3	0	0	3	40	60	-	100
GE Lab-3	BH1512	Chemistry Laboratory-II	0	0	3	1	-	-	100	100
GE-4	BH1342	Mathematics-II	2	1	0	3	40	60	-	100
PC-3	BH1162	Electricity And Magnetism	4	0	0	4	40	60	-	100
PC Lab-3	BH1562	Electricity And Magnetism Laboratory	0	0	3	2	-	-	100	100
PC-4	BH1164	Wave And Optics	4	0	0	4	40	60	-	100
PC Lab-4	BH1564	Wave And Optics Laboratory	0	0	3	2	-	-	100	100
		Total credit	**18**	**1**	**13**	**26**	**240**	**360**	**500**	**1100**

3rd SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
GE-5	BH2311	Chemistry-III	3	0	0	3	40	60	-	100
GE Lab-5	BH2511	Chemistry Laboratory-III	0	0	3	1	-	-	100	100
GE-6	BH2341	Mathematics-III	2	1	0	3	40	60	-	100
PC-5	BH2161	Thermal Physics And Properties Of Matter	4	0	0	4	40	60	-	100
PC Lab-5	BH2561	Thermal Physics And Properties Of Matter Laboratory	0	0	3	2	-	-	100	100
PC-6	BH2163	Analog System And Application	4	0	0	4	40	60	-	100
PC Lab-6	BH2563	Analog System Laboratory	0	0	3	2	-	-	100	100
PC-7	BH2165	Mathematical Physics -II	4	0	0	4	40	60	-	100
PC Lab-7	BH2565	Mathematical Physics Laboratory-II	0	0	3	2	-	-	100	100
		Total credit	**17**	**1**	**12**	**25**	**200**	**300**	**400**	**900**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

4th SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
AECC-3	BH2402	Environmental Science	2	0	0	2	40	60	-	100
SEC-3	BH2432	Organizational Behavior	2	0	0	2	40	60	-	100
GE-7	BH2342	Mathematics-IV	2	1	0	3	40	60	-	100
PC-8	BH2162	Elements Of Modern Physics	4	0	0	4	40	60	-	100
PC Lab-8	BH2562	Modern Physics Laboratory	0	0	3	2	-	-	100	100
PC-9	BH2164	Digital System And Application	4	0	0	4	40	60	-	100
PC Lab-9	BH2564	Digital System Laboratory	0	0	3	2	-	-	100	100
PC-10	BH2166	Mathematical Physics-III	4	0	0	4	40	60	-	100
PC Lab-10	BH2566	Mathematical Physics Laboratory-III	0	0	3	2	-	-	100	100
		Total credit	**18**	**1**	**9**	**25**	**240**	**360**	**300**	**900**

5th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-11	BH3161	Quantum Mechanics And Application	4	0	0	4	40	60	-	100
PC Lab-11	BH3561	Quantum Mechanics Laboratory	0	0	3	2	-	-	100	100
PC-12	BH3163	Solid State Physics	4	0	0	4	40	60	-	100
PC Lab-12	BH3563	Solid State Physics Laboratory	0	0	3	2	-	-	100	100
DSE-1	BH3261 / BH3263	Advanced Mathematical Physics / Communication System	4	0	0	4	40	60	-	100
DSE Lab-1	BH3565 / BH3567	Advanced Mathematical Physics Laboratory / Communication System Laboratory	0	0	3	2	-	-	100	100
DSE-2	BH3265 / BH3267	Fluid Mechanics / Applied Dynamics	4	0	0	4	40	60	-	100
DSE Lab-2	BH3569 / BH3571	Fluid Mechanics Laboratory / Applied Dynamics Laboratory	0	0	3	2	-	-	100	100
		Total credit	**16**	**0**	**12**	**24**	**160**	**240**	**400**	**800**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

6th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-13	BH3162	Electromagnetic Theory	4	0	0	4	40	60	-	100
PC Lab-13	BH3562	Electromagnetic Laboratory	0	0	3	2	-	-	100	100
PC-14	BH3164	Statistical Mechanics	4	0	0	4	40	60	-	100
PC Lab-14	BH3564	Statistical Mechanics Laboratory	0	0	3	2	-	-	100	100
DSE-3	BH3262 / BH3264 / BH3266	Introduction To Nuclear And Particle Physics / Physics Of Devices And Communication / Embedded Systems - Introduction To Microcontroller	4	0	0	4	40	60	-	100
DSE Lab-3	BH3566 / BH3568 / BH3570	Introduction To Nuclear And Particle Physics Laboratory / Physics Of Devices And Communication Laboratory / Embedded Systems - Introduction To Microcontroller Laboratory	0	0	3	2	-	-	100	100
DSE-4	BH3268 / BH3270	Measurement Techniques / Dissertation	4	0	0	4	40	60	-	100
DSE Lab-4	BH3572 / BH3574	Measurement Techniques Laboratory / Dissertation	0	0	3	2	-	-	100	100
		Total credit	**16**	**0**	**12**	**24**	**160**	**240**	**400**	**800**

7th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-15	BH4161	Classical Mechanics	4	0	0	4	40	60	-	100
PC-16	BH4163	Mathematical Methods In Physics	4	0	0	4	40	60	-	100
PC-17	BH4165	Quantum Mechanics-I	4	0	0	4	40	60	-	100
PC-18	BH4167	Electrodynamics	4	0	0	4	40	60	-	100
PC Lab-15	BH4561	General Physics Laboratory	0	0	3	1.5	-	-	100	100
PE	BH4461	Research Methodology	0	0	3	2	40	60	-	100
OE Lab	CS4581	Advanced Computational Physics Laboratory	0	0	3	1.5	-	-	100	100
		Total credit	**16**	**0**	**9**	**21**	**200**	**300**	**200**	**700**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

8th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-19	BH4162	Statistical Mechanics	3	0	0	3	40	60	-	100
PC-20	BH4164	Physics Of Semiconductor Devices	4	0	0	4	40	60	-	100
PC-21	BH4166	Quantum Mechanics-II	4	0	0	4	40	60	-	100
PC-22	BH4168	Experimental Techniques	3	0	0	3	40	60	-	100
PC-23	BH4170	Electronics	3	0	0	3	40	60	-	100
PC Lab-16	BH4562	Electromagnetic And Optics Lab	0	0	3	1.5	-	-	100	100
PC Lab-17	BH4564	Basic Electronics Laboratory	0	0	3	1.5	-	-	100	100
		Total credit	**17**	**0**	**6**	**20**	**200**	**300**	**200**	**700**

9th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-24	BH5161	Advanced Quantum Mechanics And Quantum Field Theory	4	0	0	4	40	60	-	100
PC-25	BH5163	Nuclear And Particle Physics	4	0	0	4	40	60	-	100
PC-26	BH5165	Basic Condensed Matter Physics	4	0	0	4	40	60	-	100
PC-27	BH5167	Nano Science And Technology	3	0	0	3	40	60	-	100
SEMINAR	BH5761	Literature Review And Seminar	0	0	4	2	-	-	100	100
PC Lab-18	BH5561	Advanced Electronics Laboratory	0	0	3	1.5	-	-	100	100
PC Lab-19	BH5563	Basic Condensed Matter Physics Lab	0	0	3	1.5	-	-	100	100
		Total credit	**15**	**0**	**10**	**20**	**160**	**240**	**300**	**700**

10th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-28	BH5162	Atomic And Molecular Physics	3	0	0	3	40	60	-	100
PE-1	BH5262 / BH5264	Advanced Condensed Matter Physics / Advanced Particle Physics	4	0	0	4	40	60	-	100
PE-2	BH5266 / BH5268	Vacuum Technology And Cryogenics / Material Science	3	0	0	3	40	60	-	100
PROJECT	BH5662	Project	0	0	6	6	-	-	100	100
PC Lab-20	BH5562	Modern Physics Laboratory	0	0	3	1.5	-	-	100	100
PE Lab-1	BH5564 / BH5566	Advanced Condensed Matter Physics Laboratory / Advanced Particle Physics Laboratory	0	0	3	1.5	-	-	100	100
		Total credit	**10**	**0**	**12**	**19**	**120**	**180**	**300**	**600**

FIRST SEMESTER

Classical Mechanics and Special Theory of Relativity

Marks-100

Course Objective:

This course enables the student

- To emphasize the understanding of Classical Mechanics using the Lagrangian and Hamiltonian Approaches.
- To introduce the necessity of Special Theory of Relativity.

Course Outcome:

Students learn about the motion of a particle.

1. Determine the various Four vectors: position, velocity, acceleration, momentum, Force etc.
2. Identify the motion of a mechanical system using Lagrange-Hamilton formalism.
3. Apply the formalism of Lagrangian and Hamiltonian in generating equations of motion for complicated mechanical systems of classical mechanics.
4. Compare Lagrangian and Hamiltonian formalism, Galilean and Lorentz transformation and various reference frames.
5. Apply the theory of relativity to determine time dilation, length contraction and simultaneity,

MODULE-I

(7 hours)

Newtonian Mechanics

Mechanics of a Particle: Conservation of linear momentum, Conservation of angular momentum, Conservation of energy. Mechanics of a System of Particles: External and internal forces, Centre of mass, conservation of linear momentum, Centre of mass-frame of reference, Conservation of angular momentum, Conservation of energy.

MODULE-II

(10 hours)

Lagrangian Dynamics

Constraints: Holonomic constraints, Nonholonomic constraints, Forces of constraints. Generalized coordinates, Principle of Virtual Work, D' Alembert's principle, Lagrangian's equation from D' Alembert's principle, Procedure for formation of Lagrange's equations, Lagrange's equation in the presence of Non-conservative forces, Generalized Potential-Lagrangian for a charged particle moving in an Electromagnetic field.

MODULE-III

(13 hours)

Hamiltonian Dynamics

Generalized momentum and cyclic coordinates, Conservation theorems and Symmetry properties, Conservation of linear momentum, Conservation of angular momentum, Significance of translation and rotation cyclic coordinates, Hamiltonian function and conservation of energy: Jacobi's Integral, Hamiltonian's equations, Hamiltonian's equations in different coordinate systems, Examples in Hamiltonian's Dynamics: Harmonic oscillator, Motion of a particle in a central force field, Charged particle moving in an electromagnetic field, Compound pendulum, Two-dimensional harmonic oscillator, Routhain.

MODULE-IV

(10 hours)

Special Theory of Relativity

Galilean Transformations, Principle of relativity, Transformation of force from one Inertial system to another, the covariance of the physical laws, Principle of relativity and speed of light, The Michelson-Morley Experiments, Ether hypothesis, Postulates of the special theory of relativity, Lorentz transformation, Consequence of Lorentz transformation, Velocity Addition.

Text Books:

- Introduction to Classical Mechanics: D. Morin, Cambridge.
- Classical Mechanics: R.D. Gregory, Cambridge.
- Classical Mechanics: J.C. Upadhyaya, Himalaya Publishing House.

Mathematical Physics-I

Marks: 100

Course Objective:

This course enables the student

- To introduce the students to understand the physical meaning of different mathematical methods
- Highlights the use of computational methods to solve physical problems.

Course Outcome:

After completing the course students will / on completion of the course, the students shall be able to:

1. Acquire knowledge of methods for ordinary differential equations and solve partial differential equations.
2. Able to understand the mathematical and physical interpretation of vector calculus.
3. Able to handle different coordinate systems, the general coordinate transformation and the relevant transformation equations.
4. Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries.
5. Learn the Dirac delta function and its properties, which have applications in various branches of Physics, especially quantum mechanics.
6. Understand vector differentiation and integration.

MODULE-I

(10 hours)

Calculus-I: Plotting of functions, Intuitive ideas of continuous, differentiable functions and plotting of curves, Approximation: Taylor and binomial series **(**statements only**)**, First Order Differential Equations and Integrating Factor, Second Order Differential equations: Homogeneous Equations with constant coefficients, Statement of existence and Uniqueness Theorem for Initial Value Problems, Particular Integral.

MODULE-II

(10 hours)

Calculus-II: Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with a simple illustration, Constrained Maximization using Lagrange Multipliers,

Vector algebra: 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.

MODULE-III

(10 hours)

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems, Comparison of velocity and acceleration in the cylindrical and spherical coordinate system

Dirac Delta function and its properties: Definition of Dirac delta function. Representation as the limit of a Gaussian function and rectangular Function, Properties of Dirac delta function.

MODULE-IV

(10 hours)

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: Ordinary Integrals of Vectors, Multiple integrals, Jacobian, Notion of infinitesimal line, surface and volume elements, Line, surface and volume integrals of Vector fields, Flux of a vector field, Gauss' divergence theorem, Green's and Stokes Theorems and their applications **(**no rigorous proofs**)**

Text Books:

- Mathematical Methods for Physicists: G.B.Arfken, H.J.Weber, F.E.Harris **(**2013, 7th Edn., Elsevier**)**.
- Advanced Engineering Mathematics: E. Kreyszig **(**Wiley India**).**

Reference Books:

- Mathematical Physics: C. Harper **(**Prentice Hall India**).**
- Complex Variable: Schaum's Outlines Series: M. Spiegel **(**2nd Edition, Mc-Graw Hill Education**)**.
- Complex variables and applications, J. W. Brown and R.V.Churchill.
- Mathematical Physics: Satya Prakash **(**Sultan Chand**)**.
- Mathematical Physics: B. D. Gupta **(**4th edition, Vikas Publication**)**.
- Mathematical Physics and Special Relativity: M. Das, P.K. Jena and B.K.Dash **(**Srikrishna Prakashan**)**.
- Mathematical Physics: H.K.Dass, Dr. Rama Verma **(**S. Chand Publishing**)**.

Mechanics Laboratory-I

Marks-100

Course Objective:

This course enables the student

- To introduce different Experiments to test the basic understanding of physics concepts.
- To learn different techniques to determine some physical quantities associated with mechanical properties of materials like surface tension, coefficient of viscosity of any liquid, moment of inertia of an object, spring constant, elastic constants, gravitational acceleration etc.

Course Outcome:

1. The hands-on exercises undergone by the students will help them to apply physics principles.
2. The students will learn how to determine physical quantities experimentally like surface tension, coefficient of viscosity, the moment of inertia, and elastic constants etc.

Experiments List:

1. Determination of accurate weight of a body using balance by Gauss method.
2. Error analysis using Vernier calliper, screw gauge and spherometer.
3. Determination of velocity of sound by resonance column method.
4. To determine the acceleration due to gravity by bar pendulum and study the effect of amplitude on time period.
5. To determine the acceleration due to gravity by Kater's pendulum.
6. Verification of laws of vibration of string using sonometer.
7. Determination of Young's modulus of wire by Searle's method.
8. Determination of rigidity modulus of a rod by static method.
9. Determination of surface tension of water by using the capillary rise method.
10. Determination of specific heat of solid/liquid applying radiation correction.
11. To study the velocity of sound by Kundt's tube.
12. To determine the moment of inertia of a flywheel about its axis of rotation.
13. To determine Young's modulus of a wire using the optical lever method.

Mathematical Physics Laboratory-I

Marks: 100

Course Objective:

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

- Highlights the use of computational methods to solve physical problems
- The course will consist of lectures **(**both theory and practical**)** in the Lab
- The evaluation did not on the programming but on formulating the problem
- Aim at teaching students to construct the computational problem to be solved
- Students can use anyone operating system Linux or Microsoft Windows

Introduction and Overview: Computer architecture and organization, memory and Input/output devices.

Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow emphasize the importance of making equations in terms of dimensionless variables and iterative methods. Algorithm **Errors and error Analysis:** Truncation and round-off errors, Absolute and relative errors, Floating-point computations. Systematic and Random Errors, Propagation of Errors, Normal Law of Errors, Standard and Probable Error.

Review of C and C++ Programming: Introduction to Programming, constants, variables and Fundamentals data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements **(**decision making and looping statements**) (**If Statement, If else Statement, Nested If structure, Else If Statement, Ternary operator, Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops**)**, Arrays **(**1D and 2D**)** and strings, user-defined functions, Structures and Unions, Ideas of classes and objects

Programs: Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search

Random number generation: Area of a circle, area of the square, the volume of the sphere, value of π.

Reference Books:

- Introduction to Numerical Analysis: S.S. Sastry, 5th Edn. (2012) PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C++: J.Hubbard (2000) McGraw-HillPub.
- Numerical Recipes in C: The Art of Scientific Computing: W.H. Pressetal, 3rd Edn. (2007) Cambridge University Press.
- The first course in Numerical Methods: U.M. Ascher and C. Greif (2012) PHI Learning.
- Elementary Numerical Analysis: K.E. Atkinson, 3rd Edn. (2007) Wiley India Edition.
- Numerical Methods for Scientists and Engineers: R.W. Hamming (1973) Courier Dover Pub.
- An Introduction to Computational Physics, T.Pang, 2nd Edn., 2006, Cambridge Univ. Press.

Mathematics-I

Marks-100

Course Objective:

- Identify essential characteristics of ordinary differential equations.
- Develop essential methods of obtaining closed form solutions numerical solutions.
- Explore the use of differential equations as models in various applications.
- Explore the use of series methods to solve problems with variable coefficients.
- Explore methods of solving initial value problems by transform methods.

Course Outcome:

After the successful completion of this course, the students will be able to

1. know different kinds of ordinary differential equations of first order and first degree, first order and higher degree and find their solutions using the methods discussed.
2. recognize linear differential equations of higher order with constant coefficients and variable coefficients and solve the problems using the methods provided.
3. have knowledge on existence and uniqueness of solutions of an initial value problem; learn series solution of differential equations about regular points and singular points.
4. have knowledge on specific polynomials and functions (Legendre's polynomial and Bessel's function) and their properties; know how to solve Strum-Liouville problems.

MODULE-I

(10 hours)

Basic Concepts of Differential Equation: Origin and Classification of Differential equation, Solution of Differential Equation, Kinds of solution, Initial and Boundary value problem, Existence and uniqueness of solution, Formation of Differential equation. First Order First Degree Equation: Variable separable, Homogenous Equation, Exact Differential equation, Integrating Factors, Linear equations, Equation reducible to linear form. Equations of First order but of Higher Degree: Equations solvable for p, Equation solvable for y, Equation solvable for x,

MODULE-II

(10 hours)

Linear Equations with Constant coefficient: Linear differential equation of nth order, Homogenous Linear equation with constant coefficient, Non- Homogenous Linear equation with constant coefficient, Operators and its use to solve linear differential equations with constant coefficient, Method of Variation of Parameter, Linear Differential Equation with variable coefficient: Method of reduction of order, method based on the removal of the first derivatives. Existence and Uniqueness of solution: Picard's method of successive Approximation, Existence and uniqueness Theorem.

MODULE-III

(10 hours)

Series Solution and special function: Power series, Radius of convergence of power series, Ordinary point, singular point and regular singular point(only definition), Series solution about an ordinary point, Legendre equation and Legendre polynomial, Orthogonality, Power series method about singular point, Bessel 's equation and Bessel's function, Orthogonality in Bessel function. Boundary value problem for Ordinary Differential Equation; Sturm –Liouville Problems.

Text Books:

- A Course on Ordinary and Partial Differential Equation: J. Sinha Roy, S Padhy, Kalyani Publisher. Chapters: 1 **(**1.1-1.4**)**, 2 **(**2.1-2.7**)**, 3 **(**3.1-3.4**)**, 4 **(**4.1-4.6**)**, 6 **(**6.1, -6.3**)**, 7 **(**7.1, 7.2, 7.3.1, 7.4.1**))**, 10 **(**10.1, 10.2**)**.

Reference Books:

- Ordinary Differential Equation: P C Biswal **(**Pub-PHI**)**.

Chemistry-I

Marks-100

Course Objective:

- To make aware about comparison study of different properties of solid, liquid and gas.
- Students can predict atomic structure, chemical bonding or molecular geometry based on accepted models.
- To provide ideas on the properties of atoms in a systematic manner.

Course Outcome:

Students can

1. Know the critical phenomenon
2. Analyse the packing of atoms in solids
3. Know about the behaviour of subatomic particles
4. Know the types of attraction between the atoms in molecules

MODULE-I

(10 hours)

States of Matter: Gaseous state:

Postulates of Kinetic theory of gases, derivation from ideal behavior, van der Wall's equation of state. Critical phenomena: PV isotherm of real gases, continuity of states, the isotherms of van der Wall's equation, the relationship between Van Der Waals constant and critical constants, the law of corresponding states, reduced equation of state.

Liquid state:

Intermolecular forces, the structure of liquids **(**qualitative description**)**, liquid crystals: the difference between liquid crystal, solid and liquid.

Solid state:

space lattice and unit cell. Qualitative description of X-ray diffraction in crystals. Derivation of Bragg's equation.

MODULE-II

(10 hours)

Atomic structure:

de-Broglie matter waves, Uncertainty principle, Schrodinger wave equation, quantum numbers and their significance, the shape of s, p, d orbitals, and electronic configuration of elements.

Periodic properties:

Screening effect, effective nuclear charge, size of atoms and ions, ionization potential, electron affinity, electronegativity, variable valency and oxidation states, horizontal, vertical and diagonal relationship.

MODULE-III

(10 hours)

Chemical bonding:

Ionic bond, polarizability, Fajan's rule, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic compounds, Covalent bond: Lewis theory, dipole moment and its application, percentage ionic character from dipole moment and electronegativity, VBT, hybridization, VSEPR theory, MOT **(**homo and heteronuclear diatomic molecule**)**, Resonance Metallic bond **(**free electron and band theories**)** H-bond, Vanderwaals force.

Reference Books:

- Concise Inorganic Chemistry: J.D. Lee, Wiley India, 5th Edn. (2008).
- Inorganic Chemistry Principle, Structure and Reactivity, J.E. Huheey, E.A. Keiter and R.L. Keiter, Harper Collins College, 4thEdn., 1997.
- Inorganic Chemistry: R.D. Madan, S. Chand, 4thEdn. (1987).
- Principles of Physical Chemistry: B.R. Puri, L.R. Sharma & M.S. Pathania, Vishal Publishing Co, 47th Edn. (2017).

Chemistry-I Laboratory

Marks-100

Course Objective:

- The students will know the theoretical basis of qualitative inorganic analysis containing common and less common ions.
- To carry out simple experiments to study the kinetics of reactions

Course Outcome:

1. The student will gain laboratory skills in qualitative analysis of different acids and basic radicals.

Experiments List:

I. Qualitative analysis of the mixture of inorganic substances containing four ions **(**including anions like phosphate, and fluoride and the mixture of anions like carbonate, sulfite, sulfide, nitrate, chloride, bromide, phosphate, arsenate, nitrate, iodate and sulfate and cations of qualitative groups I, II, III, IV, V and VI**)**

II. Kinetics Experiment:

1. To determine the specific reaction rates of acid hydrolysis of the esters at room temp.
2. To study the effect of acid strength on hydrolysis of the esters
3. To study kinetically the reaction rate of iodide-H_2O_2 reaction

III. Distributive Law Experiment:

1. To study the distribution of iodine between water and CCl_4
2. To study the distribution of benzoic acid between water and benzene.

English for Communication

Marks: 100

Course Objective:

- To introduce engineering students to the theory and practice of communication.
- To equip them with both theoretical vocabulary and basic tools that will help them develop as better communicators.
- To initiate them to select literary texts and establish how these texts contribute to the afore-mentioned objectives.

Course Outcome:

1. Usage of communication theory and practice is developed.
2. They are able to develop various tools for comprehension for the purpose of communication (speaking and writing).
3. Are able to use various texts including literary for proper writing and communication purposes.
4. Communicative applicability and technical writing is developed.

MODULE-I

Introduction to Communication: **(8 hours)**

1.1 Importance of Communication in English **(**1 hour**)**
1.2 The process of communication and factors that influence the process of communication: Sender, receiver, channel, code, topic, message, context, feedback, 'noise'. **(**2 hours**)**
1.3 Principles of Communication. **(**1hour**)**
1.4 Barriers to Communication & Communication Apprehension **(**1 hour**)**
1.5 Verbal **(**Spoken and Written**)** and non-verbal communication, Body language and its importance in communication. **(**3 hours**)**

MODULE-II

Phonetics and Functional Grammar **(7 hours)**

2.1 Sounds of English: Vowels **(**Monophthongs and Diphthongs**)**, Consonants **(**1 hour**)**
2.2 Syllable division, stress **(**word, contrastive stress**)** & intonation **(**1 hour**)**
2.3 MTI and problem sounds **(**1 hour**)**
2.4 Review of Parts of Speech **(**2 hours**)**
2.5 Subject and Predicate, Tense, Voice Change **(**1 hour**)**
2.6 Idioms and Phrasal Verbs **(**1 hour**)**

(Note: This unit should be taught in a simple, non-technical, application-oriented manner, avoiding technical terms as far as possible.**)**

MODULE-III

Reading Literature **(5 hours)**

Prose:

i) Stephen Leacock: My Financial Career
ii) Mahatma Gandhi: from My Experiments with Truth.
iii) O'Henry: The Last Leaf

Poetry:

i) Nissim Ezekiel: Professor
ii) Jack Prelutsky: Be glad your nose is on your face.
iii) Maya Angelou: Still I rise **(**Abridged**)**

Reference Books:

- Technical Communication: P.V. Anderson,, Cengage Learning (2014).
- A Communicative Grammar of English, G. Leech and J. Swartik (2003).
- Better English Pronunciation: J.D. O'Connor, Cambridge University Press (1980).
- English Grammar and Composition: P.C. Wren & H. Martin, S.Chand (1995).

English for Communication Laboratory

Marks-100

Course Objective:

- The laboratory experience for this course aims at acquainting the learners with their strengths and weaknesses in expressing themselves, their interests and academic habits.
- To improve their skills of LSRW **(**Listening, Speaking, Reading and Writing**)** through mutual conversation and activities related to these skills.
- To promote the creative and imaginative faculty of the students through practice before the teacher-trainer.

Course Outcome:

1. Is able to express themselves in all situations including personal and professional.
2. The LSRW (Listening, Speaking, Reading and Writing) skills are improved and utilized.
3. The creative and imaginative faculty is brushed.
4. Develops professional writing skills.

There will be 10 sessions of 2 hours each. Lab sessions will give a platform for the students to indulge in activities based on the first two modules of theory taught in the class room. All the lab classes will be divided in such a manner that all four aspects of language **(**LSRW**)** are covered.

Ist session:

Speaking: Ice-breaking and Introducing each other **(**1 hour**)**, Writing: Happiest and saddest moment of my life **(**1 Hour**)**

IInd session:

Listening: Listening practice **(**ear-training**)**: News clips, Movie clips, Presentations, Lecture or speech by a speaker **(**1 Hour**)**, Speaking: Debate **(**1 Hour**)**

IIIrd session:

Reading: Reading comprehension **(**1 Hour**)**, Writing: Creative writing **(**Short story: Hints to be given by the teacher**) (**1 Hour**)**

IVth session:

Reading: Topics of General awareness, Common errors in English usage **(**1 Hour**)**, Writing: Construction of different types of sentences **(**1 Hour**)**

Vth session:

Speaking: Practice of vowel and consonant sounds **(**1 Hour**)**, Writing: Practice of syllable division **(**1 Hour**)**

VIth session:

Speaking: My experience in the college/ or any other topic as per the convenience of the student **(**1 Hour**)**, Writing: Phonemic transcription practice **(**1 Hour**)**

VIIth session:

Listening: Practice phonetics through the ISIL system and also with the help of a dictionary **(**1 hour**)**, Speaking: Role-play in groups **(**1 Hour**)**

VIIIth session:

Speaking: Practice sessions on Stress and Intonation **(**1 hour**)**, Writing: Practice sessions on Grammar **(**Tense and voice change**) (**1 Hour**)**

IXth session:

Speaking: Extempore, **(**1 Hour**)**, Writing: Framing sentences using phrasal verbs and idioms **(**1 Hour**)**.

Xth session:

Watching a short English movie **(**1 Hour**)**, Writing: Critical analysis of the movie **(**1 Hour**)**.

Reference Books:

- English Language Communication Skills: Lab Manual Cum Workbook: Cengage Learning (2014).

Note: 70 marks will be devoted to sessions, 10 marks for record submission, 10 marks for viva voce and 10 marks for project work.

End-term assignment: Students are required to make a project report of at least 5 pages on a topic on the following broad streams: Technology, General awareness, Gender, Environment, Cinema, Books and the like. The assignment should involve data collection, analysis and reporting.

Fundamentals of Computers and Programming in C

Marks-100

Course Objective:

- Develop a greater understanding of the issues involved in programming language design and implementation
- Develop an in-depth understanding of functional, logic, and object-oriented programming paradigms
- Implement several programs in languages other than the one emphasized in the core curriculum
- Understand design/implementation issues involved with variable allocation and binding, control flow, types, subroutines, parameter passing
- Develop an understanding of the compilation process

MODULE-I

(10 hours)

Digital Logic Fundamentals:
Logic Gates, Introduction to Multiplexer, Demultiplexer, Encoder, Decoder & Flip-Flops.
Introduction to Computer Fundamentals:
The basic architecture of computers, Functional Units, Operational concepts, Bus structures, Von Neumann Concept. Instruction code, Instruction set, Instruction sequencing, Instruction cycle, Instruction format, addressing modes, Micro instruction, Data path, Hardwired controlled **MODULE-**, Micro programmed controlled **MODULE-**. Generation of Programming languages, Compiler, Linker, Loader

MODULE-II

(10 hours)

C language fundamentals:
Character set, Keywords, Identifiers, data types, constants and Variables, Statements, Expressions, Operators, Precedence and associativity of operators, Side effects, Type conversion, Managing input and output
Control structures:
Decision-making, branching and looping.
Arrays:
one-dimensional, multidimensional array and their applications, Declaration, storage and manipulation of arrays
Strings:
String variable, String handling functions, Array of strings
Functions:
Designing structured programs, Functions in C, Formal vs. actual arguments, Function category, Function prototype, Parameter passing, and Recursive functions.
Storage classes:
Auto, Extern, register and static variables

MODULE-III

(10 hours)

Pointers:
Pointer variable and its importance, pointer arithmetic and scale factor, Compatibility, Dereferencing, L-value and R-value, Pointers and arrays, Pointer and character strings, Pointers and functions, Array of pointers, pointers to pointers, Dynamic memory allocation
Structure and union:
declaration and initialization of structures, Structure as function parameters, Structure pointers, and Unions.
File Management:
Defining and opening a file, Closing a file, Input/output Operations in files, Random Access to files, Error handling
Text Books:

- "Computer Organization and Architecture": W. Stalling, Pearson Education.
- "C Programming": E. Balagurusamy, Tata McGraw-Hill.

Reference Books:

- "Computer Architecture and Organization": J. P. Hayes, McGraw Hill Education India.
- "C the complete Reference": H. Schildt, McGraw-Hill.
- "Mastering C": K.R. Venugopal, S.R. Prasad, McGraw-Hill Education India.

Programming in C Laboratory

Marks-100

Experiments List:

Experiment No. 1

a) Write a C program to find the sum of individual digits of a positive integer.
b) A Fibonacci sequence is defined as follows: the first and second terms in the sequence are 0 and 1. Subsequent terms are found by adding the preceding two terms in the sequence. Write a C program to generate the first n terms of the sequence.
c) Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user.

Experiment No. 2

a**)** Write a C program to calculate the following Sum:
Sum=1-x2
/2! +x4
/4!-x6
/6!+x8
/8!-x10/10!
b**)** Write a C program to find the roots of a quadratic equation.

Experiment No. 3

a**)** Write C programs that use both recursive and non-recursive functions
i**)** To find the factorial of a given integer.
ii**)** To find the GCD **(**greatest common divisor**)** of two given integers.
iii**)** To solve the Towers of Hanoi problem.

Experiment No. 4

a**)** Write a C program to find both the largest and smallest number in a list of integers.
b**)** Write a C program that uses functions to perform the following:
i**)** Addition of Two Matrices
ii**)** Multiplication of Two Matrices

Experiment No. 5

a**)** Write a C program that uses functions to perform the following operations:
i**)** To insert a substring into to given main string from a given position.
ii**)** To delete n Characters from a given position in a given string.
b**)** Write a C program to determine if the given string is a palindrome or not

Experiment No. 6

a**)** Write a C program to construct a pyramid of numbers.
b**)** Write a C program to count the lines, words and characters in a given text.

Experiment No.7

a**)** Write a C program that uses functions to perform the following operations:
i**)** Reading a complex number
ii**)** Writing a complex number
iii**)** Addition of two complex numbers
iv**)** Multiplication of two complex numbers
(Note: represent complex numbers using a structure.**)**

Experiment No. 8

a**)** Write a C program that copies one file to another.
b**)** Write a C program to reverse the first n characters in a file.
(Note: The file name and n are specified on the command line.**)**

Reference Books:

- Project Using C: P.V.N. Varalakshmi, Scitech Publish.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

SECOND SEMESTER

Electricity and Magnetism

Marks: 100

Course Objective:

- To impart knowledge on the concepts of electrostatics, magnetostatics and Maxwell's electromagnetic theory.
- To understand and apply KVL and KCL.

Course Outcome:

1. To understand and apply fundamental laws of electricity and able to calculate potential
2. To analyse and apply the fundamental laws of Magnetism.
3. To study Maxwell equations and their applications.
4. To apply Kirchoff's voltage and current laws to electrical circuits.

MODULE-I

(10 hours)

Electric field: Electric field lines, Electric flux, Gauss Law with applications to charge distributions with spherical, cylindrical and planar symmetry, Conservative nature of Electrostatic Field. Electrostatic Potential, Potential and Electric Field of a dipole, Force and Torque on a dipole, Potential calculation in different simple cases, Laplace's and Poisson equations, and The Uniqueness Theorem.

Method of images and their application to **(**1**)** Plane Infinite Sheet and **(**2**)** Sphere. Electrostatic energy of the system of charges, Electrostatic energy of a charged sphere, Conductors in an electrostatic Field, Surface charge and force on a conductor.

MODULE-II

(10 hours)

Magnetic Field: Magnetic Force, Lorentz Force, Biot Savart's Law, Current Loop as a Magnetic Dipole and its Dipole Moment **(**analogy with Electric Dipole**)**, Ampere's Circuital Law and its application to **(**1**)** Solenoid **(**2**)** Toroid **(**3**)** Helmholtz coil,

Properties of B: curl and divergence, Vector Potential, Ballistic Galvanometer: Torque on a Current Loop, Current and Charge Sensitivity, Electromagnetic damping, Logarithmic damping, CDR.

MODULE-III

(10 hours)

Dielectric Properties of Matter: Electric Field in the 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. 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.

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, Derivation of Maxwell equation in differential form, Displacement current, Modified Ampere circuital Law, equation of continuity, Poynting Theorem.

MODULE-IV

(10 hours)

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

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. Transient Currents Growth and decay of current in RC and LR circuits.

Text Books:

- Introduction to Electrodynamics: D. J. Griffiths **(**Pearson, 4th edition, 2015**)**
- Foundations of Electromagnetic Theory: J. R. Reitz and F. J. Milford R. W. Christy **(**Pearson**)**.

Reference Books:

- Classical Electrodynamics: J. D. Jackson **(**Wiley**)**.
- Electricity and Magnetism: D. C. Tayal **(**Himalaya Publishing house**).**
- Electricity, Magnetism and Electromagnetic Theory: S. Mahajan and S. Rai Choudhury **(**Tata McGraw Hill**).**
- Feynman Lectures Vol.2: R. P. Feynman, R. B. Leighton, M. Sands **(**Pear-son**)**.
- Electricity and Magnetism: J. H. Fewkes and J. Yarwood. Vol. I **(**Oxford Univ. Press**)**.

Waves and Optics

Marks: 100

Course Objective:

- This course reviews the concepts of waves and optics from a more advanced perspective and goes on to build new concepts.
- The course also provides an in-depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Course Outcome:

1. Harmonic motion gives the knowledge of the composition of two simple harmonic motions and the construction of Lissajous figures. It also gives the true knowledge of various types of oscillations. The wave motion chapter describes the various mathematical equations of wave motion and the characteristics of various waves.
2. Fermat's Principle can be used to establish laws of reflection and refraction at spherical surfaces. The matrix method is used in refraction at spherical surfaces and thin lenses. Lens system gives the relation among various magnifications.
3. The interference chapter gives the concept of light wave and its equation, meaning of coherence, interference fringes etc.
4. The diffraction chapter explains various types of diffractions in detail, knowledge of grating and its resolving power.

MODULE-I

(10 hours)

Wave Motion: Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive **(**Traveling**)** Waves, Wave Equation, Particle and Wave Velocities, Differential Equation, Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave. Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures **(**1: 1 and 1: 2**)** and their uses, Superposition of N harmonic waves.

MODULE-II

(10 hours)

Geometrical optics: Fermat's principle, reflection and refraction at the plane interface, Matrix formulation of geometrical Optics, Cardinal points and Cardinal planes of an optical system, Idea of dispersion, Application to thick Lens and thin Lens, Ramsden and Huygens eyepiece. Wave Optics: Electromagnetic nature of light. Definition and properties of wavefront Huygens Principle. Temporal and Spatial Coherence.

MODULE-III

(10 hours)

Interference: Division of amplitude and wavefront, Young's double-slit Experiment, Lloyds Mirror and Fresnel's Bi-prism, Phase change on reflection: Stokes treatment, Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination **(**Haidinger Fringes**)**, Fringes of equal thickness **(**Fizeau Fringes**)**, Newton's Rings: Measurement of wavelength and refractive index. Interferometer: Michelson's Interferometer-**(**1**)** Idea of form of fringes **(**No theory required**)**, **(**2**)** Determination of Wavelength, **(**3**)** Wavelength Difference, **(**4**)** Refractive Index, and **(**5**)** Visibility of Fringes, Fabry-Perot interferometer.

MODULE-IV

(10 hours)

Fraunhofer diffraction: Single slit, Circular aperture, Resolving Power of a telescope, double slit, multiple slits, Diffraction grating, and Resolving power of grating. Fresnel Diffraction: Fresnels Assumptions, Fresnel's Half-Period Zones for Plane Wave, Explanation of Rectilinear Propagation of Light, and Theory of a Zone Plate: Multiple Foci of a Zone Plate, Fresnels Integral, and Fresnel diffraction pattern of a straight edge, a slit and a wire.

Text Books:

- Waves and Oscillations: N.Subrahmanyam and Brij Lal **(**S.Chand Publishing**).**
- Optics: AjoyGhatak **(**McGraw Hill**)**.

Reference Books:

- Optics: E. Hecht **(**Pearson**).**
- Fundamentals of Optics: F.A.Jenkins and H.E.White **(**McGraw-Hill**)**.
- Geometrical and Physical Optics: R.S. Longhurst **(**Orient Blackswan**)**.
- The Physics of Vibrations and Waves: H.J.Pain **(**JohnWiley**)**.
- Optics: P.K.Chakrabarty.
- Principles of Optics: Max Born and Emil Wolf **(**Pergamon Press**)**.
- The Physics of Waves and Oscillations: N.K.Bajaj **(**McGraw-Hill**)**.

Electricity and Magnetism Laboratory

Marks: 100

Course Objective:

- To learn the utility of millimeters, potentiometer and various bridges through experiments.
- To learn the network theorems and use them practically to simplify complicated networks.

Course Outcome:

1. The students will know the workings of different bridge circuits and resonance circuits to determine unknown quantities like resistance, current/ voltage, inductance, capacitance etc.
2. The students will understand the network theorems practically.

(minimum of 6 Experiments are to be done)

Experiments List:

1. Use a Multimeter for measuring **(**a**)** Resistances, **(**b**)** AC and DC Voltages, c**)** DC Current, **(**d**)** Capacitances, and **(**e**)** Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using a Potentiometer.
4. To determine an unknown Low Resistance using Carey Fosters
5. Measurement of field strength B and its variation in a solenoid **(**determine dB/dx**)**
6. To verify the Thevenin and Norton theorems.
7. To determine the self-inductance of a coil by Anderson's bridge.
8. To study the response curve of a Series LCR circuit and determine its **(**a**)** Resonant frequency, **(**b**)** Impedance at resonance, **(**c**)** Quality factor Q, and **(**d**)** Bandwidth.
9. To study the response curve of a parallel LCR circuit and determine its **(**a**)** Antiresonance frequency and **(**b**)** Quality factor Q.
10. To compare capacitance using the De Sauty's bridge

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 and Ramakrishna, 11th Ed. (2011) Kitab Mahal.
- Advanced level Physics Practicals: Michael Nelson and Jon M. Ogborn, 4th Edition. (reprinted 1985) Heinemann Educational Publishers.
- A Laboratory Manual of Physics for undergraduate classes: D.P. Khandelwal (1985) Vani Pub.

Waves and Optics Laboratory

Marks: 100

Course Objective:

- To learn the technique to determine optical parameters like refractive index, dispersive power of prism, wavelength of different light sources etc. using plane diffraction gratings.

Course Outcome:

1. The students will learn the method to find out various physical parameters that may be useful to study the properties of optical materials and sources e.g. prisms, gratings, Na light etc.

(minimum of 5 Experiments are to be done)

Experiments List:

1. To determine the frequency of an electric tuning fork by Meldes Experiment and verify the 2T law.
2. To plot the I-D curve of a prism using a Spectrometer.
3. To determine the refractive index of the Material of a prism using a sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using a mercury source.
5. To determine the wavelength of sodium light using Newton's Rings.
6. To determine the wavelength of the Na source using plane diffraction grating
7. To determine the dispersive power and resolving power of a plane diffraction grating.
8. Determination of grating element of a diffraction grating.
9. To study Lissaujous figure

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 and Ramakrishna, 11th Ed. (2011) Kitab Mahal
- Advanced level Physics Practicals: Michael Nelson and Jon M. Ogborn, 4th Edition (reprinted 1985) Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes: D. P. Khandelwal (1985) Vani

---

Mathematics-II

Marks: 100

Course Objective:

- To understand concepts of real numbers, open sets and closed sets.
- Demonstrate knowledge and understanding of sequences, their convergence conditions, limits of sequences
- Demonstrate knowledge and understanding of groups, subgroups, cosets of a subgroup, normal subgroup, quotient groups.
- To build the concept of group homomorphism and isomorphism.
- Demonstrate knowledge and understanding of permutation groups and their properties.

Course Outcome:

After the successful completion of this course, the students will be able to

1. Determine if sets are open, closed. Recognize convergent, divergent, bounded, Cauchy and monotone sequences, recognize alternating, convergent, conditionally and absolutely convergent series.
2. Determine if a function is discontinuous, continuous, or uniformly continuous.
3. Use various canonical types of groups (including cyclic groups and groups of permutations).
4. Produce rigorous proofs of propositions arising in the context of abstract algebra.

MODULE-I

(10 hours)

Bounded and unbounded sets, Infimum and Supremum of a set and their properties, Order completeness property of R, Archimedean property of R, Density of rational and irrational numbers in R.
Neighbourhood, Open set, Interior of a set, Limit point of a set, Closed set, Countable and uncountable sets, Derived set, closure of a set, Bolzano- Weierstrass theorem for sets.

MODULE-II

Sequence of real numbers, Bounded sequence, limit points of a sequence, limit interior and limit superior convergent and non-convergent sequences, Cauchy's sequence, Cauchy's general principle of convergence. Infinite series and its convergence, Test for convergence of positive term series, Comparison test, Ratio test, Cauchy's root test.

MODULE-III

Preliminary Notations, Group Theory: Algebraic structures, Groups, Some Examples of Groups, Subgroups, A Counting Principle, Cosets, Normal Subgroups and Quotient Groups,
Group Homomorphisms, Isomorphisms, Automorphisms, Permutation Groups.Ring Theory: Definition &; Example of Rings, Some Special Classes of Rings.

Text Books

- Fundamentals of Mathematical Analysis, G. Das &; S. Pattnaik, TMH
- Topics In Algebra, by I. N. Herstein, Wiley Eastern.Ch. 1, Ch. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.10, Ch. 3.1, 3.2, 3.3, 3.4

Reference Books

- Introduction to Real Analysis, R. G. Bartle and D.R. Sherbert, Wiley.4 th Edition
- Elementary Analysis: The Theory of Calculus, Under graduate Texts in Mathematics, K. A. Ross, Springer (SIE), Indian reprint, 2004.
- A course in Calculus and Real Analysis, Limaye, Undergraduate Text in Mathematics, Sudhir R Ghorpade and Balmohan V.., Springer (SIE). Indian reprint, 2004.
- Modern Algebra by A. R. Vasishtha, Krishna, PrakashanMandir, Meerut.
- Topics in Algebra by P.N.Arora, Sultan Chand &; Sons.

Chemistry-II

Marks: 100

Course Objective:

- To provide a bridge between basic and advanced organic chemistry knowledge. It also makes connections from chemical principles to the structures and functions of different organic molecules.
- Apply principle and knowledge in stereo chemical aspects of different organic molecules and reactions.
- To provide a basic idea of the reactions and mechanisms involving aliphatic and aromatic hydrocarbons.
- Students are required to apply mathematical skills **(**derivations and integrations**)** and basic physics to understand chemical reactions and related processes.
- Students will gain a good foundation of knowledge and skills for further study in Physical Chemistry.

Course Outcome:

1. Understand the formation, stability and structure of different reaction intermediates.
2. Able to identify the type of reaction and mechanism.
3. Knowledge of the basic mechanisms of elimination **(**E1, E2, E1cb, electron transfer**)**
4. Naming and identifying the structures including configurational isomers **(**stereo-isomers and geometric isomers**)** and conformational isomers.
5. Analyse the mechanism and kinetics of a chemical reaction

MODULE-I

(10 hours)

General Organic Chemistry:

Nomenclature of Organic molecules: Brief revision, Nomenclature of polycyclic compounds including bridged, spiro and other special structures.

Structure and Bonding: Nature of bonding in aliphatic, aromatic compounds; Aromaticity in benzenoid and non-benzenoid compounds. Inductive and Field effects, Resonance; hyperconjugation, structural effects on acidity and basicity.

Types of reagents-Electrophiles, nucleophiles, Reactive Intermediates-Carbocations; carbanions; free radicals, radical anions and cations; **(**Introduction to structure, stability, and reactions**)**.

MODULE-II

(10 hours)

Isomerism and Reaction Mechanism:

Stereochemistry: Conformational analysis of acyclic systems and cyclohexane systems, axial and equatorial bonds, conformation of monosubstituted cyclohexane, Introduction of terminologies such as erythro, threo, exo, endo, epimers, etc. Optical isomerism **(**in compounds containing more than one chiral centre, in biphenyls, allenes and spiro compounds.**)**, resolution of enantiomers, inversion, racemisation and retention

Relative and absolute configuration, sequence rule, D, L and R, S systems of nomenclature

Geometric isomerism: determination of configuration **(**cis, trans and E, Z**)**, oximes and alicyclic compounds.

Reaction mechanism: Substitution reaction: Aliphatic substitutions: SN1, SN2, reactions; Free radical substitutions, electrophilic aromatic substitution **(**idea only**)**; addition reaction **(**addition of H2, X2, HX type**)**, markownikoff and anti-markownikoff addition, Eliminations: E1, E2,

MODULE-III

(10 hours)

Chemical Kinetics and catalysis:

Rates of reactions, factors influencing rates of reaction-conc., temp, press, solvent, light, catalyst. **(**Arrhenius eqn. concept of activation energy**)**, collision theory of reaction rates, Order and molecularity, mathematical characteristics of simple chemical reactions-zero order, first order, second order, pseudo order, half and mean life. Determination of the order of reaction **(**differential method, half-life period method, method of isolation and integration**)**

Catalysis: characteristic of catalysed reactions, classification of catalysis .

Reference Books:

- Principles of Physical Chemistry: B.R. Puri, L.R. Sharma and M.S. Pathania, Vishal Publishing Co, 47th Edn. (2017).
- Organic Chemistry: J. Clayden, N. Greeves and S. Warren, Oxford press, 2nd Edn. (2012).
- Organic Chemistry: P.Y. Bruice, Pearson, 8th Edn. (2017).

Chemistry-II Laboratory

Marks: 100

Course Objective:

- To know the principle and procedure of determination of viscosity
- Know the flash and fire point of Lubricating Oil
- The use of spectrophotometer and its use

Course Outcome:

Students can

1. Set out the environmental conditions to prevent any accident in the industry
2. Find out the qualities of water used in various industries
3. Find out the composition of components in a mixture

Experiments List:

1. To determine the percentage composition of a given mixture **(**non-reacting system**)** by viscosity method.
2. To determine the viscosity of amyl alcohol in water at different concentrations and calculate of excess viscosity of these solutions
3. To determine the percentage composition of a given binary mixture **(**acetone and ethyl methyl ketone**)** by surface tension method.
4. Estimation of Ca^{2+} and Mg^{2+} by EDTA
5. Determination of pH of a buffer solution
6. Determination of viscosity of lubricating oil.
7. Determination of flash and fire point of an oil by Pensky-Marten apparatus.
8. Determination of concentration of a coloured solution by a spectrophotometer.

Communication in Practice

Marks: 100

Course Objective:

- To introduce students to various building blocks of communication, both within and outside their formal articulations.
- To train students in the basic science of writing and help them use the same in various sites such as report, paragraph etc.
- To create conditions in the classroom that encourage students to engage in meaningful conversation.

Course Outcome:

1. It will enable development of clear cut understanding of various blocks/barriers of Communication.
2. It will enable students' capability towards meaningful conversation.
3. Develop basics of writing reports and paragraphs.
4. Develop confidence to attend meetings, interview and other professional interactions.

MODULE-I

Basics of Communication in Practice **(4 hours)**

1.1 Types of Communication in an organization: Formal **(**internal and external**)** and Informal **(**grapevine**) (**1 Hour**)**
1.2 Communication Channels: Upward, Downward, Diagonal and Horizontal **(**1 Hour**)**
1.3 Introduction to cross-cultural communication. **(**2 Hour**)**
1.4 Bias-free communication & use of politically correct language in communication **(**1 Hour**)**
1.5 Importance of reading and ethics of writing **(**1 hour**)**
1.6 Negotiation Skills, Argumentation & Consensus building.

MODULE-II

Business Writing **(10 hours)**

2.1 Skills of Writing: Coherence, Cohesion, Sentence Linkers, Clarity of Language and stylistic variation, process of writing. **(**3 Hour**)**
2.2 Paragraph writing: Topic Sentence, supporting sentence & Concluding sentence, Logical structuring **(**Inductive approach and deductive approach**) (**2 Hours**)**
2.3 Letters, Applications **(**2 Hours**)**
2.4 Reports and Proposals **(**1 Hour**)**
2.5 Memos, Notices, Summaries, Abstracts& e-mails **(**1 Hour**)**
2.6 Writing a CV/Resume': Types of CV **(**2 Hours**)**
2.7 Writing a Cover letter **(**1 Hour**)**

MODULE-III

Speaking and Presentation **(7 Hours)**

3.1 Oral Presentation: 4 P's of presentation, PPT **(**2 Hour**)**
3.2 Group Discussion: Structured and Unstructured, Various types of topics **(**abstract, absurd, contemporary etc.**) (**3 Hours**)**
3.3 Types of Interview: Preparing an Interview and techniques **(**2 Hours**)**
3.4 Grooming and dress code, Personality development **(**2 Hours**)**

Text Books:

- Business Communication: C. M. Lehman, D. D. Dufrene and M. Sinha., Cengage Learning. 2nd Ed. (2016).
- Technical Communication: P. V. Anderson, Cengage Learning (2014).
- Business Communication Today: C.L. Bovee, Courtland. L. et al., Pearson, 2011.
- Jeff Butterfield, Soft Skills for Everyone, Cengage Learning, 2015

Communication in Practice Laboratory

Marks: 100

Course Objective:

- To enable the students, to engage in polite, negotiating and argumentative conversation.
- To train the learners in writing CV, Report, Minutes, Business Letters etc.
- To give students an opportunity for a PowerPoint presentation relating to topical issues.

Course Outcome:

1. Develop effective communication practice in workplace.
2. Developing capability to prepare CVs, minutes and business correspondence.
3. Developing public speaking skills for effective professional outcome.
4. Developing presentation skills required for professional work.

There will be 10 lab sessions of 2 hours each. Lab sessions will be used to give the students an in-hand experience of communication taking place in an organization. This will help the students to understand the requirements of communication in the workplace. Students will be encouraged to brush-up themselves in activities based on all the modules of theory taught in the classroom. Special emphasis will be given to speaking and writing business correspondences.

Ist session:
Speaking: Greeting an acquaintance/ friend, introducing oneself, introducing a third person to a friend, breaking off a conversation politely, leave-taking, describing people, objects, places, processes etc. **(**1 Hour**)**, Writing an application **(**1 Hour**)**

IInd session:
Speaking: making and responding to inquiries; expressing an opinion; expressing agreement/ disagreement, contradicting/ refuting an argument; expressing pleasure, sorrow, regret, anger, surprise, wonder, admiration, disappointment etc **(**1 Hour**)**, Writing an informal letter/Business Letter **(**1 Hour**)**

IIIrd session:
Speaking: Narrating or reporting an event **(**1 Hour**)**, Writing a Report **(**1 Hour**)**

IVth session:
Speaking: Ordering/directing someone to do something, Making requests; accepting/refusing a request, Expressing gratitude; responding to expressions of gratitude, Asking for or offering help; responding to a request for help, Asking for directions **(**e.g. how to reach a place, how to operate a device etc.**)** and giving directions, Speaking: asking for and granting/ refusing permission, prohibiting someone from doing something, suggesting, advising, persuading, dissuading, making a proposal, praising, complementing, felicitating, expressing sympathy **(**e.g. condolence etc.**)**, Complaining, criticizing, reprimanding etc., **(**1 Hour**)**, Writing a proposal **(**1 Hour**)**

Vth Session:
Speaking: Understanding and interpreting graphs, flowcharts, pictograms, pictures, curves etc., **(**1 Hour**)**, Writing: Describing, explaining and interpreting graphs, flowcharts, pictograms, pictures, curves etc.

VIth session:
Speaking: Group discussion **(**1 Hour**)**, Writing a memo, notice and circular **(**1 Hour**)**

VIIth session:
Speaking: In-house communication on work-related situations **(**1 Hour**)**, Writing a CV **(**1 Hour**)**

VIIIth session: Presentation 1 **(**Students will make and present a topic in power point on a pre-assigned topic**) (**1 Hour**)**, Writing an e-mail **(**1 Hour**)**

IXth session: Presentation 2 **(**Students will make and present a topic in power point on a pre-assigned topic**) (**1 Hour**)**, Writing an abstract **(**1 Hour**)**

Xth session: Presentation 3 **(**Students will make and present a topic in power point on a pre-assigned topic**) (**1 Hour**)**, Writing a summary **(**1 Hour**)**

Reference Books:

- Kumar, Sanjay & Lata, Pushp, Communication Skills A Workbook, OUP, 2018.

Note: 70 marks will be devoted for sessions, 10 marks for record submission, 10 marks for viva-voce and 10 marks for project work.

End term assignment: Students are required to make a review report of at least 5 pages on a topic of their own choice (The topic should be pre-approved by teacher).

OOPS Using C++

Marks: 100

MODULE-I

(10 hours)

Introduction to object-oriented programming, user-defined types, structures, unions, polymorphism, encapsulation. Getting started with C++ syntax, data-type, variables, strings, functions, default values in functions, recursion, namespaces, operators, flow control, arrays and pointers.

MODULE-II

(10 hours)

Abstraction mechanism: Classes, private, public, constructors, destructors, member data, member functions, inline functions, friend functions, static members, and references.

Inheritance: Class hierarchy, derived classes, single inheritance, multiple, multilevel, hybrid inheritance, the role of the virtual base class, constructor and destructor execution, base initialization using derived class constructors.

Polymorphism: Binding, Static binding, Dynamic binding, Static polymorphism: Function Overloading, Ambiguity in function overloading, Dynamic polymorphism: Base class pointer, object slicing, late binding, method overriding with virtual functions, pure virtual functions, abstract classes.

Operator Overloading: This pointer, applications of this pointer, Operator function, member and non-member operator function, operator overloading, and I/O operators.

Exception handling: Try, throw, and catch, exceptions and derived classes, function exception declaration.

MODULE-III

(10 hours)

Dynamic memory management, new and delete operators, object copying, copy constructor, assignment operator, virtual destructor. Template: template classes, template functions.

Namespaces: user-defined namespaces, namespaces provided by the library.

Text Books:

- Object-Oriented Programming with C++-E. Balagurusamy, McGraw-Hill Education **(**India**)**
- ANSI and Turbo C++-Ashoke N. Kamthane, Pearson Education
- Big C++-Wiley India
- C++: The Complete Reference-Schildt, McGraw-Hill Education **(**India**)**
- C++ and Object-Oriented Programming-Jana, PHI Learning.
- Object-Oriented Programming with C++-Rajiv Sahay, Oxford

OOPS Using C++ Laboratory

Marks: 100

Experiments List:

1. Programs on the concept of classes and objects
2. Programs using inheritance
3. Programs using static polymorphism
4. Programs on dynamic polymorphism
5. Programs on operator overloading
6. Programs on dynamic memory management using new, delete operators
7. Programs on copy constructor and usage of assignment operator
8. Programs on exception handling
9. Programs on generic programming using template function & template class
10. Programs on file handling

School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

THIRD SEMESTER

Thermal Physics and Properties of matter

Marks: 100

Course Objective:
students will be able to understand various thermodynamic processes, different forms of energy and can identify and describe different properties of matter.

Course Outcome:

1. To describe the working of ideal and real heat engines.
2. To interpret the concept of entropy, nature and role of thermodynamic properties
3. To represent a thermodynamic system by a control mass or control volume.
4. To distinguish the system from its surroundings
5. To recognize and understand the different forms of energy and the law of thermodynamics.
6. To introduce properties of solids, liquids and gases.

MODULE-I

(10 hours)

Thermodynamic system, Principles of thermodynamics, concept of thermodynamic state, Zeroth law of thermodynamics, work done in isothermal and isobaric processes, Heat and Work, Free energy and their application, internal energy function and the first law of thermodynamics, application to various processes, Heat capacity, C_P -C_V, Equation of state for adiabatic process, work done in adiabatic process, Equations of state. Ideal gases and their P-V-T relations.

MODULE-II

(10 hours)

The second law of thermodynamics, Carnot's engine, Carnot theorem, the thermodynamic scale of temperature, Entropy, entropy change in reversible and irreversible processes, mathematical formulation of second law, Maxwell's relations, first TdS equation, second TdS equation, Phase change, Clausius - Clapeyron equation, Newton's law of cooling method, Joule's Kelvin coefficient for ideal and van der waal gases, Joules Thomson effect, Temperature of inversion, Joule's Thomson cooling.

MODULE-III

(10 hours)

Maxwell -Boltzmann formula for distribution of molecular speed **(**statement of formula and discussion**)**, Average RMS and most probable speed, Mean free path, Degrees of freedom, The principle of equipartition of energy, The Vanderwaals equation of state, Evaluation of critical constants, Transport phenomenon in ideal gasses **(**1**)** viscosity **(**2**)** thermal conductivity **(**3**)** diffusion, Brownian motion and its significant.

MODULE-IV

(10 hours)

Properties of Matter: Stress and strain, Hooke's law, three types of elasticity, Poisson's ratio, effect of a suddenly applied load, twisting couple on a cylinder, Torsional pendulum, bending of Beams, Bending moment, cantilever, transverse vibration of a loaded cantilever.

Text Books:

- Heat and Thermodynamics: B. Subramanyam
- Heat and Thermodynamics: M.Das, P.K Jena
- Heat and thermodynamics: B Gupta, H. Ray **(**New Age**)**

Reference Books:

- Heat and thermodynamics: M. W. Zemansky and Dittman **(**McGraw Hill**)**
- Advance textbook of heat: P.K. Chakraborty **(**Hindustan Publication**)**
- A treatise on heat: M.N. Saha and B.N. Srivastava **(**The Indian Press**)**
- Heat and thermodynamics: D. S Mathur.
- Properties of matter: FH. Newman V.H.L. Searle **(**Edward Arnold publication**)**
- Properties of matter: D.S. Mathura **(**S. Chand**)**

Analog System and Application

Marks: 100

Course Objective:

The student will be able to understand various semiconductor devices, their working and applications.

Course Outcome:

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

1. Identify various analog circuits.
2. Understand Semiconductor diodes and bipolar junction transistors.
3. Sketch, explain and design the amplifier circuit for a given specification and analyze them
4. Discuss oscillator principles and frequency stability.

MODULE-I

(10 hours)

Semiconductor Diodes:

P and N-type semiconductors, energy level diagram, conductivity and Mobility, Concept of Drift velocity, PN junction fabrication **(**simple idea**)**, Barrier formation in PN Junction Diode, Static and Dynamic Resistance, Current flow mechanism in Forward and Reverse Biased Diode, Drift velocity, derivation for Barrier Potential, Barrier Width and current Step Junction. Two terminal devices and their applications: **(**1**)** Rectifier Diode: Half-wave Rectifiers. centre-tapped and bridge type Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, L and C Filters **(**2**)** Zener Diode and Voltage Regulation, Principle and structure of LEDs, **(**2**)** Photodiode **(**3**)** Solar Cell.

MODULE-II

(10 hours)

Bipolar Junction Transistors:

Bipolar Junction Transistors: n-p-n and p-n-p transistors, Characteristics of CB, CE and CC Configurations, Current gains a and b, Relation between a and b, Load line analysis of Transistors, DC Load line and Q-point, Physical mechanism of current flow, Active, Cut-off and Saturation Regions. Transistors Biasing Transistor Biasing and Stabilization circuits, Fixed Bias and Voltage Divider Bias. Amplifiers: Transistors as 2-port network h-parameter Equivalent Circuit, Analysis of a single-stage CE amplifier using Hybrid Model, Input and Output impedance, Current, Voltage and Power Gains, Classification of class A, B and C amplifiers, Push-pull amplifier **(**class B**)**.

MODULE-III

(10 hours)

Coupled Amplifier:

Coupled Amplifier: RC-coupled amplifier and its frequency response. Feedback in Amplifiers: Effect of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain Stability, Distortion and Noise. Sinusoidal Oscillations: Barkhausens Criterian for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency, Hartley and Colpitts oscillators.

MODULE-IV

(10 hours)

Operational Amplifiers **(**Black Box approach**)**: Characteristics of an Ideal and Practical OP-AMP **(**IC741**)**. Open-loop and Closed-loop Gain. Frequency Response. CMRR, Slew Rate and concept of virtual ground.

Text Books:

- Foundations of Electronics: D. Raskhit and P.C. Chattopadhyay **(**New age International Publication**)**
- Concept of Electronics: D.C.Tayal **(**Himalay Publication**)**
- Principles of Electronics: V. K. Mehta and Rohit Mehta **(**S. Chand Publication**)**

Reference Books:

- Electronic devices and circuits: R.L.Boylstad **(**Pearson India**)**
- Electronic Principles: A.P.Malvino **(**Tata McGraw-Hill**)**
- OP-Amps and Linear Integrated Circuit: R. A. Gayakwad **(**Prentice-Hall**)**
- Physics of Semiconductor Devices: Donald A Neamen **(**Prentice-Hall**)**

Mathematical Physics-II

Marks: 100

Course Objective:

Students will be able to know the methods of mathematical physics and the required mathematical skills to solve mathematical problems.

Course Outcome:

Upon completion of this course, students should be able to:

1. Demonstrate the utility and limitations of a variety of powerful calculation techniques.
2. Understand elementary ideas in linear algebra, special functions and complex analysis.
3. Solve problems in classical, statistical and quantum mechanics, electromagnetism as well as solid-state physics.
4. Use integral transform methods **(**Fourier Transform and Laplace Transform**)** to solve elementary differential equations in physics.

MODULE-I

(10 hours)

Fourier Series-I: Periodic functions, Orthogonality of sine and cosine functions, Dirichlet Conditions **(**Statement only**)**, Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients, 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 and Application, Summing of Infinite Series, Term-by-Term differentiation and integration of Fourier Series, Parseval Identity.

MODULE-II

(10 hours)

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance, Singularities of Bessels and Laguerre Equations, Frobenius method and its applications to differential equations: Legendre and Hermite Differential Equations, Legendre and Hermite Polynomials: Rodrigues Formula, Generating Function, Orthogonality.

MODULE-III

(10 hours)

Polynomials: Simple recurrence relations of Legendre and Hermite Polynomials, Expansion of function in a series of Legendre Polynomials, Associated Legendre Differential Equation, Associated Legendre polynomials, Spherical Harmonics
Some Special Integrals: Beta and Gamma Functions and the relation between them, Expression of Integrals in terms of Gamma Functions, and Error Function **(**Probability Integral**)**.

MODULE-IV

(10 hours)

Partial Differential Equations: Solutions to partial differential equations using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Conducting and dielectric sphere in an external uniform electric field. Wave equation and its solution for vibrational modes of a stretched string

Text Books:

- Mathematical Physics and Special Relativity: M. Das, P.K. Jena and B.K. Dash **(**Srikrishna Prakashan**)**
- Mathematical Physics: H. K. Dass, Dr. Rama Verma **(**S. Chand Publishing**)**
- Mathematical Physics: Satya Prakash **(**Sultan Chand**)**

Reference Books:

- Mathematical Physics : C. Harper **(**Prentice HallIndia**)** Complex Variable:
- Schaum's Outlines Series : M. Spiegel **(**2nd Edition, McGraw Hill Education**)**
- Complex variables and applications : J.W.Brown and R.V.Churchill
- Mathematical Physics : B.D.Gupta **(**4th edition, Vikas Publication
- Mathematical Methods for Physicists : G.B.Arfken, H.J.Weber, F.E.Harris **(**2013, 7th Edn., Elsevier**)**
- Advanced Engineering Mathematics : Erwin Kreyszig **(**Wiley India**)**

Thermal Physics and Properties of Matter Laboratory

Marks: 100

Course Objective:

This course enables the students to do experiments based on some basic concepts and phenomena of thermal physics and properties of matter.

Course Outcome:

1. Construction and use of specific measurement instruments and experimental apparatuses used in the thermal physics lab, including necessary precautions.
2. Analysis of experimental data, error estimation and writing of scientific report

Experiments List:

1. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus
2. To determine the Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method
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 the Lees method.
5. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
6. To determine J by Calorimeter.
7. Determination of coefficient of rigidity of a wire dynamically.
8. Determination of Y of rubber.
9. Determination of surface tension and angle of contact of mercury by Quinck's method Theory

---

Analog System Laboratory

Marks: 100

Course Objective:

To setup various types of laboratory experiments on analogue electronics and understand some different concepts of electronics

Course Outcome:

1. Understand the basics of diode and working of rectifier circuits and characteristics
2. Analyze the characteristics of transistor and transistor biasing circuits
3. Perform the procedures for the working of single-stage and multistage amplifier
4. Analyze the relationship between amplifier and oscillators
5. Understand the applications of op-amps inverting and non-inverting modes.

(Minimum 5 Experiments are to be done)

Experiments List:

1. To study the V-I characteristics of a Zener diode and its use as a voltage regulator.
2. Study of V-I and power curves of solar cells.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To study the frequency response of voltage gain of an RC-coupled transistor amplifier.
6. To design a Wien bridge oscillator for a given frequency using an op-amp.
7. To design a phase shift oscillator of given specifications using BJT.
8. To study the Colpitt's oscillator.
9. To design a CE amplifier of a given gain using voltage divider bias.

Reference Books:

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

Mathematical Physics Laboratory-II

Marks: 100

Course Objective:

To deploy computational methods to solve physical problems using scientific software like Scilab.

Course Outcome:

1. Scilab software, their utility, advantages and disadvantages.
2. Different computational techniques are used to solve physics problems.
3. Deploy the computational methods to solve the physical problem

Topics

Introduction to Numerical computation software Scilab: Introduction to Scilab, Advantages and disadvantages, Scilab computation software Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built-in Scilab functions, Introduction to plotting, 2D and 3D plotting **(**2**)**, Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization **(**2**)** User-defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays **(**2**)** an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program **(**2**)**.

Curve fitting, least square fit, Goodness of fit, standard Deviation: Ohms law to calculate R, Hooks law to calculate the spring constant

The solution of the Linear system of equations by Gauss elimination Solution method and Gauss-Seidel method. Diagonalization matrices, Inverse of a matrix, Eigenvectors, problems: Solution of mesh equations of electric circuits **(**3 meshes**)**, Solution of coupled spring-mass systems **(**3 masses**)**

The solution of ODE First-order Differential equation: Euler modified methods, Finite difference method

- Radioactive decay
- Current in RC, LC circuits with DC source
- Newton's law of cooling
- Classical equations of motion

Second-order Differential Equation using the Euler & Runge-Kutta method

- Harmonic oscillator **(**no friction**)**
- Damped Harmonic oscillator
- Over damped
- Critical damped
- Oscillatory
- Forced Harmonic oscillator
- Transient and Steady-state solution
- Apply the above to LCR circuits also

Reference Books:

- Mathematical Methods for Physics and Engineers: K.FRiley, M.P.Hobson and S. J.20 Bence, 3rd ed., 2006, Cambridge University Press
- Complex Variables: A.S. Fokas and M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- The first course in complex analysis with applications: D.G.Zill and P.D.Shanahan, 1940, Jones and Bartlett
- Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernndez. 2014 Springer
- Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
- Scilab **(**A free software to Matlab**)**: H.Ramchandran, A.S.Nair.2011S. Chand and Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

---

Mathematics-III

Course Objectives:

- Understand how complex numbers provide a satisfying extension of the real numbers
- Understand the concept of asymptotes. Explain concepts of curve tracing, curvature which forms the basis of many mathematical problems
- Understanding the concept of partial derivatives and use it to compute the maxima and minima of functions of two variables
- Demonstrate the knowledge of solving integrals using Green's theorem, Gauss theorem and Stokes theorem
- Demonstrate knowledge of geometrical figures such as sphere, cylinder, cone

Course Outcome:

1. Write an equation of conics and identify conics from a given equation. Give geometrical interpretation of many mathematical problems.
2. Compute partial differentiation of various functions and determine their maximum and minimum values, apply gradient to solve problems involving steepest ascent and normal vectors to level curves
3. Apply Fundamental Theorem of Line Integrals, Green's Theorem, Stokes' Theorem, or Divergence Theorem to evaluate integrals.
4. Explain the fundamental concepts of complex analysis and their role in modern mathematics and applied contexts.

MODULE-I

(10 hours)

Asymptotes in Cartesian coordinates, intersection of curve and its asymptotes, asymptotes in polar coordinates, curvature, radius of curvature for Cartesian curves, polar curves, Newton's method, centre of curvature, circle of curvature, chord of curvature. Cusp, Nodes & conjugate points, Types of cusps, Tracing of curves in Cartesian, Parametric, and Polar coordinates, Trace (Folium of Descartes, Strophoid, Astroid, Cycloid, Cardioids, Lemniscates of Bernoulli)

MODULE-II

(10 hours)

General equation of the Sphere, intersection of a sphere and a plane, intersection of two spheres, family of spheres, Intersection of a sphere and a line, Tangent plane, condition of tangency, equation of a cone, Enveloping cone of a sphere, cylinder, Enveloping cylinder of a sphere, Right circular cone & cylinder.

MODULE-III

(10 hours)

Functions of several variables, Limit and Continuity, Partial derivatives, Differentiability, Chain rule, Directional derivatives, Gradient vectors, tangent planes, Extreme values and saddle points, Lagrange multiplier,

Vector differential calculus: vector and scalar functions and fields, Derivatives, Curves, tangents and arc length, double integral, triple integral, gradient, divergence, curl .

Vector integral calculus: Line Integrals, Green Theorem, Surface integrals, Gauss theorem and Stokes Theorem.

The complex number system: The real numbers, The field of complex numbers, the complex plane, polar representation and roots of complex numbers, Line and half planes in the complex plane.

Text Books:

- Differential Calculus by Shanti Narayan &; P K Mittal, S. Chand Publication, Chapters 14 (14.1-14.6), 15, 16, 17
- Calculus by M.J. Strauss, G.L. Bradley &; K.J. Smith, 3 rd edition, Pearson, Chapters 10 (10.1-10.2), 11 (11.1-11.8), 12, 13
- Analytical Geometry of Quadratic Surfaces by B P Acharya &; D C Sahu, Kalyani publisher Chapters: 2, 3
- Advanced Engineering Mathematics by E. Kreyszig, 10 th Edition, Wiley.

Reference Books:

- Analytical Solid Geometry: Shanti Narayan
- Calculus and Analytic Geometry: G.B. Thomas and R.L. Finney, 9 th edition, Addison- Wesley.

Chemistry-III

Marks: 100

Course Objective:

- The proposed course aims to provide basic ideas on electrochemistry, redox reactions, thermodynamic quantities of cell reactions and theories of corrosions and methods to combat it.
- To provide a basic idea of aliphatic and aromatic hydrocarbons, preparation methods and properties.
- To provide knowledge on coordination compounds, ideas about effective atomic number, isomerism and valence bond theory.

Course Outcome:

1. Learn fundamental principles of electrochemistry, and thermodynamic quantities of cells.
2. Learn the preparation and properties of aliphatic and aromatic compounds.
3. Learn about coordination compound, Werner's coordination theory and valency bond theory

MODULE-I

[12 hours]

Electrochemistry: Types of reversible electrodes-gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrodes. Electrode reactions, Nernst equation, derivation of cell EMF and single electrode potential, standard hydrogen electrode-reference electrodes-standard electrode potential, sign conventions, electrochemical series and its significance. Electrolytic and Galvanic cells-reversible and irreversible cells, conventional representation of electrochemical cells. EMF of a cell and its measurements. Computation of cell EMF. Calculation of thermodynamic quantities of cell reactions **(**ΔG, ΔH and K**)**, polarization, over potential and hydrogen overvoltage. Concentration cell with and without transport, liquid junction potential, application of concentration cells, valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pKa, determination of pH using hydrogen, quinhydrone and glass electrodes by potentiometric methods. Buffers-mechanism of buffer action, Henderson-Hazel equation. Hydrolysis of salts. Corrosion types, theories and methods of combating it.

MODULE-II

[12 hours]

Chemistry of Aliphatic Hydrocarbons: Carbon-Carbon sigma bonds **(**Alkanes**)**: Kolbe's reaction. Free radical substitutions: Halogenation-relative reactivity and selectivity. Carbon-Carbon pi bonds **(**Alkenes & Alkynes**)**: Formation of alkenes and alkynes by elimination reactions, Mechanism of E_1, E_2, E1cb reactions. Saytzeff and Hofmann eliminations.

Chemistry of Aromatic Hydrocarbons: Aromaticity: Hückel's rule, Aromaticity in benzenoid and non-benzenoid compounds, annulenes, antiaromaticity, homo-aromaticity, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation. Directing effects of the groups.

MODULE-III

[6 hours]

Coordination compounds

Warner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, and valence bond theory of transition metal complexes.

Text Books:

- Atkin's Physical Chemistry, P. W. Atkins, J. D. Paula, 10th Edn., Oxford University Press, 2014.
- A Textbook of Physical Chemistry-Vol. 1, Kapoor, K. L., McGraw Hill Education **(**India**)** 2019.
- Organic reaction mechanism, V.K.Alluwalia, R.K.Parashar, Narosa Publishing House, 3rd Edn,.
- Organic Chemistry, V. Mehta, M. Mehta, PHI learning pvt ltd, Eastern Economy Edition. 2nd Edn.

Chemistry-III Laboratory

Marks: 100

Course Objective:

- To learn the techniques of acid-base titration using pH meter and conductivity meter
- To learn the techniques of determination of conductivity cells.
- To learn how to determine the critical micellar concentration **(**CMC**)** by conductivity meter.

Course Outcome:

1. Learn the techniques of acid-base titration using a pH meter and conductivity meter
2. Learn to determine the critical micelle concentration by conductivity meter

Experiments List:

1. Acid-base titration using a pH meter **(**only HCl**)**
2. Acid-base titration using pH meter **(**mixture, HCl and CH_3COOH**)**
3. Acid-base titration using a conductivity meter **(**only HCl**)**
4. Acid-base titration using a conductivity meter **(**mixture, HCl and CH_3COOH**)**
5. Determination of cell constant of a conductivity cell.
6. Determination of equivalent conductance at infinite dilution of a strong electrolyte.
7. Determination of critical micellar concentration **(**CMC**)** by using a conductivity meter.
8. Mechanical equivalent of heat by Joule's calorimeter.
9. Velocity of sound by resonance column method.
10. Thermal conductivity of a bad conductor by lee's method.

Reference Books:

- R.C. Das and B. Behera, Experimental Physical Chemistry, Tata McGraw Hill 2000
- D. Alart, Practical Physical Chemistry, Longman, 1993.

FOURTH SEMESTER

Elements of Modern Physics

Marks: 100

Course Objective:

- Students can learn various topics to understand about atomic structure, photons, nuclear structure, and be able to know phenomena in laser physics.

Course Outcome:

Students can be able to:

1. Explain the structure of atoms and the origin of the observed spectra.
2. Define matter wave and wave-particle duality
3. Understand various models describing nuclear structure.
4. Learn about various decays, nuclear reactions and sources of stellar energy.

MODULE-I

(10 hours)

Atomic Spectra and Models: Inadequacy of classical physics, Brief Review of Black body Radiation, Photoelectric effect, Compton Effect, dual nature of radiation wave nature of particles, atomic spectra, Line spectra of the hydrogen atom, Ritz Rydberg combination principle, Alpha Particle Scattering, Rutherford Scattering Formula, Rutherford Model of the atom and its limitations.

Atomic Model: Bohr model of Hydrogen atom, explanation of atomic spectra, correction for the finite mass of the nucleus, Bohr correspondence principle, limitations of Bohr model, discrete energy exchange by atom, Frank Hertz Experiment, LASER, Sommerfeld's modification of Bohr's theory.

MODULE-II

(10 hours)

Wave Packet: superposition of two waves, phase velocity and group velocity, wave packets, Gaussian Wave Packet, the spatial distribution of wave packet, Wave-Particle Duality, Complementarity.

Wave-Particle Duality: de Broglie hypothesis, X-ray Diffraction, Experimental confirmation of matter-wave, Davisson Germer Experiment, the velocity of de Broglie wave,

MODULE-III

(10 hours)

Nuclear Physics-I: Size and structure of the atomic nucleus and its relation with atomic weight, Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle, Nature of the nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

MODULE-IV

(10 hours)

Nuclear Physics-II: Radioactivity, stability of the nucleus, Law of radioactive decay, Mean life and Half-life Alpha decay, Beta decay-energy released, spectrum and Paulis prediction of neutrino, Gamma-ray emission energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus, Fission and fusion mass deficit, relativity and generation of energy, Fission-nature of fragments and emission of neutrons, Nuclear reactor: slow neutron interacting with Uranium 235, Fusion and thermonuclear reactions driving stellar energy **(**brief qualitative discussion**)**.

Text Books:

- Concepts of Modern Physics : Arthur Beiser **(**McGraw-Hill**).**
- Modern Physics : Murugeshan and Sivaprasad **(**S.Chand**).**

Reference Books:

- Quantum Mechanics : Theory and Applications, A.K.Ghatak and S.Lokanathan, **(**Macmillan**).**
- Introduction to Quantum Theory : David Park **(**Dover publications**)**.
- Theory and Problems of Modern Physics : Schaum's outline, R.Gautreau and W.Savin-**(**Tata McGraw-Hill**)**
- Modern Physics : Serway **(**CENGAGE Learnings**)**.
- Physics of Atoms and Molecules : Bransden and Joachim **(**Pearson India**)**.
- Atomic and Nuclear Physics : A.B.Gupta **(**New Central**).**
- Theoretical Nuclear Physics : J.M.Blatt and V.F. Weisskopf **(**Springer**).**

Digital System and Application

Marks: 100

Course Objective:

This Course Enables the Student

To understand the basic concepts of digital systems, integrated circuits, Boolean algebra, data processing circuits, and computer architecture.

Course Outcome:

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

1. Understand the qualitative treatment of Integrated Circuits and data processing circuits.
2. Learn both theoretical and experimental knowledge about digital electronics.
3. Develop the Understanding of computer architecture and Boolean algebra.
4. Verify and design various logic gates.
5. Learn and apply the 555 IC timer circuits in the case of different multivibrators.
6. Understand the basics of CRO and its applications.

MODULE-I

(10 hours)

Integrated Circuits (Qualitative treatment only): Active and Passive Components, Discrete components, Wafer Chip, Advantages and Drawbacks of ICs, Scale of Integration: SSI, MSI, LSI and VLSI **(**basic idea and definitions only**)**, Classification of ICs, Examples of Linear and Digital ICs.

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

MODULE-II

(10 hours)

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

Introduction to CRO: Block Diagram of CRO, Electron Gun, Deflection system and Time Base, Deflection Sensitivity,

Applications of CRO: (1**)** Study of Wave Form, **(**2**)** Measurement of Voltage, Current, Frequency and Phase Difference.

MODULE-III

(10 hours)

Data Processing Circuits: Basic Idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2s complement. Half and Full Adders. Half and Full Subtractors, 4-bit binary Adder/Subtractor.

Timers: IC 555: block diagram and application in Astable multivibrator and Monostable multivibrator.

MODULE-IV

(10 hours)

Introduction to Computer Organization: Input/Output Devices, Data storage **(**the idea of RAM and ROM**)**, Computer memory, Memory organization and addressing, Memory Interfacing, Memory Map.

Text Books:

- Digital Principles and Applications : A.P. Malvino, D.P. Leach and Saha **(**Tata McGraw**).**
- Foundations of Electronics : D. Raskhit and P.C. Chattopadhyay **(**New age International Publication**).**

Reference Books:

- The Art of Electronics : Paul Horowitz and Winfield Hill, Cambridge University.
- Digital Circuits and Logic Design : Samuel C. Lee **(**Prentice Hall**)**.
- Electronics : Allan R. Hambley, Prentice Hall.
- Principles of Electronics : V.K.Mehta and Rohit Mehta **(**S.Chand Publishing**).**
- Digital Logic and Computer Design : M. Morris Mano **(**Pearson**).**
- Concepts of Electronics : D.C.Tayal **(**Himalaya Publishing House**).**

Mathematical Physics-III

Marks: 100

Course Objective:

This Course Enables the Student

To develop a clear understanding of the fundamental concepts of Complex Analysis, ideas of Fourier & laplace Transforms and their applications

Course Outcome:

1. To study the techniques of complex variables and functions together with their derivatives, Contour integration and transformations.
2. To study complex power series, classification of singularities, calculus of residues and its applications in the evaluation of integrals, and other concepts and properties.
3. To understand the Infinite Fourier transform, Fourier Sine and Cosine transform of elementary functions from the definition.
4. Apply the Finite Fourier cosine and sine transform in solving boundary value problems.
5. To study the Laplace transform of a function and the Inverse Laplace transform of a function using definition.
6. Use the Method of Laplace transforms to solve initial-value problems for linear¬ differential equations with constant coefficients.

MODULE-I

(12 hours)

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

MODULE-II

(8 hours)

Integral Transforms-I: Fourier Transforms: Fourier Integral theorem, Fourier Transform, Examples, Fourier Transform of trigonometric, Gaussian, finite wave train and other functions, Representation of Dirac delta function as a Fourier Integral, Fourier transform of derivatives, Inverse Fourier Transform.

MODULE-III

(10 hours)

Integral Transforms-II: Convolution theorem, Properties of Fourier Transforms **(**translation, change of scale, complex conjugation**)**, Three dimensional Fourier transforms with examples, Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat flow Equations.

MODULE-IV

(10 hours)

Laplace Transforms Laplace Transforms **(**LT**)** of Elementary functions,

Properties of Laplace Transforms: Change of Scale Theorem, Shifting Theorem, LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of Functions, Derivatives and Integrals of LTs, Dirac Delta function, Periodic Functions, Inverse LT, Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

Text Books:

- Mathematical Methods for Physicists : G.B. Arfken, H.J.Weber, F.E.Harris **(**2013, 7th Edn., Elsevier**).**
- Advanced Engineering Mathematics : Erwin Kreyszig **(**Wiley India**).**

Reference Books:

- Mathematical Physics and Special Relativity : M.Das, P.K.Jena and B.K. Dash **(**Srikrishna Prakashan**).**
- Mathematical Physics : H. K. Das, Dr. Rama Verma **(**S. Chand Publishing**).**
- Mathematical Physics : C. Harper **(**Prentice Hall India**).**
- Complex Variable : Schaum's Outlines Series M. Spiegel **(**2nd Edition, Mc-Graw Hill Education**).**
- Complex variables and applications : J.W. Brown and R.V. Churchill.
- Mathematical Physics : Satya Prakash **(**Sultan Chand**).**
- Mathematical Physics : B.D.Gupta **(**4th edition, Vikas Publication**).**

Modern Physics Laboratory

Marks: 100

Course Objective:

To provide students experiments about some concepts of Quantum Mechanics, basic Laser principles and Properties and evaluate different fundamental constants.

Course Outcome:

1. To determine Planck's constant.
2. To evaluate charge and charge by mass ratio of an electron by different methods.
3. To understand quantum concepts like the tunneling effect
4. To find the wavelength of the laser by diffraction method.

Experiments List:

(Minimum of 4 experiments are to be done**)**:

1. To show the tunnelling effect in tunnel diode using I-V characteristics.
2. To determine the wavelength of the laser source using diffraction of a single slit.
3. To determine the wavelength of the laser source using diffraction of double slits.
4. To determine **(**1**)** wavelength and **(**2**)** angular spread of He-Ne laser using plane diffraction grating.
5. To determine the Planck's constant using LEDs of at least 4 different colours.
6. To determine the value of e/m by **(**a**)** Magnetic focusing or **(**b**)** Bar magnet.
7. To set up the Millikan oil-drop apparatus and determine the charge of an electron.

Digital System Laboratory

Marks: 100

Course Objective:

To teach the students the utility of CRO, make them familiar with the design and function of various logic circuits and data processing circuits and the designing of multivibrators using a simple 555 timer IC.

Course Outcome:

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

1. Understand the use of CRO which is used for diagnosing signals.
2. Learn the design of various multivibrators using 555 IC timers.
3. Develop an understanding of various types of Flip-Flop circuits.
4. Understand the use of different binary circuits.

(minimum of 6 Experiments are to be done):

Experiments List:

1. To measure **(**a**)** Voltage, and **(**b**)** the Time period of a periodic waveform using CRO and to test a Diode and Transistor using a Multimeter.
2. To design a switch **(**NOT gate**)** using a transistor.
3. Half Adder, Full Adder and 4-bit binary Adder.
4. Half Subtractor, Full Subtractor using Full Adder I.C.
5. To build Flip-Flop **(**RS and JK**)** circuits using NAND gates.
6. To design an astable multivibrator of given specifications using 555 Timer.
7. To design a monostable multivibrator of given specifications using 555 Timer.
8. To design a combinational logic system for a specified Truth table.

Reference Books:

- Basic Electronics : A Textbooks lab manual, P.B. Zbar, A.P. Malvino. M.A. Miller, 1994, Mc-McGraw-Hill.
- OP-Amps and Linear Integrated Circuit : R. A. Gayakwad, 4th edition, 2000, Prentice-Hall.
- Electronic Principle : Albert Malvino, 2008, Tata Mc-Graw Hill.
- Electronic Devices and circuit Theory : R.L.BoylestadandL. D.Nashelsky, 20 09, Pearson.

Mathematical Physics Laboratory-III

Marks: 100

Course Objective:

- To know Scilab-based programming to solve simple differential equations and evaluate Fourier coefficients for periodic functions.

Course Outcome:

1. To learn computer-based Scilab programming.
2. To solve simple differential equations.
3. To evaluate special functions.
4. To deduce Fourier coefficient.

Experiments List:

Scilab/C^{++} based simulations experiments based on Mathematical Physics problems like

1. Solve differential equations:

   $dy/dx = e^{-x}$ with $y = 0$ for $x = 0$

   $dy/dx + e^{-x}y = x^2$

   $d^2y/dt^2 + 2\, dy/dt = -y$

   $d^2y/dt^2 + e^{-t}dy/dt = -y$

2. Dirac Delta Function:

   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{-(x-2)^2}{2\sigma^2}}(x+3)dx$, for $\boldsymbol{\sigma}$ = 1, 0.1, 0.01 and show it tends to 5.

3. Fourier Series:

   Program to sum $\sum_{n=1}^{\infty}(0.2)^n$

   Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special functions:

   $\int_{-1}^{+1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m}$

   Plot $P_n(x)$, $j_v(x)$

   Show recursion relation

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

7. Evaluation of trigonometric functions e.g. *sin θ,* Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.

8. Compute the n^{th} roots of unity for n = 2, 3, and 4.

9. Find the two square roots of $-5+12j$.

10. Integral transform: FFT of e^{-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. 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.
- Scilab by example : M. Affouf, 2012. ISBN: 978-1479203444.
- Scilab **(**A free software to Matlab**) :** H.Ramchandran, A.S.Nair. 2011 S.Chand & Company.
- Scilab Image Processing : Lambert M. Surhone. 2010 Betascript Publishing.
- https: //web.stanford.edu/~boyd/ee102/laplace_ckts.pdf
- http: //ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

Mathematics-IV

Marks: 100

Course Objective:

- Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
- Apply numerical methods to obtain approximate solutions to mathematical problems.
- It is shown that majority of problems can be converted to computable forms (discretized) using three fundamental ideas in the approximation theory, namely Taylor series expansion, polynomial interpolation and least square approximation.
- In addition, the student is expected to clearly understand role of the following four fundamental tools Linear Algebraic Equation Nonlinear Algebraic Equations Ordinary Differential Equations- Initial Value Problem Optimization.
- Understand the concept of Linear system of equations using matrices and vector space.

Course Outcome:

After the successful completion of this course the students will be able to

1. Devise and implement an algorithm to solve it numerically;
2. Describe classic techniques and recognize common pitfalls in numerical analysis;
3. Analyze an algorithm's accuracy, efficiency and convergence properties.
4. Apply the concept of eigen value and eigen vector to solve various problems.

MODULE-I

(10 hours)

Vector space, linear dependence of vectors, basis and dimension, Linear systems of equations, linear independence, rank of a matrix, inverse of a matrix, Gauss elimination and Gauss-Jordan elimination, Eigenvalues, eigenvectors, symmetric, skew-symmetric and orthogonal matrices, Diagonalization.

Errors, Algorithims and Convergence, Transcendental and polynomial equations: Introduction, Bisection method, Regula-falsi method, Secant method, Fixed Point iteration, Newton-Raphson method, Rate of convergence. Error Analysis for iterative methods,

.

MODULE-II

(10 hours)

System of Linear Equations: Pivoting Strategies, Matrix inversion, LU-Decomposition, Gauss Jacobi, Gauss –Seidel Method, Relaxation Techniques

Interpolation and Approximations: Introduction, Langrages and Newton Interpolation, Least Square Approximation, Uniform Approximation. Differentiation.

MODULE-III

(10 hours)

Numerical Integration: Newton Cotes Algorithm, Trapezoidal rule, Simpson's rule, Gauss – Legendre Integration Method, Ordinary Differential Equations: Euler's Method, Euler Modified Method, Runge -kutta Method.

Text Books:

- Numerical Methods for Scientific and Engineering Computation : M.K. Jain, S.R.K. Iyengar, R.K. Jain.
- Advanced Engineering Mathematics : E. Kreyszig, John Willey &; Sons Inc. 10 th Edition (For First Part of Module I)

Reference Books:

- Numerical Methods : B.P. Acharya & R.N. Das.
- An Introduction to Numerical Analysis : K. Atkinson, Wiley
- Linear algebra and its applications : Gilbert Strang, Cengage learning.

Environmental science

Marks: 100

Course Objective:
This course enables students to learn how the natural world works and the interaction of humans with the environment and to find the ways to deal with environmental problems.

Course Outcome:
1. To know Ecological Concepts and Natural Resources.
2. To describe various water and noise pollution.
3. To learn the ways to deal with different pollution.
4. To create ideas about waste minimization.

MODULE-I

(10 hours)

Ecological Concepts and Natural Resources: Ecological perspective and value of the environment. Environmental auditing, Biotic components, Ecosystem Process: Energy, Food Chain, Water cycle, Air cycle etc., Environmental gradients, Tolerance levels of environment factor, EU, US and Indian Environmental Law, Global Perspective. Chemistry and Microbiology in Environmental Engineering: Physical and chemical properties of water, Atmospheric chemistry, Soil chemistry, Microbiology, Chemical and biochemical reactions, Material balances and Reactor configurations. The concepts in Hydrology: Hydrological cycle, Water balance, Energy budget, Precipitation, Infiltration, evaporation and evapotranspiration, Rainfall-runoff relationships, Urban hydrology, Groundwater, Groundwater chemistry, Water contamination and pollution prevention.

MODULE-II

(10 hours)

Water Pollution: water quality standards and parameters, Assessment of water quality, Aquatic pollution, Freshwater pollution, Estuarine water quality, Marine pollution, Organic content parameters, DO and BOD demand in streams, Transformation process in water bodies, Oxygen transfer by water bodies, Turbulent mixing, Water quality in lakes and preservers, Groundwater quality. Air Pollution: Air pollution and pollutants, criteria pollutants, Acid deposition, Global climate change-greenhouse gases, non-criteria pollutants, emission standard from industrial sources, air pollution meteorology, Atmospheric dispersion. Noise Pollution: Physical Properties of sound, Noise criteria, Noise Standards, Noise measurement, Noise control.

MODULE-III

(10 hours)

Water Treatment: Water quality standards, Water sources and their quality, Water treatment processes, Pretreatment of water, Conventional process, Advanced water treatment process. Waste Water Treatment: Water flow rate and characteristics, Design of wastewater network, Wastewater treatment process, pre-treatment, primary and secondary treatment of wastewater, Activated sludge treatment: Anaerobic digestion and its microbiology, Reactor configurations and methane production. Application of anaerobic digestion. Biosolids regulations, Characteristics and processing of biosolids, first and second stage processing of sludge. Sludge disposal, Integrated sewage and sludge management. Solid Waste Management: Source classification and composition of MSW: properties and separation, storage and transportation, MSW Management, Waste minimization of MSW, Reuse and recycling, Biological treatment, Thermal treatment, Landfill, Integrated waste management. Hazardous Waste Management, Hazardous waste and their generation, Medical hazardous waste, Household waste, Transportation and treatment of hazardous waste: Incinerators, Inorganic waste treatment, Treatment systems for hazardous waste, handling of treatment plant residue. 38 Industrial Air Emission Control: Characterization of the air stream, Equipment selection, Equipment design, Special Methods: Flue gas desulphurization, NOx removal, Fugitive emissions.

MODULE-IV

(10 hours)

Waste Minimization: Concept, Life Cycle Assessment, Elements of waste minimization strategy, Benefits of waste minimization, Elements of waste minimization programme, Waste reduction techniques. Environment Impact Assessment, Origin and procedure of EIA, Project Screening for EIA, Scope studies, Preparation and review of EIS.

Text Books:

- Environmental Engineering : G. Kiely, Irwin/ McGraw Hill International Edition, 1997.
- Principles of Environmental Engineering and Science : M. L. Davis and S. J. Masen, McGraw Hill International Edition, 2004.

Organizational Behavior

Marks: 100

Course Objective:
This course enables students to understand how individual, groups and structure have impact on the organizational effectiveness and efficiency.

Course Outcome:
1. To the study of Organizational Behavior:
2. To develop creative and innovative ideas that could positively save the organization
3. To discuss the Nature, Types, Reasons behind forming groups in organization.

MODULE-I

(10 hours)

The study of Organizational Behavior: Definition, Meaning, Why study OB; Learning – Principles of learning and learning theories; Personality- Meaning, Determinants, Types, Personality and OB; Perception- Perceptual Process, perceptual errors, Importance of perception in organizations; Motivation-Nature and Importance, Theories of motivation **(**Herzberg, Maslow, McGregor**)**.

MODULE-II

(10 hours)

Group level: Groups in Organizations –Nature, Types, Reasons behind forming groups, Determinants, factors contributing to Group Cohesiveness, Group Decision Making- Process, advantages and disadvantages; Team- Effective Team Building; Types of Leadership- Effective Leadership, Styles of leadership, Leadership Theories-Trait Theory and Contingency Theory, Leadership and Followership; Conflict- Healthy Vs Unhealthy conflict, Conflict Resolution Techniques

MODULE-III

(10 hours)

Structural level: Organizational Culture: culture and organizational effectiveness; Organizational Change: Types of change, Reasons to change, Resistance to change and to manage resistance. Introduction to organizational development.

Text Books:
- OrganisationalBehaviour : Stephens P Robbins, PHI.
- OrganisationalBehaviour : K. Aswatthappa, HPH.

Reference Books:
- Organizational Behavior : Kavita Singh, Pearson
- Organizational Behavior : D.K. Bhattacharya, OUP.
- Organizational Behavior : Pradeep Khandelwal, TMH
- Organizational Behavior : Keith Davis,, McGrawHillNelson Quick, ORGB, Cengage Learning.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

FIFTH SEMESTER

Quantum Mechanics and Application

Marks-100

Course Objective:

This course enables the student

To introduce the concept of Quantum Mechanics in simple microscopic systems and its connection to actual observables.

Course Outcome:

1. To study time-dependent and independent Schrodinger's equations with solutions in simple potentials including harmonic oscillators.
2. To be able to recognize a valid wave function in terms of its being single-valued, continuous and differentiable.
3. To explain the concept of eigenvalue problems and quantum mechanical operators.
4. To develop an understanding of postulates of quantum mechanics and to learn to apply them to solve some quantum mechanical system
5. To understand the scientific ideas behind the historical atomic models and recognize and justify the various modifications of classical ideas.

MODULE-I

(10 hours)

Schrodinger equation: Time-dependent Schrodinger equation, Properties of Wave Function, Interpretation of wave function, Probability and probability current densities in three dimensions, Conditions for Physical Acceptability of Wave Function, Normalization, Linearity and Superposition Principles. Wave function of a free particle, Wave Packet, Fourier Transform and momentum space Wave function, Spread of Gaussian Wave packet, Evolution with time, Position and Momentum Uncertainty.

MODULE-II

(10 hours)

Operators: Operators, Commutator Algebra, Position, Momentum Angular Momentum and Energy operators, Hermitian Operators, Expectation values of position and momentum, Ehrenfest Theorem, Eigenvalues and Eigenfunctions of Hermitian Operator, Energy Eigen Spectrum, Degeneracy, Orthonormality of Eigenfunctions, Linear Dependence. Orthogonalisation.

MODULE-III

(10 hours)

Time Independent Schrodinger equation in one dimension **(**1d**)**, 2d and 3d, Hamiltonian, stationary states and energy Eigenvalues, expansion of an arbitrary wave function as a linear combination of energy Eigenfunctions, General solution of the time-dependent Schrodinger equation in terms of linear combinations of stationary states. General Discussion of Bound states in an arbitrary potential: Continuity of wave function, Boundary condition and the emergence of discrete energy levels, Application to one-dimensional problem-Square well potential, Quantum mechanics of simple Harmonic Oscillator-Energy Levels and energy Eigenfunctions, ground state, zero-point energy and the uncertainty principle, One dimensional infinitely rigid box energy Eigenvalues and Eigenfunctions, normalization, quantum dot as an example, Quantum mechanical scattering and tunnelling in one dimension across a step potential and rectangular potential barrier.

MODULE-IV

(10 hours)

Atoms in Electric and Magnetic Fields: Electron angular momentum. Space quantization, Electron Spin and Spin Angular Momentum, Larmors Theorem, Spin Magnetic Moment, Stern Gerlach Experiment, Vector Atom Model, L-S and J-J coupling, Zeeman Effect, Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect, Paschen back and Stark Effect **(**qualitative Discussion only**)**

Text Books:

- Introduction to Quantum Theory: D. J. Griffiths **(**Pearson**).**
- Introduction to Quantum Mechanics: M.Das , P.K.Jena **(**Shri Krishna Publication**).**

Reference Books:

- Quantum Mechanics, Theory and applications: A.Ghatak , S.Lokanathan **(**McMillan India**).**
- Quantum Mechanics: G.Aruldhas **(**Printice Hall of India**).**
- Quantum Physics: S. Gasiorowicz **(**Wiley**).**
- Quantum Mechanics: G.R.Chatwal , S.K.Anand.
- Quantum Mechanics:.L. Powell , B. Craseman **(**Narosa**).**
- Introduction to Quantum Theory: D. Park **(**Dover publications**).**

Solid State Physics

Marks: 100

Course Objective:
To discuss the basic crystallography and physical properties of solids, and different theories related to free electrons in solids.

Course Outcome:
After completing the course students will / on completion of the course, the students shall be able to:

1. a broad understanding of crystallography and to identify different crystal structures.
2. a high-level understanding of the band theory of solids.
3. know about the free electron theory and lattice vibrations of solids.
4. familiar with the different electrical and magnetic properties of materials and their applications.

MODULE-I

(10 hours)

Crystal Structure: Solids, Amorphous and Crystalline Materials, Lattice translation Vectors, Lattice with a Basis. Central and Non-Central Elements. Unit- Cell, Miller Indices, Types of Lattices, Reciprocal Lattice, Brillouin zones, Diffraction of X-rays by crystals, Bragg Law, Atomic and Geometrical Factor

MODULE-II

(10 hours)

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear, Monatomic 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, T3 Law

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin's theory of dia and Paramagnetic Domains, Curie's law, Weiss Theory of Ferromagnetism and Ferromagnetic Domains, Discussion of B-H Curve, Hysteresis and energy loss.

MODULE-III

(10 hours)

Dielectric Properties of Materials: Polarization Local Electrical Field at an Atom, Depolarization Field, Electric Susceptibility, Polarizability, Clausius Mosotti Equation, Classical theory of Electronic Polarizability.

Lasers: Einstein's A and B coefficients, Metastable States, Spontaneous and Stimulated emissions, Optical Pumping and population Inversion, Three Level and Four-Level Lasers, Ruby Laser and He-Ne Laser.

MODULE-IV

(10 hours)

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

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

Text Books:

- Introduction to Solid State Physics: C. Kittel **(**Wiley India**).**

Reference Books:

- Solid State Physics: N.W. Ashcroft , N.D.Mermin **(**Cengage**).**
- Solid State Physics: R.K.Puri , V.K. Babbar **(**S.Chand Publication**).**
- Solid State Physics: S. O. Pillai **(**New Age Publication**).**
- Lasers and Nonlinear Optics: B.B.Laud **(**Wiley Eastern**)** .
- Elements of Solid-State Physics: J.P. Srivastava **(**Prentice Hall of India**)**.
- Elementary Solid-State Physics: Ali Omar **(**Addison Wiley**).**
- LASERS: Fundamentals and Applications: Thyagarajan and Ghatak **(**McMillan India**)**.

Quantum Mechanics Laboratory

Marks-100

Course Objective:
To teach the student to solve quantum mechanical problems using programming language **(**C/C++ /SCI Lab**).**

Course Outcome:

1. It provides students with a thorough understanding of the key topics covered in basic quantum mechanics, enabling them to understand the wave function by solving the Schrodinger equations.

Experiments List:

Use C/C^{++}/Scilab for solving the following problems based on Quantum Mechanics like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

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

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, hc = 1973 (eVÅ) and m = $0.511x10^6$ eV/c^2.

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

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

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = $0.511x10^6$ eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units hc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

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

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

For the anharmonic oscillator potential

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

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

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

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

Where μ is the reduced mass of the two-atom system for the Morse potential

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

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

Take: m = $940x10^6 eV/C^2$, D = 0.755501 eV, α = 1.44, r_e = 0.131349 Å

Reference Books:

- Schaum's Outline of Programming with C++: J.Hubbard (2000) McGraw– Hill Publication.

- Numerical Recipes in C: The Art of Scientific Computing: W.H. Press et al., 3rd Edn. (2007) Cambridge University Press.
- An introduction to computational Physics: T.Pang, 2nd Edn. (2006) Cam- bridge Univ. Press.
- Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C.V. Fernndez. 2014 Springer.
- Scilab **(**A Free Software to Matlab**)**: H. Ramchandran, A.S. Nair. 2011S. Chand and Co.
- A Guide to MATLAB: B.R. Hunt, R.L. Lipsman, J.M. Rosenberg (2014) 3rd Edn., Cambridge University Press.
- Scilab Image Processing: L.M. Surhone (2010) Betascript Publishing ISBN: 9786133459274.

Solid State Physics Laboratory

Marks: 100

Course Objective:
To have hands-on experience in the estimation of several parameters related to electrical as well as magnetic properties.

Course Outcome:
Upon successful completion of this course, the students will be able to estimate

1. several magnetic parameters of solids and liquids showing magnetic properties
2. and electrical parameters with the help of the Hall effect set up.
3. the band gap of semiconductors

Experiments List:

1. Measurement of the susceptibility of paramagnetic solution **(**Quincks Tube-Method**)**
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of dielectric Materials with frequency
4. To determine the Hall coefficient of a semiconductor sample.
5. To draw the BH curve of Fe using a solenoid and to determine the energy loss from Hysteresis.
6. To measure the bandgap of a given semiconductor by the four-probe method

Reference Books:

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

Discipline-Specific Elective
Theory

DSE-I Theory
DSE-II Theory

Practical

DSE-I Laboratory
DSE-II Laboratory

SIXTH SEMESTER

Electromagnetic Theory

Marks-100

Course Objective:
This course enables the student
To understand the fundamental properties related to electromagnetic theory.

Course Outcome:

1. To know the importance of polarization.
2. To understand Maxwell's equations of electromagnetism boundary condition and polarization.
3. To apply Maxwell equation, boundary conditions and polarisation in electromagnetic fields.
4. To evaluate brewster's angle, critical angle other various physical quantities in electromagnetism**.**

MODULE-I

(10 hours)

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, Electro-magnetic **(**EM**)** Energy Density, Physical Concept of Electromagnetic Field Energy Density

MODULE-II

(10 hours)

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

MODULE-III

(10 hours)

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

MODULE-IV

(10 hours)

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization, Uniaxial and Biaxial Crystals, Light Propagation in Uniaxial Crystal, Double Refraction, Polarization by Double Refraction, Nicol Prism, Ordinary and extraordinary refractive indices, Production and detection of Plane, Circularly and Elliptically Polarized Light,

Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinets Compensator and its Uses, Analysis of Polarized Light.

Rotatory Polarization: Optical Rotation, Biot's Laws for Rotatory Polarization, Fresnel theory of optical rotation, Calculation of angle of rotation, Experimental verification of Fresnel's theory, Specific rotation, Laurents half-shade polarimeter.

Text Books:

- Introduction to Electrodynamics: D.J. Griffiths **(**Pearson**).**
- Electricity and Magnetism: DC Tayal **(**HimalayaPublication**).**

Reference Books:

- Classical Electrodynamics: J.D.Jackson.
- Foundation of electromagnetic theory: RitzandMilford **(**Pearson**)** .
- Principles of Optics: MaxBorn and E.Wolf.
- Optics: A.K.Ghatak.
- Electricity and Magnetism: Chattopadhyaya, Rakhit **(**NewCentral**)** .

Statistical Mechanics

Marks-100

Course Objective:

This course in statistical mechanics provides
The basic idea of probability and distributions of particles in thermodynamic systems.

Course Outcome:

1. To find the connection between statistics and thermodynamics.
2. Determine the probability of any type of event.
3. Interpret different types of probabilistic events.
4. Understood the concept of phase space and its volume.
5. Distinguish between different types of particles and statistics and can easily distribute bosons, fermions and classical particles among energy levels.
6. Studying Fermi Dirac statistics, students have learnt to deal with many-electron systems in real life and to Explain the transfer of energy in waves by radiation.

MODULE-I

(10 hours)

Classical Statistics-I: Macrostate and Microstate, Elementary Concept of Ensemble, Microcanonical, Canonical and Grand Canonical Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function

MODULE-II

(10 hours)

Classical Statistics-II: Thermodynamic Functions of an Ideal Gas, classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of equipartition of Energy **(**with proof**)**-Applications to Specific Heat and its Limitations, Thermodynamic Functions of a two energy levels system, Negative Temperature.

MODULE-III

(10 hours)

Quantum Statistics: Identical particles, macrostates and microstates, Fermions and Bosons, Bose-Einstein distribution function and Fermi-Dirac distribution function. Bose-Einstein Condensation, Bose deviation from Planck's law, Effect of temperature on Fermi-Dirac distribution function, degenerate Fermi gas, Density of States Fermi energy.

MODULE-IV

(10 hours)

Radiation: Properties of Thermal Radiation, Blackbody Radiation, Pure Temperature dependence, Kirchhoff's law, Stefan Boltzmann law: Thermodynamic proof, Radiation Pressure, Weins Displacement law, Wiens distribution Law, Sahas Ionization Formula, Rayleigh-Jeans Law, Ultra Violet catastrophe.

Planck's Law of Black Body Radiation:

Experimental verification, Deduction of **(**1**)** Wiens Distribution Law, **(**2**)** Rayleigh-Jeans Law, **(**3**)** Stefan Boltzmann Law, **(**4**)** Weins Displacement Law from Planck's Law.

Text Books:

- Statistical Mechanics: K.K Sharma, B.S Satyal.
- Statistical Physics Berkeley Physics Course: F.Reif **(**Tata McGraw-Hill**)**.
- Introduction to Statistical Physics: Kerson Huang **(**Wiley**)**.

Reference Books:

- Statistical Mechanics: B.K. Agarwal and Melvin Eisner (New Age International).
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Francis W. Sears and Gerhard L.Salinger (Narosa).
- Statistical Mechanics: R.K. Pathria and Paul D. Beale **(**Academic Press**)** .

Electro-Magnetic Theory Laboratory

Marks-100

Course Objective:
To understand electromagnetic wave propagation in different types of mediums.

Course Outcome:
1. Understand the concepts of polarization.
2. Familiarize with the polarization of EM waves, polarizing and analyzing instruments

(minimum of 4 Experiments are to be done):

Experiments List:
1. To verify the law of Malus for plane-polarized light.
2. To determine the specific rotation of sugar solution using a Polarimeter.
3. To determine the refractive index of a liquid by total internal reflection using Wollaston air-film.
4. To determine the refractive index of **(**1**)** glass and **(**2**)** a liquid by total internal reflection using a Gaussian eyepiece.
5. To study the polarization of light by reflection and determine the polarizing angle for the air-glass interface.
6. To verify Stefan's law of radiation.
7. To determine the Boltzmann constant using V-I characteristics of the PN junction diode.
8. To prove the inverse square law in magnetism using a deflection magnetometer**.**
9. Determination of reduction factor of tangent Galvanometer.
10. Determination of the figure of merit of a moving coil Galvanometer
11. Measurement of high resistance with a Galvanometer

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- An advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Books - Book of Practical Physics, I.Prakash and Ramakrishna, 11 Ed., 2011, Kitab Mahal Electromagnetic Field Theory for Engineers and Physicists, G. Lehner, 2010, Springer.

Statistical Mechanics Laboratory

Marks: 100

Course Objective:
To relate the theoretical radiation model and the modifications by performing computational analysis.

Course Outcome:
1. Analysis of different phenomena through computer programming
2. Use of numerical simulations for solving the problems based on Statistical Mechanics.

Experiments List:
Use C/C++/Scilab for solving problems based on Statistical Mechanics like
1. Plot Planck's law for Black Body radiation and compare it with Weins
2. Law and Rayleigh-Jeans Law at high temperature **(**room temperature**)** and low temperature.
3. Plot Specific Heat of Solids by comparing **(**a**)** Dulong-Petit law, **(**b**)** Einstein distribution function, and **(**c**)** Debye distribution function for high temperature **(**room temperature**)** and low temperature and compare them for these two cases
4. Plot Maxwell-Boltzmann distribution function versus temperature.
5. Plot Fermi-Dirac distribution function versus temperature.
6. Plot Bose-Einstein distribution function versus temperature.

Reference Books:

- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. (2007) Wiley India Edition.
- Statistical Mechanics: R.K. Pathria, Butterworth Heinemann: 2nd Ed. (1996) Oxford University Press.
- 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.
- Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A. V. Wouwer, P. Saucez, C.V. Fernndez (2014) Springer ISBN: 978-3319067896.
- Scilabby example: M. Affouf (2012) ISBN: 978-1479203444.
- ScilabImage Processing: L.M.Surhone (2010) Betascript Pub., ISBN: 978-6133459274.

Discipline Specific Elective

Theory

DSE-III Theory
DSE-IV Theory

Practical

DSE-III Laboratory
DSE-IV Laboratory

Discipline-Specific Elective Papers

DSE-I: Advanced Mathematical Physics

Marks-100

Course Objective:

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

Course Outcome:

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

1. Understand algebraic structures in n-dimension and the basic properties of the linear vector spaces.
2. Represent Linear Transformations as matrices and understand the basic properties of matrices
3. Apply vector spaces and matrices in the quantum world.
4. Learn basic properties of Cartesian and general tensors with physical examples such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.
5. Learn how to express the mathematical equations for the Laws of Physics in their covariant forms.

MODULE-I

(10 hours)

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

Matrices: Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit- Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and SkewSymmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product.

MODULE-II

(10 hours)

Eigen-values and Eigenvectors. Cayley- Hamilton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix.

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

MODULE-III

(10 hours)

Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. The angle between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. The foot of the Perpendicular from a Point on a Line. Rotation Tensor **(**No Derivation**)**. Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

MODULE-IV

(10 hours)

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

Text Books:

- Mathematical Methods for Physicists: G.B. Arfken, H.J. Weber, and F.E. Harris (1970) Elsevier.

Reference Books:

- Mathematical Tools for Physics: J. Nearing (2010) Dover Publications.
- Modern Mathematical Methods for Physicists and Engineers: C.D. Cantrell (2011) Cambridge University Press 3.
- Introduction to Matrices and Linear Transformations: D.T. Finkbeiner (1978) Dover Pub.
- Linear Algebra: W. Cheney, E.W.Cheney & D.R.Kincaid (2012) Jones & Bartlett Learning.
- Mathematics for Physicists: S.M. Lea (2004) Thomson Brooks/Cole.
- Mathematical Methods for Physicis & Engineers: K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed. (2006) Cambridge University Press.

DSE-I: Communication System

Marks: 100

Course Objective:
Students will be exposed to communication and navigation systems like satellite communication and mobile telephony systems.

Course Outcome:
Upon successful completion of this course, students will be able to:

1. Overall idea about communication system, modulation, TRAI and concept of noise.
2. Understand the analogue modulation system.
3. Understand the satellite communication system and navigation system.
4. Also, they understand the architecture of mobile communication systems which will enable them for further study in this growing area.

MODULE-I

(10 hours)

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

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM **(**Emitter Modulation**)**, Amplitude Demodulation **(**diode detector**)**, Concept of Single sideband generation and detection. Frequency Modulation **(**FM**)** and Phase Modulation **(**PM**)**, modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector **(**slope detector**)**, Qualitative idea of Superheterodyne receiver

MODULE-II

(10 hours)

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

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying **(**ASK**)**, Frequency Shift Keying **(**FSK**)**, Phase Shift Keying **(**PSK**)**, and Binary Phase Shift Keying **(**BPSK**)**.

MODULE-III

(10 hours)

Introduction to Communication and Navigation Systems:

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

Mobile Telephony System-Basic concept of mobile communication, frequency bands used in mobile communication, the concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption,

MODULE-IV

(10 hours)

Architecture **(**block diagram**)** of mobile communication network, the idea of GSM, CDMA, TDMA and FDMA technologies, a simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts **(**qualitative only**)**

GPS navigation system **(**qualitative idea only**)**

Text Books:

- Electronic Communications: D. Roddy and J. Coolen, Pearson Education India.

Reference Books:

- Advanced Electronics Communication Systems: Tomasi, 6th edition, Prentice-Hall.
- Electronic Communication Systems: G. Kennedy, 3rdEdn. (1999) Tata McGraw Hill.
- Principles of Electronic communication systems: Frenzel, 3rd edition, McGraw Hill.
- Communication Systems: S. Haykin, 2006, Wiley India.
- Electronic Communication system: G. Kennedy, B. Davis, 5th edition.
- Wireless communications: A. Goldsmith (2015) Cambridge University Press.

DSE-II: Fluid Mechanics

Marks-100

Course Objective:
This course enables the student
To know basic things and theories related to fluid mechanics.

Course Outcome:

1. To know basic things related to fluids at rest and in motion.
2. To understand fluid flow and Bernoullis theorem
3. To apply Pascal's equation, Bernoulli's equation.
4. To explain the angle of contact, surface tension and capillary rise
5. To evaluate the coefficient of viscosity and other physical quantities

MODULE-I

(10 hours)

Hydrostatics: Fluids, hydrostatic pressure, Pascal's law, the principle of Archimedes, equilibrium of floating bodies, stability of equilibrium, determination of metacentric height, pressure due to a compressible fluid or gas, measurement of atmospheric pressure, correction of Barometer reading.

MODULE-II

(10 hours)

Flow of liquid and viscosity: Rate of flow of a liquid, energy of the liquid, Bernoulli's theorem and its applications, critical velocity, Poiseuille's equation for flow of liquid through a tube, Motion in a viscous medium, determination of coefficient of liquid, Stoke's method, variation of viscosity of a liquid with temperature.

MODULE-III

(10 hours)

Surface tension: Molecular range, Sphere of influence, surface tension, surface film and surface energy, the free energy of a surface, pressure difference across a liquid surface, Drops and Bubbles: excess pressure inside a liquid drop, excess pressure inside a soap bubble, determination of the surface tension of a bubble.

MODULE-IV

(10 hours)

Capillarity: Layer of liquid between two plates, Shape of the liquid meniscus in a capillary tube, Angle of contact, measurement of angle of contact, rise of liquid in a capillary tube, energy required to raise a liquid in a capillary tube, raise of liquid between two parallel plates.

Text Books:

- Properties of matter: D.S. Mathura **(**S.chand**).**

Reference Books:

- Properties of matter: FH. Newman V.H.L. Searle **(**Edward Arnold publication**).**
- Mechanics: K.R. Symon **(**Addison Wesley**).**

DSE-II: Applied Dynamics

Marks: 100

Course Objective:
To initiate the students to the concepts, techniques and applications of non-linear dynamics and deterministic chaos in continuous and discrete systems.

Course Outcome:
Upon successful completion of this course, students will be able to:

1. Develop a heuristic and holistic understanding of dynamics occurring in Physical, Chemical and Biological systems.
2. Apply tools of phase space dynamics to analyze system dynamics and chaos develop.
3. A basic understanding of Fluid Dynamics and apply the laws to elementary problems of fluid dynamics

MODULE-I

(10 hours)

Introduction to Dynamical Systems: Definition of a continuous first-order dynamical system. The idea of phase space flows and trajectories. Simple mechanical systems as first-order dynamical systems: the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, and relating the equations and pictures to the underlying physical intuition.
Other examples of dynamical systems- In Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits

MODULE-II

(10 hours)

In Chemistry: Rate equations for chemical reactions e.g. autocatalysis, bistability In Economics: Examples from game theory. Illustrative examples from other disciplines.
Fixed points, attractors, the stability of fixed points, the basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples.
Computing and visualizing trajectories on the computer using software packages. Discrete dynamical systems. The logistic map is an example.

MODULE-III

(10 hours)

Introduction to Chaos and Fractals: Examples of 2-dimensional billiards, Projection of the trajectory on momentum space. Sinai Billiard and its variants.Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of the obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems are visualization of their trajectories on the computer. Self-similarity and fractal geometry: Fractals in nature trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics-Sierpinski gasket and DLA.
Chaos in nonlinear finite-difference equations-Logistic map: Dynamics from time series. Parameter dependence-steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos-aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period-Doubling route to chaos.

MODULE-IV

(10 hours)

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

Text Books:

- Nonlinear Dynamics and Chaos: S.H. Strogatz, Levant Books, Kolkata, (2007).

Reference Books:

- Understanding Nonlinear Dynamics: D. Kaplan and L. Glass, Springer.
- An Introduction to Fluid Dynamics: G.K.Batchelor, Cambridge Univ. Press, (2002).
- Fluid Mechanics: 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, (1987)..

DSE-III: Introduction to Nuclear and Particle Physics

Marks-100

Course Objective:

- To provide an understanding of the static properties of nuclei, nuclear force and nuclear models.
- To familiarize with the fundamental forces and the dynamics of elementary particles under these forces.
- The aim and objective of the course on Nuclear Physics is to enable us to understand the basic concepts of static properties of nuclei, radioactive decay, nuclear forces, nuclear reactions, and radiation interaction.
- The course on Nuclear Accelerators and Radiation Physics enables the students to understand nuclear radiation, neutron classification, neutron detection, and diffusion of thermal neutrons, nuclear detectors, different types of detectors, nuclear accelerators, and various types of accelerators, Nuclear reactors.

Course Outcome:

After completing the course students will / on completion of the course, the students shall be able to:

1. Understand the nuclear structure, radioactivity, and quantum behaviour.
2. Identify different concepts of detection of various types of nuclear radiation.
3. Describe the different types of nuclear reactions and their applications.
4. To introduce the concepts of nuclear theory involving nuclear models.
5. Understand the principles and workings of particle detectors and particle accelerators.
6. Understand the basic principles of elementary particle physics.

MODULE-I

(10 hours)

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

Radioactivity decays: (a**)** Alpha decay: basics of alpha-decay processes, the theory of alpha-emission, Gamow factor, Geiger Nuttall law **(**b**)** beta-decay: energy kinematics for beta-decay, positron emission, electron capture, neutrino hypothesis. **(**c**)** Elementary idea of Gamma decay.

MODULE-II

(10 hours)

Nuclear Models: Liquid drop model approach, semi-empirical mass formula and significance of its various terms, conditions of nuclear stability, two nucleon separation energies, evidence for nuclear shell structure, nuclear magic number, basic assumption of shell models.

MODULE-III

(10 hours)

Detector for nuclear radiations: Detector for nuclear radiations: Gas detectors: estimation of the electric field, mobility of particles, for ionization chamber and GM Counter. Basic Principle of Scintillation Detectors and Construction of photo-multiplier tube **(**PMT**)**. Semiconductor Detectors **(**Si and Ge**)** for charge Particle and photon detection **(**Concept of charge carrier and mobility**)**, neutron detector.

Particle Accelerators: Van-de Graff generator **(**Tandem Accelerator**)**, Linear accelerator, Cyclotron, Synchrotrons

MODULE-IV

(10 hours)

Particle Physics: Particle interactions, basic features, types of particles and their families, Symmetries and conservation laws: Energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, strangeness and charm, Elementary ideas of quarks and gluons.

Text Books:

- Introduction to Nuclear Physics: R.R. Roy and B.P. Nigam.
- Atomic and Nuclear Physics: N.Subramanyam, Brij Lal and Jivan Seshan **(**S. Chand Publishing**)**.

Reference Books:

- Introduction to Modern Physics: H.S.Mani and G.K.Mehta **(**Affiliated East and West**).**
- Introductory Nuclear Physics: K.S. Krane **(**Wiley India Pvt. Ltd**)**.
- Introduction to Elementary Particles: D. Griffith **(**John Wiley and Sons**).**
- Concepts of Nuclear Physics: B.L. Cohen. **(**Tata Mcgraw Hill**)**.
- Concepts of Modern Physics: A. Beiser **(**McGraw-Hill**).**

DSE-III: Physics of Devices and Communication

Marks: 100

Course Objective:
Learning about different techniques involved in digital data communication systems.

Course Outcome:
Upon successful completion of this course, students will be able to:

1. Understand the characteristics of JFET, MOSFET UJT etc.
2. Design filters and rectifiers.
3. Verify theorems and analyze several circuits by simulation.
4. Take an analytical approach to problems in their future endeavors.

MODULE-I

(10 hours)

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

Power supply and Filters: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, and Short circuit protection.

MODULE-II

(10 hours)

Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters.

Multivibrators: Astable and Monostable Multivibrators using transistors.

Phase-Locked Loop **(**PLL**)**: Basic Principles, Phase detector **(**XOR & edge triggered**)**, Voltage Controlled Oscillator **(**Basics, varactor**)**. Loop Filter-Function, Loop Filter Circuits, transient response, lock and capture. The basic idea of the PLL IC **(**565 or 4046**)**.

MODULE-III

(10 hours)

Processing of Devices: Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Liftoff Technique. Diffusion and implantation.

MODULE-IV

(10 hours)

Digital Data Communication Standards:

Serial Communications: RS232, Handshaking, Implementation of RS232 on PC.

Universal Serial Bus **(**USB**)**: USB standards, Types and elements of USB transfers. Devices **(**the Basic idea of UART**)**.

Parallel Communications: General Purpose Interface Bus **(**GPIB**)**, GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC.The basic idea of sending data through a COM port.

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

Text Books:

- Electronic devices and integrated circuits: A.K. Singh (2011) PHI Learning Pvt. Ltd.

Reference Books:

- Physics of Semiconductor Devices: S.M. Sze & K.K. Ng, 3rd Ed. (2008) John Wiley & Sons.
- Op-Amps & Linear Integrated Circuits: R.A.Gayakwad, 4 Ed. (2000) PHI Learning Pvt. Ltd.
- Electronic Devices and Circuits: A. Mottershead (1998) PHI Learning Pvt. Ltd.
- Electronic Communication Systems: G. Kennedy (1999) Tata McGraw Hill.
- Introduction to Measurements & Instrumentation: A.K. Ghosh, 3rd Ed. (2009) PHI Learning Pvt. Ltd.
- Semiconductor Physics and Devices: D.A. Neamen (2011) 4th Edition, McGraw Hill.
- PC-based instrumentation; Concepts & Practice: N.Mathivanan (2007) Prentice-Hall of India.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

DSE-III: Embedded Systems-Introduction to Microcontroller

Marks: 100

Course Objective:

To make the student learn about the embedded system, its applications and challenges.

Course Outcome:

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

1. Understand the embedded system and its application.
2. Understands microprocessor-based systems in detail.
3. Gains knowledge about the design and development of an embedded system.

MODULE-I

(10 hours)

Embedded system introduction: Introduction to embedded systems and general-purpose computer systems, the architecture of embedded systems, classifications, applications and purpose of embedded systems, challenges & design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.

Review of microprocessors: Organization of Microprocessor-based system, 8085μp pin diagram and architecture, the concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and their implementation, delay subroutines, hardware and software interrupts.

MODULE-II

(10 hours)

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

8051 I/O port programming: Introduction of I/O port programming, pinout diagram of8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 **(**using assembly language**)**, I/O programming: Bit manipulation.

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

MODULE-III

(10 hours)

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

Interfacing 8051 microcontrollers to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing.

MODULE-IV

(10 hours)

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

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

Text Books:

- Embedded Systems: Architecture, Programming & Design: R.Kamal (2008) Tata McGraw Hill.

Reference Books:

- The 8051 Microcontroller and Embedded Systems Using Assembly and C: M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed. (2007) Pearson Education India.
- Embedded microcomputer system: Real-time interfacing: J.W.Valvano (2000) Brooks/Cole.
- Microcontrollers in practice: I. Susnea and M. Mitescu (2005) Springer.
- Embedded Systems: Design & Applications: S.F. Barrett (2008) Pearson Education India.
- Embedded Microcomputer Systems: Real-time interfacing: J.W. Valvano (2011) Cengage Learning.

DSE-IV: Measurement Techniques

Marks: 100

Course Objective:
To understand how to take measurements with accuracy and efficiency

Course Outcome:
Upon successful completion of this course, the student will be able to:

1. Understand the importance of accuracy in measurement.
2. Understand the working and application of transducers.
3. Learn about all these and LCR circuits by practice mode.

MODULE-I

(10 hours)

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

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

MODULE-II

(10 hours)

Transducers & industrial instrumentation (working principle, efficiency, applications):
Static and dynamic characteristics of Measurement Systems. Generalized performance of systems, zero order first order, second-order and higher-order systems. Electrical, Thermal and Mechanical systems. Calibration.
Transducers and sensors. Characteristics of Transducers. Transducers as the electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors **(**AD590, LM35, LM75**)** and signal conditioning.

Transducers continued
Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer **(**LVDT**)**, Capacitance change transducers.

MODULE-III

(10 hours)

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

MODULE-IV

(10 hours)

Impedance Bridges and Q-meter: Block diagram and working principles of RLC Bridge. Q-meter and it's working operation. Digital LCR Bridge.

Sensors: Radiation Sensors: Principle of Gas-filled detector, ionization chamber, scintillation detector

Text Books:

- A Course in Electrical and Electronic Measurements and Instrumentation: A. K. Sawhney.

Reference Books:

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

DSE-I: Advanced Mathematical Physics Laboratory

Marks-100

Course Objective:

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics and also to highlight the use of computational methods to solve physical problems.

Course Outcome:

In the laboratory course, students will be able to solve the problems using the Scilab/C++ computer language:

1. Eigenvalues and Eigenvectors of a given matrix, determination of wave functions for stationary states as eigenfunctions, eigen energy values of Hermitian differential operators, Lagrangian formulation in classical dynamics etc.

Experiments List:

Scilab/C++-based simulations Experiments based on Mathematical Physics problems like

1. Linear algebra: • Multiplication of two 3 x 3 matrices • Eigenvalue and eigenvectors of
2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of the moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differential operator.
5. The Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces **(**surface of a sphere, etc**)**.

Text Books:

- 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.

Reference Books:

- Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444.
- Scilab Image Processing: L.M.Surhone (2010) Betascript Pub., ISBN: 978-6133459274.

DSE-I: Communication System Laboratory

Marks: 100

Course Objective:

To impart practical skills to design analog and digital communication systems.

Course Outcome:

At the end of this course students will demonstrate the ability to

1. Analyze and compare different analog modulation schemes like AM, FM for their efficiency and bandwidth.
2. Study the behavior of a communication receiver system module.
3. Analyze pulsed modulation systems and their performance.
4. Learn different digital modulation schemes, Digital receiver system modules.

Experiments List:

1. To design an Amplitude Modulator using Transistor
2. To study envelope detectors for demodulation of AM signal
3. To study FM-Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing **(**TDM**)**
7. To study Pulse Amplitude Modulation **(**PAM**)**
8. To study Pulse Width Modulation **(**PWM**)**
9. To study Pulse Position Modulation **(**PPM**)**
10. To study ASK, PSK and FSK modulators

Text Books:

- Electronic Communication Systems: G. Kennedy (1999) Tata McGraw Hill.

Reference Books:

- Electronic Communication system: Blake, Cengage, 5th edition.

DSE-II: Fluid Mechanics Laboratory

Marks: 100

Course Objective:

The main objectives of the course are

To know basic things related to fluid mechanics.

Course Outcome:

After completing the course students can be able

1. To understand and apply Archimedes' principle.
2. To examine the properties of fluids and to conduct experiments
3. To determine the coefficient of viscosity by various methods
4. To examine capillary rise due to surface tension.
5. To determine the moment of inertia in various cases.

Experiments List:

1. To determine the surface tension of soap solution by the capillary rise method.
2. To determine the coefficient of viscosity of a known fluid using Stokes' method.
3. To determine the Surface Tension of Liquid by Jaeger's Method.
4. To find Reynolds number for a pipe flow.
5. To determine the coefficient of viscosity of water by Poiseuille’s Method
6. Measurement of density and specific gravity
7. Study of the effect of capillary elevation between flat sheets
8. Study of Archimedes’ principle
9. Measurement of the viscosity of a fluid using a sphere viscometer
10. Determination of the coefficient of friction of flow in a pipe
11. To verify Bernoulli's Theorem.
12. To show the velocity and pressure variation with radius in a forced vortex flow.

DSE-II: Applied Dynamics Laboratory

Marks: 100

Course Objective:

The Applied Dynamics lab combines a focus on mathematical modeling and simulation with core strengths in the areas of multibody dynamics.

Course Outcome:

1. To introduce dynamical systems in various branches of physics
2. To learn about chaos and fractals with examples.

Experiments List:

Laboratory/Computing and visualizing trajectories using software such as Scilab, Maple, Octave, and XPPAUT based on Applied Dynamics problems like

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of a damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, and simple genetic circuits.
5. To study rate equations for chemical reactions e.g. autocatalysis, and bistability.
6. To study examples from game theory.
7. Computational visualization of trajectories in the Sinai Billiard.
8. Computational visualization of trajectories Electron motion in mesoscopic conductors as a chaotic billiard problem.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of the self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature-trees, coastlines, and earthquakes.
12. Computational Flow visualization-streamlines, pathlines, Streaklines.

Text Books:

- Nonlinear Dynamics and Chaos: S.H. Strogatz, Levant Books, Kolkata (2007).

Reference Books:

- Understanding Nonlinear Dynamics: D. Kaplan and L. Glass, Springer.
- An Introduction to Fluid Dynamics: G.K.Batchelor, Cambridge Univ. Press (2002).
- Fluid Mechanics: 2ndEdn, L.D.Landau & E.M. Lifshitz, Pergamon Press, Oxford (1987).
- 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.
- Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444.
- Scilab Image Processing: L.M.Surhone (2010) Betascript Pub., ISBN: 978-6133459274.

DSE-III: Introduction to Nuclear and Particle Physics Laboratory

---

Marks: 100

Course Objective:
To understand nuclear radiation.

Course Outcome:
1. Study the background radiation levels using a radiation meter.

Experiments List:
1. Study of counting statistics using background radiation using a GM counter.
2. Detection of alpha particles using reference source & determining its half-life.
3. Study of absorption of beta particles using a GM counter.
4. To study radiation from gamma sources.
5. To identify unknown sources.
6. Rutherford Scattering
7. Gamma-ray spectrometer
8. Compton scattering

DSE-III: Physics of Devices and Communication Laboratory

Marks: 100

Course Objective:
This course gives students deep knowledge about various electronic devices in both theoretical and practical level.

Course Outcome:
After successful completion of the course student will be able to:

1. Design and analyze the basic operations of MOSFET. and JFET in various configurations to determine frequency response and concept of voltage gain.
2. Know about different power amplifier circuits, their design and use in electronics and communication circuits.
3. Know the transistor high frequency working and its frequency response
4. Design simple circuits using voltage regulators.
5. Compare ideal op. amp and practical op. amp.

Experiments List:
At least any 8 of the following are to be done.
Experiments from both Section A and Section B:

Section-A

1. To design a power supply using a bridge rectifier and study the effect of C-filter.
2. To design the active Low pass and High pass filters of a given specification.
3. To design the active filter **(**wide bandpass and band-reject**)** of the given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.
6. To study the output characteristics of a MOSFET.
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using a Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using a transistor.
11. To study a PLL IC **(**Lock and capture range**)**.
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via the USB port of the PC.
15. Sense the input voltage at a pin of the USB port and subsequently glow the LED connected with another pin of the USB port.

Section-B:
SPICE/MULTISIM simulations for electrical networks and electronic circuits

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

Text Books:

- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A.Miller (1994) Mc-Graw Hill.

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.
- OP-Amps and Linear Integrated Circuit: R. A. Gayakwad, 4thedn. (2000) Prentice-Hall.
- Introduction to PSPICE using ORCAD for circuits & Electronics: M.H. Rashid (2003) PHI Learning.
- PC-based instrumentation; Concepts & Practice: N.Mathivanan (2007) Prentice-Hall of India.

DSE-III: Embedded Systems-Introduction to Microcontroller Laboratory

---

Marks: 100

Course Objective:

The main objective of the course is to provide practical exposure to the students on microcontroller based programmes..

Course Outcome:

1. To design and coding knowledge on 8051 Microcontroller-based programs.
2. To give the knowledge and practical exposure on connectivity and execution of interfacing devices with 8051 kit like LED displays, Keyboards, and various other devices.

Experiments List:

At least any 8 of the following are to be done.

8051 Microcontroller-based Programs and Experiments

1. To find whether the given numbers are prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LEDs. Simulate binary counter **(**8-bit**)** on the LED.
5. Program to glow the first four LEDs and then the next four using the TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segments LED display.
8. To interface the seven-segment LED display with 8051 microcontrollers and display ‘HELP’ in the seven segments LED display.
9. To toggle ‘1234’ as ‘1324’ in the seven segment LED display.
10. Interface the stepper motor with 8051 and write a program to move the motor through a given angle in the clockwise or counterclockwise direction.
11. Application of embedded systems: Temperature measurement, some information on the LCD display, interfacing a keyboard.

Arduino-based programs and Experiments:

12. Make an LED flash at different time intervals.
13. To vary the intensity of LED connected to Arduino
14. To control the speed of a stepper motor using a potentiometer connected to an Arduino
15. To display “PHYSICS” on LCD/CRO.

Text Books:

- Embedded Systems: Architecture, Programming & Design: R.Kamal (2008) Tata McGraw Hill.

Reference Books:

- The 8051 Microcontroller and Embedded Systems Using Assembly and C: M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed. (2007) Pearson Education India.
- Embedded Microcomputer System: Real-Time Interfacing: J.W.Valvano (2000) Brooks/Cole.
- Embedded System: B.K. Rao (2011) PHI Learning Pvt. Ltd.
- Embedded Microcomputer Systems: Real-time interfacing: J.W. Valvano (2011) Cengage Learning.

DSE-IV: Measurement Techniques Laboratory

Marks: 100

Course Objective:

The students will learn the use of different types of transducers and sensors to measure different parameters.

Course Outcome:

1. To characterize different types of transducers.
2. To calibrate and measure a group of semiconductor-type sensors.
3. To study and measure transducers.
4. To design and analyze different types of circuits.

Experiments List:

1. Determine output characteristics of an LVDT & measure displacement using a LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of the level using the capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters.
5. Study of distance measurement using ultrasonic transducers.
6. Calibrate Semiconductor type temperature sensor **(**AD590, LM35, or LM75**)** To measure the change in temperature of ambient using Resistance Temperature Device **(**RTD**)**.
7. Create a vacuum in a small chamber using a mechanical **(**rotary**)** pump and measure the chamber pressure using a pressure gauge.
8. Comparison of pickup of noise in cables of different types **(**co-axial, single shielded, double shielded, without shielding**)** of 2m length, understanding of the importance of grounding using a function generator of mV level & an oscilloscope.
9. To design and study the Sample and Hold Circuit.
10. Design and analyze the Clippers and Clampers circuits using junction diode
11. To plot the frequency response of a microphone.
12. To measure the Q of a coil and the influence of frequency, use a Q-meter.

Text Books:

- Electronic circuits: Handbook of design and applications: U. Tietze and C. Schenk (2008) Springer.

Reference Books:

- Basic Electronics: A text lab manual: P.B. Zbar, A.P. Malvino, M.A. Miller (1990) Mc-Graw Hill.
- Measurement, Instrumentation and Experiment Design in Physics & Engineering: M. Sayer and A. Mansingh (2005) PHI Learning.

DSE-IV: Dissertation / Project

Marks: 100

Optional Dissertation or project work in place of one Discipline Specific:

Elective paper (6 credits) in 6th Semester

SEVENTH SEMESTER

Classical Mechanics

Marks-100

Course Objective:

- Know the physical concepts and become familiar with classical mechanics and also its mathematical form.
- Develop skills in formulating and solving problems of different systems using classical mechanics.

Course Outcome:

1. Define and understand the basic concepts of mechanical systems.
2. Describe and understand the motion of a rigid body and understand the motion of a mechanical system using Lagrange and Hamilton formalism.
3. Demonstrate the working knowledge of classical mechanics and its application to standard problems such as (a) central forces, (b) the dynamics of the system of particles, (c) the motion of the rigid body.
4. Demonstrate the working knowledge of (a) Hamilton Jacobi theory, (b) Small oscillation problems, (c) complicated mechanical systems, and (d) Chaos.

MODULE-I (8 hours)

Mechanics of a system of particles:
Lagrangian Formulation, Velocity dependent potentials and Dissipation Function, conservation theorems and symmetry properties, Homogeneity and Isotropy of space and Conservation of linear and Angular momentum, Homogeneity of time, and conservation of energy.

Hamiltonian Formulation:
Calculus of variations and Euler-Lagrange's equation, Brachistochrone problem, Hamilton's principle, extension of Hamilton's principle to non-holonomic systems, Legendre transformation and the Hamilton equations of motion, physical significance of Hamiltonian, Derivation of Hamilton's equations of motion from a variational principle, Routh's procedure, Principle of least action.

MODULE-II (9 hours)

Canonical transformations:
Canonical Transformation, types of generating function, conditions for Canonical Transformation, integral invariance of Poincare, Poisson's theorem, Poisson and Lagrange bracket, Poisson and Lagrange Brackets as canonical invariant, Infinitesimal canonical Transformation and conservation theorems, Liouville's theorem.

Hamilton -Jacobi Theory:
Hamilton - Jacobi equation for Hamilton's principal function, Harmonic oscillator and Kepler's problem by Hamilton - Jacobi method, Action angle variables for the completely separable system, Kepler's problem in Action angle variables, Geometrical optics and wave mechanics.

MODULE-III (14 hours)

Small oscillation:
Problem of small oscillations, Example of two coupled oscillators, General theory of small oscillations, Normal coordinates and Normal modes of vibration, Free vibrations of a linear Tri-atomic molecule.

Rigid body motion:
The independent coordinates of a rigid body, orthogonal transformations, The Euler's angles, The Cayley-Klein parameters, Euler's theorems on the motion of a rigid body, infinitesimal rotations, rate of change of a vector, The Coriolis Force.

MODULE-IV (9 hours)

Rigid body dynamics:
Angular momentum, and kinetic energy of motion about a point. The Inertia Tensor, momentum of Inertia, Eigen-values of Inertia Tensor and the principal Axis transformation. The Heavy symmetrical Top with one point Fixed.

Non-Linear Systems:
Elementary idea about non-linearity, and chaos.

Text Book:

- Classical Mechanics: H. Goldstein.

Reference Book:

- Mechanics: L. D. Landau and E. M. Liftshitz.
- Classical Mechanics: H. C. Corben and P. Stehle.
- Classical Dynamics: J. B. Marion and S. T. Thornton.
- Analytical Mechanics: L. N. Hand and J. D. Finch.
- Classical Mechanics: J. C. Upadhyaya.

Mathematical Methods in Physics

Marks-100

Course Objective:

- Provide basic skills necessary for the application of mathematical methods in physics.
- Develop an understanding of how to use methods within the field of study of research and in the field of scientific knowledge to work independently.

Course Outcome:

1. Define the utility and limitations of a variety of powerful calculation techniques, and provide a deeper understanding of the mathematics useful in theoretical physics.
2. Understand elementary ideas in linear algebra, special functions and complex analysis.
3. Apply these to solve problems in classical, statistical, and quantum mechanics, electromagnetism as well as solid state physics.

MODULE-I

(7 hours)

Complex Variables:
Cauchy's Integral Theorem, Cauchy's integral formula, Calculus of Residues, Cauchy's residue theorem, Evaluation of definite integrals.

MODULE-II

(11 hours)

Tensor Analysis:
Cartesian tensors in three-space, Curves in three-space and Frenet formula, General Tensor Analysis, Covariant derivative, Levi-Civita and Christoffel symbol, Riemann & Ricci tensor.

MODULE-III

(11 hours)

Special Functions:
Solutions of Bessel, Laguerre, Hypergeometric, and Confluent Hypergeometric Equations by generating function methods and their properties. Solutions of inhomogeneous Partial Differential Equations by Green's function method.

MODULE-IV

(11 hours)

Groups and Group representation:
Definition of groups, Finite groups, example from solid state physics, sub groups and classes, Group Representation, Combining Representation (Chlebsch Gorden) Characters, Infinite groups and Lie groups, Lie algebra and application, Irreducible representation of SU(2), SU(3)and O(3).

Text book:

- Mathematical Methods for Physicists: G.B.Arfken, H.J.Weber **(**2013, 7th Edn., Elsevier**).**
- Mathematical Physics: H. K. Dass, Dr. Rama Verma **(**S. Chand Publishing**)**.

Reference Book:

- Methods of Theoretical Physics: P.M. Morse and H. Feshbach Vol-I, Vol-II.
- Mathematical methods for physicists: P. Dennery & A. Krzywicki.
- Group Theory and Its Application to Physical Problems: M. Hamermesh.
- Mathematical methods of physics: J. Mathews & R. L. Walker.

Quantum Mechanics-I

Marks-100

Course Objective:

- The objective of this course is to study the fundamental postulates and formalism of quantum mechanics. Along with this the student will be familiarized with operator algebra. This course also extends the discussion to study Schrodinger equation in Hydrogen atoms, harmonic oscillator etc.

Course Outcome:

1. State basic postulates of quantum mechanics in linear vector space.
2. Indicate the properties of different operators such as Hermitian operators, projection operators, unitary operators etc.
3. Solve Schrodinger's equation of harmonic oscillator problem completely by the operator method.
4. Analyze the addition of angular momentum theorems, orbital angular momentum and spin angular momentum statistics.
5. Evaluate the energy eigenvalue and eigen-function for the hydrogen atom using the Schrodinger equation.

MODULE-I

(10 hours)

General principle of Quantum mechanics:
Linear Vector Space Formulation: Linear vector Space (LVS) and its generality. Vectors: Scalar product, metric space, basis vectors, linear independence, linear superposition of general quantum states, orthonormality of basis vector, completeness relation, Schmidt's orthonormalization procedure, Dual space, Bra and Ket vectors.

Operators:
Linear, Adjoint, Hermitian, Unitary, inverse, anti-linear operators, Non-commutativity and uncertainty relation, complete set of compatible operators, simultaneous Measurement, Projection operator, eigenvalue and Eigenvector of linear, Hermitian, Unitary operators, Matrix representation of vectors and operators, matrix elements, eigenvalue equation and expectation value, algebraic result on Eigenvalues, transformation of basis vectors, similarity transformation of vectors and operators, diagonalization. Vectors of LVS, and wave function in co-ordinate, momentum, and energy representations.

MODULE-II

(6 hours)

Quantum Dynamics:
Time evolution of quantum states, time evolution of operators and their properties, Schrodinger picture, Heisenberg picture, Dirac/Interaction picture, Equation of motion, Operator method of solution of 1D Harmonic oscillator, time evolution and matrix representation of creation and annihilation operators.

MODULE-III

(14 hours)

Rotation and orbital angular momentum:
Rotation matrix, Angular momentum operators as the generation of rotation, components of angular momentum Lx, Ly, Lz and L^2 and their commutator relations, Raising and lowering operators L+ and L-; Lx, Ly, Lz and L^2 in spherical polar co-ordinates, eigenvalue and eigenfunction of Lz and L^2 (operator method), Spherical harmonics, matrix representation of Lz, L+, L_ and L^2.

Spin angular momentum:
Spin 1/2 particle, Pauli spin matrices and their properties, Eigenvalues and Eigen function, Spinor transformation under rotation.

Addition of angular momentum:
Total angular momentum J, Eigenvalue problem of Jz and J^2, Angular momentum matrices, Addition of angular momentum, and C. G. Coefficients, Angular momentum states for the composite system in the angular momenta (1/2, 1/2) and (1, 1/2).

MODULE-IV

(10 hours)

Motion in Spherical symmetric Field:
The hydrogen atom, Reduction to one-dimensional one-body problem, radial equation, Energy eigenvalue and Eigen function, degeneracy, radial probability distribution. Free particle problem in incoming, and outgoing spherical waves, expansion of plane waves in terms of spherical waves. Bound states in a 3-D square well potential, particle in a sphere.

Text book:

- Quantum Mechanics: S. Gasiorowicz.
- Quantum Mechanics: J. Sukurai/L-I Schiff/ E.Merzbacher/ A.Messiah, Vol.I.

- Quantum Mechanics: N. Zettili.
- Quantum Mechanics: R. Shankar.
- Quantum Mechanics: S. N. Biswas.
- Quantum Mechanics: A. Ghatak and S. Lokanathan.

Reference Book:

- Quantum Mechanics: A. Das.
- Quantum Mechanics (Non-Relativistic theory): L. D. Landau and E. M. Lifshitz.
- Elementary Theory of Angular Momentum: M. E. Rose.
- Principles of Quantum Mechanics: P. A. M. Dirac.

Electrodynamics

Marks-100

Course Objective:

- To understand the basic ideas and underlying mathematical formalism of electromagnetic fields.
- Use of electromagnetic field equations in vacuum and various media in different shapes and forms.

Course Outcome:

1. Define and analyze Maxwell's wave equation in different media.
2. Derive scalar and vector potential in the presence of different sources, Poynting theorem.
3. Apply the Gauge invariance condition to Maxwell's equation. Derive Maxwell's equation in co-variant form.
4. Analyze different modes of electromagnetic waves in waveguides.
5. Evaluate the angular distribution of radiation and power emitted by the dipole.
6. Show that accelerating charge produces electromagnetic radiation.

MODULE-I

(12 hours)

Maxwell's equation:
Maxwell's equations in free space; Magnetic charge; Maxwell's equations inside matter; Displacement current; Vector and scalars potentials; Wave equation for potentials; Lorentz and Coulomb gauge conditions; Wave equation for Electric and Magnetic fields in the absence of sources.

Covariant formulation of Maxwell's equation:
Lorentz transformation; Scalars, vectors and Tensors; Maxwell's equations and equations of continuity in terms of Aμ and Jμ; Electromagnetic field tensor and its dual; Covariant form of Maxwell's equations; Lagrangian for a charged particle in the presence of external electromagnetic field and Maxwell's equation as Euler-Lagrange equations.

MODULE-II

(12 hours)

Plane waves in non-conducting media:
Plane waves in non-conducting media; velocity of wave propagation and energy flow; linear, circular and elliptic polarisation; Reflection and refraction of electromagnetic waves at a plane interface between dielectrics; normal and oblique incidence; total internal reflection and polarisation by reflection; waves in dispersive media, Kramer-Kronig relation.

Plane waves in conduction media:
Plane waves in conduction media; Reflection and transmission at a conducting surface; Cylindrical cavities, and wave guides; Modes in rectangular wave guide and resonant cavities.

MODULE-III

(10 hours)

Green's function solution for retarded potential:
Green's function solution of the potential form of Maxwell's equations, Retarded and advanced Green's functions.

Multipole radiation:
Potential, Fields and radiation due to an oscillating electric dipole; radiation due to a centre-fed linear antenna; angular distribution of power radiated; Rayleigh scattering. Magnetic dipole and electric quadrupole radiation.

MODULE-IV

(6 hours)

Radiation by point charge:
Lienard-Weichert potential, Field due to a point charge, Angular distribution of radiation and total power radiated by an accelerated charge, Larmor's formula, Thomson's scattering.

Text book:

- Classical Electrodynamics: J. D. Jackson.
- Introduction to Electrodynamics: D. J. Griffiths.

Reference Book:

- Classical Theory of Fields: L. Landau and E.M. Lifshitz.
- Principles of Optics: M. Born and E. Wolf.
- Introduction to Electrodynamics: A. Z. Capri and P.V. Panat.

Research Methodology

Mark-100

Course Objective:

- To understand the digital platforms available for literature survey of scientific research articles.
- To learn how to write scientific articles, the ethics involved in that and to do scientific data analysis.

Course Outcome:

1. Re-examine literature survey for scientific research.
2. Describe citation notation and index values of scientific research articles.
3. Learn to prepare project reports and scientific research article writings.
4. Analyze and explain scientific data such as plotting, error analysis, curve fitting etc.

MODULE-I

(10 hours)

Introduction:
Research goals, significance, scope, and classification.

Literature Survey:
Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital:
Web resources, E-journals, Journal access, graphical abstract, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC Infonet, E-Books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, Wiki- Databases, Science Direct, Sci Finder, Scopus. Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for Physics. Finding and citing published information.

MODULE-II

(10 hours)

Methods of Scientific Research and Writing Scientific Papers:
Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

MODULE-III

(10 hours)

Data Analysis:
The Investigative Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments. Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis.

Text books:

- Research Methodology: Methods & Techniques: C. R. Kothari (2nd Revised Edition).

Reference Book

- Practical skills in Chemistry: J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers, & A. Jones (2011) 2nd Ed. Prentice-Hall, Harlow.
- Data analysis for Chemistry: D. B. Hibbert & J. J. Gooding (2006) Oxford University Press.
- Errors of observation and their treatment: J. Topping (1984) Fourth Ed., Chapman Hall, London.
- How to use Excel in analytical Chemistry and in general scientific data analysis: R. de Levie (2001) Cambridge Univ. Press.

Fundamentals of Computer and Programming in C

---------- **Mark-100**

Course Objectives:

- To solve physics problems through different numerical techniques.
- Use computer programming for simulation and data analysis.

Course Outcomes:

1. Explore algorithmic approaches to problem solving.
2. Ability to analyze a problem and devise an algorithm to solve it.
3. Able to formulate algorithms, pseudo codes and flowcharts for arithmetic and logical problems.
4. Ability to implement algorithms in the 'C' language.
5. Develop modular programs using control structures and arrays in 'C'.

MODULE-I

(10 hours)

Introduction

Algorithm, flowchart, Structured Programming Approach, structure of C program (header files, C preprocessor, standard library functions, etc.), identifiers, basic data types and sizes, Constants, variables, arithmetic, relational and logical operators, increment and decrement operators, conditional operator, bitwise operators, assignment operators, expressions, type conversions, conditional expressions, precedence and order of evaluation. Input-output statements, statements and blocks, if and switch statements, loops: while, do-while and for statements, break, continue, goto, programming examples.

MODULE-II

(10 hours)

Designing structured programs:

Functions, parameter passing, storage classes- extern, auto, register, static, scope rules, user-defined functions, recursive functions. Arrays- concepts, declaration, definition, accessing elements, and functions, two-dimensional and multi-dimensional arrays, applications of arrays. pointers- concepts, initialization of pointer variables, pointers and function arguments, address arithmetic, Character pointers and functions, pointers to pointers, pointers and multidimensional arrays, dynamic memory management functions, command line arguments.

MODULE- III

(10 hours)

Derived types-structures:

Declaration, definition and initialization of structures, accessing structures, nested structures, arrays of structures, structures and functions, pointers to structures, self-referential structures, unions, typedef, bit fields, and C program examples. Input and output – concept of a file, text files and binary files, streams, standard I/O, Formatted I/O, file I/O operations, error handling, C program examples.

Text books:

- "C Programming": E. Balagurusamy, Tata McGraw-Hill.
- Computer Fundamental & Programming in C": P. Dey & M. Ghosh, "-Oxford University Press.
- "C How to programme": P. Deitel H. Deitel, Pearson Publication.

Reference Book

- Let us C: Y. Kanetkar.

General Physics Laboratory

Marks-100

Course Objective:

- Develop fundamental laboratory skills and the ability to design experiments to analyze various phenomena associated with general physics.
- Develop strong quantitative skills to analyze data, including graph plotting, curve fitting, and error calculation through experiments.

Course Outcome:

1. Acquire practical laboratory skills as well as develop the ability to think critically, analyze data, and communicate the findings effectively.
2. Relate experimental observations to theoretical physics concepts, fostering a deeper understanding of the subject.

Experiments List:

1. To calculate the velocity of ultrasonic sound through a solid medium using an ultrasonic interferometer.
2. To calculate the adiabatic compressibility of the given solid using an ultrasonic interferometer
3. Verification of Stefan's law and Stefan's constant measurement.
4. Determination of magnetic susceptibility of a paramagnetic solution using Quinck's tube method.
5. Measurement of dielectric constant by plate capacitor.
6. To determine the Planck's constant using LEDs of at least 4 different colours.
7. To study different flip-flops.
8. Measurement of very small resistance using Precision Kelvin double bridge (Maxwell double bridge).
9. To determine the wavelength and angular spread of the He-Ne laser using plane diffraction grating.
10. Calibration of an oscilloscope using standard waveform.
11. Determination of particle size of lycopodium powder by light scattering.
12. To study the dependency of the magnetic field on coil diameter and number of turns using different solenoids.
13. To study the Resonance absorption of a passive RF oscillator circuit.
14. Determining the refractive index and dispersion of liquids using a hollow prism and a light source.
15. To verify the relationship of speed of light with permeability and permittivity of air.
16. Determination of specific charge of the electron (e/m)
17. Determination of electrical permittivity of free space and dielectric constant of various materials.

Programming in C Laboratory

Marks-100

Course Objectives:

- Able to do programme in C language
- Able to understand and implement algorithm of scientific programmes.

Course Outcomes:

1. Construct suitable algorithm for mathematical formula
2. Write programmes in C language for simple mathematical formulations
3. Plot the data if obtained analyze the data.
4. Do the analysis

Experiments List:

(Minimum 10 programs to be done covering 8 Experiments)

Experiment No. 1

1. Write a C program to find the sum of individual digits of a positive integer.
2. A Fibonacci sequence is defined as follows: the first and second terms in the sequence are 0 and 1. Subsequent terms are found by adding the preceding two terms in the sequence. Write a C program to generate the first n terms of the sequence.
3. Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user.

Experiment No. 2

1. Write a C program to calculate the following Sum: Sum=1-x2 /2! +x4 /4!-x6 /6!+x8 /8!-x10/10!
2. Write a C program to find the roots of a quadratic equation.

Experiment No. 3

1. Write C programs that use both recursive and non-recursive functions i) To find the factorial of a given integer. ii) To find the GCD (greatest common divisor) of two given integers. iii) To solve the Towers of Hanoi problem.

Experiment No. 4

1. Write a C program to find both the larges and smallest numbers in a list of integers.
2. Write a C program that uses functions to perform the following: i) Addition of Two Matrices ii) Multiplication of Two Matrices

Experiment No. 5

1. Write a C program that uses functions to perform the following operations: i) To insert a sub-string into to given main string from a given position. ii) To delete n Characters from a given position in a given string.
2. Write a C program to determine if the given string is a palindrome or not

Experiment No. 6

1. Write a C program to construct a pyramid of numbers.
2. Write a C program to count the lines, words and characters in a given text.

Experiment No. 7

1. Write a C program that uses functions to perform the following operations:
   - i. Reading a complex number
   - ii. Writing a complex number
   - iii. Addition of two complex numbers
   - iv. Multiplication of two complex numbers (Note: represent complex numbers using a structure.

Experiment No. 8

1. Write a C program that copies one file to another.
2. Write a C program to reverse the first n characters in a file. (Note: The file name and n are specified on the command line.

Text books:

- "C Programming": E. Balagurusamy, Tata McGraw-Hill.
- Computer Fundamental & Programming in C": P. Dey & M. Ghosh, "-Oxford University Press.
- Project Using C Scitech Publisher.
- Programming Concepts in C, DS, C++, Java: K.V.R. Rao.
- Numerical analysis, A programming approach: V. Vachharajani.

Reference Book

- Let us C: Y. Kanetkar.
- "C How to programme": P. Deitel H. Deitel, Pearson Publication.

Advanced Computational Physics Laboratory

Course Objectives:

- Able to perform scientific computing in instructed language.

Course Outcomes:

1. Construct suitable algorithm for the scientific problem.
2. Write programmes in given language with optimized algorithm.
3. Plot the data if obtained analyze the data.
4. Do the analysis.

Marks-100

Experiments List:

Introduction to computer hardware and software, introduction to storage in computer memory, stored program concepts, storage media computer operating system, LINUX, Commands;

JAVA programs on:

1. Introduction, Compiling & executing a java program.
2. Data types & variables, decision control structures: if, nested if etc.
3. Loop control structures: do, while, for etc.
4. Classes and objects.
5. Data abstraction & data hiding, inheritance, polymorphism.
6. Threads, exception handlings and applet programs
7. Interfaces and inner classes, wrapper classes, generics

Programming with FORTRAN:

Programme solving on computers-algorithm and flow charts in FORTRAN 77 data types, Exercises for acquaintance:

1. Find the largest or smallest of a given set of numbers
2. To generate and print the first hundred prime numbers
3. The sum of an AP series, GP series, Sine series, Cosine series
4. Factorial of a number
5. Transpose of a square matrix
6. Matrix multiplication and addition
7. Evaluation of log and exponentials
8. Solution of quadratic equation
9. Division of two complex numbers
10. To find the sum of the digits of a number
11. A basic introduction to parallel programming, open MP & MPI

Numerical Methods:

1. Interpolation by Lagrange methods
2. Numerical solution of simple algebraic equation by Newton-Ralphson Methods
3. Least square fit using rational functions
4. Numerical integration: Trapezoidal methods, Simsons method, Romberg method, Gauss quadrature method.
5. Eigenvalues and Eigenvectors of a matrix
6. Solution of linear homogenous equations
7. Trace of a matrix
8. Matrix inversion
9. Solution of ordinary differential equation by Runge-Kutta Method
10. Introduction to Monte Carlo techniques

Text books:

- Programming Concepts in C, DS, C++, Java: K.V.R. Rao.
- Numerical analysis,A programming approach: V. Vachharajani.

Reference Book

- Core Java:N. Rao.
- Numerical Recepies in FORTRAN: W. H. Press,S.A. Teukoysky, B.P. Flannery,W.T. Vetterling.

EIGHTH SEMESTER

Statistical Mechanics

Marks-100

Course Objective:

- Understand postulates of classical and quantum statistical mechanics
- Understand phase transitions and the Ising model to study ferromagnetism

Course Outcome:

1. State postulates of classical and quantum statistical mechanics
2. Differentiate between microstate and macrostate
3. Use the significance of Gibb's paradox and indistinguishability in statistical mechanics
4. Analyze Planck's blackbody radiation relation, electronic specific heat in metals and Bose-Einstein condensation
5. Summarize the thermodynamics of phase transition and formulate the Ising model of phase transitions for ferromagnetism.

MODULE-I

(10 hours)

Classical Statistical Mechanics:

Classical statistical Mechanics: Postulate of classical statistical mechanics, Liouville's theorem, micro canonical ensemble, review of thermodynamics, equipartition theorem, classical ideal gas, Gibb's paradox, Canonical ensemble and energy fluctuation, grand canonical ensemble and density fluctuation, Equivalence of canonical and grand canonical ensemble.

MODULE-II

(10 hours)

Quantum Statistical Mechanics:

The density matrix, ensembles in quantum statistical mechanics, Ideal gas in micro, canonical and grand canonical ensembles, and Equation of states for ideal Fermi gas. Theory of white dwarf stars, Equation of state of an ideal Bose gas, Photons and Planck's radiation law, Bose-Einstein condensation and thermodynamics in condensed state. Phonons and behaviour of specific heat of solids at different temperatures.

MODULE-III

(10 hours)

Ising model and Phase transition:

Definition of Ising model, One-dimensional Ising model, and its application to Ferromagnetism. Phase Transition: Thermodynamics description of Phase Transitions, Phase Transitions of the first and second kind, Discontinuity of specific heat, and change in symmetry in a phase transition of the second kind.

Text books:

- Statistical Physics: K. Huang.
- Statistical Physics: B. B. Laud.
- Topics in Statistical Mechanics: B. Cowan.
- Statistical Physics: R. K. Pathria.

Reference Books:

- Physics Transitions & Critical Phenomena: H. E. Stanley.
- Fundamental of statistical & Thermal physics: F. Reif.
- Elementary Statistical Physics: C. Kittel.
- Statistical Physics: F. Mohling.
- Statistical Physics: L. D. Landau and E. M. Lifsitz.

Physics of Semiconductor Devices

Marks-100

Course Objective:

- Understand the basics of semiconductor physics, analyze the charge conduction through pn junctions & BJT.
- To develop the understanding on physics of metal-semiconductor junctions, metal-insulator -semiconductor junctions & CMOS.

Course Outcome:

1. Describe the basic materials and properties of semiconductors with application to the p-n junction.
2. Understand the application of Field-Effect Transistors.
3. Use the application of Bipolar Junction Transistors.
4. Analyse the physics of semiconductor junctions, metal-semiconductor junctions and metal-insulator-semiconductor junctions, MOS transistor.

MODULE-I

(10 hours)

Introduction to the quantum theory of solids:
Basics of Semiconductor Physics: Formation of energy bands, K-space diagram (two and three-dimensional representation), conductors, semiconductors and insulators. Electrons and Holes in semiconductors: Silicon crystal structure, Donors and acceptors in the band model, electron effective mass.
Equilibrium Carrier concentration: Density of states, Thermal equilibrium, Fermi-Dirac distribution function for electrons and holes, Fermi energy. Equilibrium distribution of electrons & holes: derivation of n and p from D(E) and f(E), Fermi level and carrier concentrations, The np product and the intrinsic carrier concentration. General theory of n and p, Carrier concentrations at extremely high and low temperatures: complete ionization, partial ionization and freeze-out. Energy-band diagram and Fermi-level, Variation of E_F with doping concentration and temperature.

MODULE-II

(5 hours)

Motion and Recombination of Electrons and Holes: Carrier drift: Electron and hole mobilities, Mechanism of carrier scattering, Drift current and conductivity. Motion and Recombination of Electrons and Holes: Carrier diffusion: diffusion current, Total current density, relation between the energy diagram and potential, electric field. Einstein's relationship between diffusion coefficient and mobility. Electron- hole recombination, Thermal generation.

MODULE-III

(12 hours)

PN Junction:
Building blocks of the pn junction theory: Energy band diagram and depletion layer of a pn junction, Built-in potential; Depletion layer model: Field and potential in the depletion layer, depletion-layer width; Reverse-biased PN junction; Capacitance-voltage characteristics; Junction breakdown: peak electric field. Tunnelling breakdown and avalanche breakdown; Carrier injection under forward bias-Quasi equilibrium boundary condition; current continuity equation; Excess carriers in forward- biased pn junction; PN diode I-V characteristic, Charge storage. Application of PN Junction: Solar Cell: Types, Principle, Working Mechanism, Parameters (Jsc, Voc)

Metal-Semiconductor Junction:
Schottky Diodes: Built-in potential, Energy-band diagram, I-V characteristics, Comparison of the Schottky barrier diode and the pn-junction diode. Ohmic contacts: tunnelling barrier, specific contact resistance.

MODULE-IV

(13 hours)

The Bipolar Transistor:
Introduction, Modes of operation, Minority Carrier distribution, Collector current, Base current, current gain, Base width Modulation by collector current, Breakdown mechanism, Equivalent Circuit Models - Ebers-Moll Model.
MOS Capacitor:
The MOS structure, Energy band diagrams, Flat-band condition and flat-band voltage, Surface accumulation, surface depletion, Threshold condition and threshold voltage, MOS C-V characteristics, Q in MOSFET.
MOS Transistor:
Introduction to the MOSFET, Complementary MOS (CMOS) technology, V-I Characteristics, Surface mobilities and high-mobility FETs, JFET, MOSFET V_t, Body effect and steep retrograde doping, pinch-off voltage.
Text book:

- Physics of Semiconductor Devices: D. A. Neumann.
- Physics of Semiconductor Devices: B. B. Swain.
- Solid state Electronics Devices Bhattacharya: Rajnish Sharma.
- Semiconductor Materials and Devices: J. B. Gupta.
- Physics of Semiconductor Devices: J. J. Mohanty.

Reference Book:

- Physics of Semiconductor Devices: S. M. Sze. (Wiley).
- Solid state Electronics Devices: Ben G. Streetman and S. Banerjee.
- Physics of Semiconductor Devices: A. Acharya.
- Physics of Semiconductor Devices: Calvin Hu.
- Physics of Semiconductor Devices: Dilip K Roy.
- Fundamentals of Semiconductor Devices: M. K. Achthan and K. N. Bhatt.

Quantum Mechanics-II

Marks-100

Course Objective:

- The objective of this course is to understand various approximation methods such as perturbation theory, variational principles, and WKB method to solve simple systems.
- Along with this the student will be familiarized with scattering theory.

Course Outcome:

1. Define the energy and wave function for physical systems using time-independent perturbation theory.
2. Explain the Stark effect, the origin of polarizability and dipole moment, the fine structure of hydrogen atoms and the Zeeman effect.
3. Apply the variational principle to interpret ground state energy in diverse physical systems and solve for quantization rules for bound states and tunneling probabilities using WKB connection formula.
4. Analyze the transition probability under time-dependent perturbation theory and hence infer dipole selection rules in various atomic transitions.
5. Evaluate the scattering cross-sections for various scattering processes such as black sphere scattering, hard-sphere scattering and inelastic scattering.

MODULE-I

(13 hours)

Approximation Method for stationary states:
Rayleigh - Schrodinger Method for Time-independent Non-degenerate Perturbation theory, First and second order correction, perturbed harmonic oscillator, An-harmonic oscillator, The Stark Effect, Quadratic Stark Effect and polarizability of a Hydrogen atom, Degenerate perturbation theory, Removal of Degeneracy, parity selection rule, the linear stark effect of hydrogen atom, Spin-orbit Coupling, Relativistic correction, ne structure of Hydrogen like atom, normal and anomalous Zeeman effect, The strong- field Zeeman effect, The weak-field Zeeman effect and Lande's g-factor.

MODULE-II

(10 hours)

Variational Methods:
Rayleigh-Ritz variational technique and its application to ground State He-atom, one-dimensional harmonic oscillator, and H-atom.

WKB Approximation:
General formalism, Validity of WKB method, Connection Formulae, derivation of Bohr quantization rule, Application to Harmonic oscillator, Bound states for potential well with one rigid wall and two rigid walls, Tunnelling through potential Barrier, Cold emission, Alpha decay and Geiger - Nutal relation.

MODULE-III

(7 hours)

Time-dependent perturbation Theory:
Transition probability, constant and harmonic perturbation, Fermi Golden rule, electric dipole Radiation and Selection Rule, Spontaneous emission: Einstein's A and B - coefficients.

MODULE-IV

(10 hours)

Scattering Theory:
Scattering amplitude, and Cross section. Born approximation, Application to Coulomb and Screened Coulomb potential, Partial wave analysis for elastic and inelastic Scattering. Optical theorem, Black disc Scattering, Hard-sphere Scattering, Resonance Scattering from square well potential, Scattering of identical particles.

Text book:

- Quantum Mechanics: S. Gasiorowicz.
- Quantum Mechanics, Concept and Applications: N. Zettili.
- Quantum Mechanics: B.H. Bransden,C.J. Joachain.
- Quantum Mechanics : R. Shankar.
- Quantum Mechanics: A. Das.
- Quantum Mechanics: A. Ghatak and S. Lokanathan.

Reference Book:

- Advanced Quantum Mechanics: P. Roman.

- Quantum Mechanics (Non-Relativistic theory): L. D. Landau and E. M. Lifshitz.
- Elementary Theory of Angular Momentum: M. E. Rose.
- Principles of Quantum Mechanics: P. A. M. Dirac
- Introductory Quantum Mechanics: R.Liboff.
- Quantum Mechanics: E.Merzbacher .
- Quantum Mechanics: S. N.Biswas.
- Quantum Mechanics: L.I.Schiff.
- Quantum Mechanics vol I: A.Messiah.
- Modern Quantum Mechanics: J. J. Sakurai.

Experimental Techniques

Marks-100

Course Objective:

- Understand basic working principles to use various experimental techniques for studying structural, morphological, optical, and electrical properties of various types of materials.
- Familiar with the strengths and limitations of various experimental techniques used in condensed matter and materials physics.

Course Outcome:

Understand

1. X-ray and electron diffraction
2. Neutron diffraction
3. Electron microscopes (SEM, TEM)
4. Spectroscopic techniques (UV-visible, FTIR, RAMAN, XPS)
5. Scanning probe microscope (AFM and STM)

MODULE-I

(10 hours)

Crystallography:

Classification of Bravais lattices, Brillouin zone, X-ray diffraction (XRD), Bragg's law, Diffraction of x-rays in crystals via Laue, rotating crystal and powder method, miller indices, atomic form factor, geometric structure factor, systematic absences and analysis of simple patterns, intensity of diffraction lines in a powder pattern, peak widths, determination of lattice parameters, crystallite size and strain (device error, Williamson-Hall Method), diffraction of electrons and neutrons.

Crystal Binding:

Bond classifications – types of crystal binding, covalent, molecular and ionic crystals, London theory of van der Waals, hydrogen bonding, cohesive and Madelung energy, Vibrational Modes

MODULE-II

(10 hours)

Error Analysis:

Types of errors, Experimental uncertainty of single measurement and repeated measurements, Standard deviation, Propagation of error, Significant figures, Data Analysis

Imaging techniques:

Transmission electron microscope (TEM), scanning electron microscope (SEM), scanning Probe Microscope (SPM), Atomic Force Microscope (AFM), Scanning tunnelling Microscope (STM)

MODULE-III

(10 hours)

Spectroscopic techniques:

UV-Visible spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR) techniques, Raman, X-ray photoelectron spectroscopy, Energy Dispersive X-ray Fluorescence (EDXRF)

Text books:

- Materials Characterization: Introduction to Microscopic and Spectroscopic Methods: Y. Leng.
- Measurement, Instrumentation and Experiment Design in Physics and Engineering: M. Sayer and A. Mansingh (1999) Prentice Hall India Learning Private Limited 1st Edition.

Reference Books:

- Transmission Electron Microscopy: D. B. Williams, C. B. Carter.
- X-Ray diffraction: A practical approach: C. Suryanarayana, M. Grant Norton.
- Semiconductor material and device characterization: D. K. Schroder.
- Scanning Probe Microscopy: B. Voigtlände.
- An Introduction to Surface Analysis by XPS and AES: J. F. Watts, J. Wolstenholme.

Electronics

Marks-100

Course Objective:

- Understand operational principles, model and analysis of various operational amplifiers, Oscillators, digital circuits.
- Understand the model and analysis of radio communication and optical fibre.

Course Outcome:

1. Define the frequency response of linear amplifiers, and feedback amplifiers.
2. Explain and design differential amplifier, and integrator.
3. Describe feedback criteria for oscillation, crystal-controlled oscillator, Klystron oscillator, and the principle of multivibrator.
4. Analyze the basic logic operations of NOT, AND, OR, NAND, NOR, XOR and flip-flops.
5. Apply the basic principles of radio communications and antennas.
6. Explain the basic principles of optical fibres and electromagnetic wave propagation in optical fibre.

MODULE-I

(12 hours)

Amplifiers:
Frequency response of linear amplifiers, amplifier pass band, Direct, RC and Transformer coupled amplifiers, Frequency response, gain band-width product, Feedback amplifiers, effects of negative feedback, Boot-strapping the FET, Multistage feedback, stability in amplifiers, noise in amplifiers.

Oscillator Circuits:
Feedback criteria for oscillation, phase shift, Wien's bridge oscillator, crystal-controlled oscillator, Klystron oscillator, Principle of multivibrator.

MODULE-II

(12 hours)

Operational amplifiers:
The differential amplifiers, rejection of common mode signals. The operational amplifier input and output impedances, application of operational amplifiers, Unity-gain buffer, summing, integrating and differentiating amplifiers, comparators and logarithmic amplifiers.

Digital Circuits:
Logic fundamentals, Boolean theorem, Logic gates RTL, DTL and TTL gates, CMOS switch, RS flip- flop, JK flip-flop, Master-slave J-K flip-flop.

MODULE-III

(6 hours)

Radio Communication and Antenna:
Ionospheric propagation, Antennas of different types, superheterodyne, receiver (Block diagram). Various types of optical fibres and optical communications.

Text books:

- Electronic Fundamental and application: J . D. Ryder.
- Integrated Electronics: J. Millman, C. Halkias, C. D. Parika.
- Foundation of Electroni: D. Chattopadhyay, P.C. Rakshit, B. Saha, and N.N. Purkait.
- Optical Fibre Communication: G. Kaiser.

Reference Books:

- Int. Digital Electronics: N. W. Heap and G. W. Martin.
- Fundamentals of Optical Fibres: J. A. Buck.

Electromagnetic and Optics Laboratory

Marks-100

Course Objective:

- To analyze various situations or phenomena associated with electromagnetics and optics using basic principles.
- To introduce a broad range of physical phenomena involving optics, and electromagnetics.

Course Outcome:

1. Verify experimentally some of the laws and principles associated with electromagnetics and optics.

Experiments List:

1. Michelson's interferometer: determination of the wavelength of sodium lines.
2. Study of Fabry-Perot interferometer.
3. To study the Hall Effect in semiconductors and determine the Hall coefficient and Hall voltage.
4. To study the Hall Effect in semiconductors and determine the number density of charge carriers.
5. To study the Hall Effect in semiconductors and determine Hall mobility and Hall angle.
6. To determine the wavelength of (1) sodium and (2) Spectral lines of mercury light using plane diffraction Grating.
7. Calibration of magnetic field using Hall apparatus.
8. To study the interference using a laser and a double slit and find the wavelength of the He-Ne laser source.
9. Determination of thickness of air wedge and Newton's ring experiment.
10. Measurement of magneto-optic effect using Faraday effect.
11. Measurement of atomic spectra of discharge lamps (H_2, He, Ne).
12. Diffraction of light by straight edge using He-Ne laser.
13. Measurement of electro-optic coefficient using Kerr effect.
14. Diffraction of light by circular aperture (Pinhole).

Basic Electronics Laboratory

Marks-100

Course Objective:

- To examine the Frequency response of the operational amplifier
- To measure the frequency, amplitude and phase of signals using oscilloscopes.

Course Outcome:

1. Derive and determine various performances-based parameters and their significance for Op-Amp
2. Understand the characteristics of IC and Op-Amp and identify the internal structure
3. Analyze basic AC & DC circuits for voltage, current and power by using KVL, KCL, and network theorems
4. Use the basic logic gates and various reduction techniques of digital logic circuits in detail

Experiments List:

1. Frequency response of operational amplifier with and without feedback.
2. To study Astable multivibrator characteristics.
3. To study Bistable multivibrator characteristics.
4. To study Monostable multivibrator characteristics.
5. To design a phase shift oscillator using BJT.
6. To add two dc voltages using Op-amp in inverting and non-inverting mode.
7. To verify the superposition and maximum power transfer theorems.
8. To design a precision differential amplifier of given I/O specification using Op-amp.
9. To investigate the use of an op-amp as an Integrator.
10. To investigate the use of an op-amp as a Differentiator.
11. To study the characteristics of the Hartley oscillator.
12. To study the analog-to-digital converter (ADC) IC
13. To study the digital-to-analog converter (DAC) IC
14. To study the Sensitivity of the Wheatstone Bridge

NINTH SEMESTER

Advanced Quantum Mechanics and Quantum Field Theory

Marks-100

Course Objective:

- To impart knowledge of advanced quantum mechanics for solving relevant physical problems.
- To deepen understanding of Quantum Mechanics.

Course Outcome:

1. A working knowledge of non-relativistic and relativistic quantum mechanics including time-dependent perturbation theory, relativistic wave equations, and second quantization.
2. Explain the relativistic quantum mechanical equations, namely, the Klein-Gordon equation and the Dirac Equation.
3. Describe the second quantization and relative concept
4. Explain the formalism of relative quantum field theory.
5. Derive a mathematical description of quantum motion in electromagnetic fields.
6. Apply the relativistic wave equations to simple single-particle problems.

MODULE-I

(10 hours)

Relativistic Quantum Mechanics:
Klein-Gordon equation, its solution and drawbacks, need for Dirac equation, Properties of Dirac matrices, Non-relativistic reduction of Dirac equation, magnetic moment, Darwin's term, Spin-Orbit coupling, Poincare transformation, Lorentz group, Covariant form of Dirac equation, Bilinear covariants, Gordon decomposition.

MODULE-II

(10 hours)

Dirac Equation for free particles and symmetry Properties:
Free particle solution of Dirac equation, Projection operators for energy and spin, Physical interpretation of free particle solution, Zitterbewegung, Hole theory, Charge conjugation, space reflection and time reversal symmetries of Dirac equation.

MODULE-III

(8 hours)

Continuous systems and fields. Transition from discrete to continuous systems, Lagrangian and Hamiltonian Formulations, Noether's theorem.

MODULE-IV

(12 hours)

Quantization of free fields:
Second quantization, Quantization of scalar and Dirac fields, Propagators for scalar, spinor and vector fields, Equal Time Commutators, Normal Ordering, covariant quantization of electromagnetic field, Gauge Invariance.

Text books:

- Advanced Quantum Mechanics: J. J. Sakurai.
- Relativistic Quantum Mechanics: J. D. Bjorken and S. D. Drell.
- Quantum Field Theory: F. Mandl and G. Shaw.

Reference Books:

- Quantum Field Theory: A Modern Introduction: Michio Kaku.
- Quantum Field Theory: C. Itzykson and J. Zuber.
- Quantum Field Theory: M. E. Peskin and D. V. Schroeder.
- Quantum Field Theory: L. H.Ryder.
- Quantum Field Theory: S. Weinberg.

Nuclear and Particle Physics

Marks-100

Course Objective:

- Introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems.
- Provide students with opportunities to develop basic knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts, theories, scientific vocabulary, terminology, conventions, scientific quantities and their determination, order-of-magnitude estimates, scientific and technological applications as well as their social, economic and environmental implications.

Course Outcome:

1. Explain the different forms of radioactivity and account for their occurrence
2. Master relativistic kinematics for computations of the outcome of various reactions and decay processes.
3. Account for the fission and fusion processes.
4. Explain the effects of radiation on biological matter.
5. Classify elementary particles according to their quantum numbers and draw simple reaction diagrams.

MODULE-I

(10 hours)

General nuclear properties:
Radius, mass, binding energy, nucleon separation energy, angular momentum, parity, electromagnetic moments, excited states.

Two Nucleon Problem:
Central and noncentral forces, deuteron and its magnetic moment and quadrupole moment; Force dependent on isospin, exchange forces, charge independence and charge symmetry of nuclear force, mirror nuclei.

MODULE-II

(10 hours)

Nuclear models & Structure:
Liquid drop model, fission, magic numbers, shell model, analysis of shell model predictions, beta stability line, collective rotations & vibrations, Form factor and charge distribution of the nucleus.

MODULE-III

(10 hours)

Nuclear reaction:
Energetics of nuclear reaction, conservation laws, classification of nuclear reaction, radioactive decay, radioactive decay law, production and decay of radioactivity, radioactive dating,

Alpha decay:
Gamow theory of alpha decay and branching ratios,

Beta decay:
Energetics, angular momentum and parity selection rules, compound nucleus theory, resonance scattering, Breit- Wigner formula, Fermi's theory of beta decay, Selection rules for allowed transition, parity violation.

MODULE-IV

(10 hours)

Particle Physics:
Particle classification, fermions and bosons, lepton favours, quark flavours, electromagnetic, weak and strong processes, Spin and parity determination, Isospin, strangeness, hypercharge, baryon number, lepton number, Gell-Mann-Nishijima Scheme,

Quarks in hadrons:
Meson and baryon octet, Elementary ideas of SU(3) symmetry, charmonium, charmed mesons and B mesons, Quark spin and need for colour degree.

Text books:

- Nuclear Physics, S. N. Ghosal.
- Nuclear Physics D C Tayal.

Reference Books:

- Nuclear physics, Satyaprakash.
- Nuclear and Particle Physics, Mital, Verma, Gupta.
- Atomic and Nuclear physics, Shatendra Sharma.

Basic Condensed Matter Physics

Marks-100

Course Objective:

- The objective of the course is to understand the crystal structure, crystal bonding types in solid and study the lattice dynamics as well as magnetic properties.
- In addition to this the student will be familiarized with the semiconductor materials, nanomaterials and superconducting materials.

Course Outcome:

1. Identify the difference between direct space and reciprocal lattice space
2. Describe the mode of vibrations and Dispersion relation
3. Apply specific heat equation for the metal and insulator
4. Analyze the properties of superconductor, cooper pair and energy gap in superconductor and high Tc superconductor

MODULE-I

(10 hours)

Diffraction by crystals:
X-rays, Electrons and Neutrons, Symmetry operations and classification of Bravais lattices, common crystal structures, reciprocal lattice, space groups, translational symmetry of crystals, symmetry operations in space groups, Brillouin zone, X-ray diffraction, Bragg's law, Von Laue's formulation, diffraction from non-crystalline systems, Geometrical factors of SC, FCC, BCC and diamond lattices; Basis of quasi-crystals.

Crystal Binding:
Bond classifications – types of crystal binding, covalent, molecular and ionic crystals, London theory of van der Waals, hydrogen bonding, cohesive and Madelung energy.

MODULE-II

(10 hours)

Lattice Dynamics:
Born-Oppenheimer Approximation, Hamiltonian for lattice vibrations in the harmonic approximation, Failure of the static lattice model, adiabatic and harmonic approximation, vibrations of linear monatomic lattice, one-dimensional lattice with basis, models of three-dimensional lattices, quantization of lattice vibrations, Einstein and Debye theories of specific heat, Specific heat of metal, phonon density of states, neutron scattering.

Magnetism and Ferro electricity:
Langevin's theory of dia- and para-magnetism, Landau diamagnetism and Pauli paramagnetism, Weiss theory of ferromagnetism, Curie Weiss law of susceptibility, Heisenberg model- condition for ferro and anti-ferromagnetic order, Anti ferro magnetic order, Neel temperature.
Ferroelectric crystals, classification of Ferroelectric crystals, Multiferroics-Elementary concept

MODULE-III

(10 hours)

Band theory of Solids:
Wave equation for an electron in a periodic potential, Bloch functions, Brillouin zones E-K diagram under free electron approximation, Density of state in one dimension, effect of temperature on Fermi-Dirac distribution, Free electron gas in three dimensions, heat capacity of electron gas, electrical and thermal conductivity of metals. Nearly free electron approximation-Diffraction of electrons by lattice planes and opening of a gap in E-K diagram. The effective mass of electrons in crystals, Holes, Kronig Penney model, Tight binding approximation.

MODULE-IV

(10 hours)

Nanomaterials:
Nano structured materials-Classification based on spatial extension (0-D, 1-D, 2-D). 0-D nanostructures-quantum dots, Widening of band gap in quantum dots, 1-D nano structures-Quantum wells-super-lattices.

Superconductivity:
Phenomenology, review of basic properties, Meissner effect, Type-I and Type-II superconductors, thermodynamics of superconductors, London's phenomenological theory, flux quantization, Cooper instability, BCS theory of superconductivity, Superconducting ground state and gap equation at T= 0K. Josephson effects, Ginzburg- Landau theory, SQUID, High Tc superconductors.

Text books:

- Introduction to Solid State Physics: C. Kittel, Wiley .
- Solid State Physics, Brooks/Cole: N. W. Ashcroft and N.D. Mermin.
- Principles of the Theory of Solids, Cambridge University Press: J. M. Ziman.
- Solid State Physics: J. Dekker, Macmillan.
- Superconductivity: V. L. Ginzburg and E. A. Andryushin (World Scientific, 1994)
- Introduction to Superconductivity and high: Tc materials by Michel Cyrot and Davor Pavuna, (World Scientific, 1992).
- Fundamentals of Crystallography: C. Giacovazzo, H. L. Monaco, D. Viterbo, F. scordari, G. Gilli, G. Zanotti, M. Cattl (Oxford University Press).

Reference Books:

- Solid State Physics: G. Burns, Academic Press.
- Condensed Matter Physics: M. P. Marder, Wiley.
- Principles of Condensed Matter Physics: P. M. Chaikin and T. C. Lubensky, Cambridge University Press.
- Introduction to Superconductivity: M. Tinkham, CBS.
- Group Theory and Its Applications in Physics: T. Inui, Y. Tanabe and Y. Onodera, (Springer Series in Solid-State Sciences).
- Introduction to Superconductors: K.H. Bennemann, J. B. Ketterson.
- The Physics of quasicrystals: P.J. Steinhardt and S. Ostulond.

Nano Science and Technology

Marks-100

Course Objective:

- Gain scientific knowledge regarding nanomaterials and the size-dependent properties of nanomaterials which form basic principles for new-generation advanced devices.
- Provide students with opportunities to develop an understanding of basic scientific phenomena, structural modifications and property variation at the nano level.

Course Outcome:

1. Understand the basic properties of nanostructured materials and their device applications.
2. Provide basic ideas regarding carbon nanostructures such as C_{60} molecule, carbon nanotubes, and their applications.
3. Learn various synthesis techniques for nanomaterial fabrication.
4. Study nanostructured crystals and their physical properties.

MODULE-I

(10 hours)

Nanostructured Materials: Classification based on spatial extension (0-D, 1-D, 2-D), Surface to volume ratio and quantum confinement, Density of states, Preparation of quantum nanostructures (top-down and bottom-up approach), Size effects, Excitons, Single electron tunnelling, Applications: infrared detectors, Quantum Dot Lasers

Properties of individual Nanoparticles: Metal nanoclusters: Magic numbers, Theoretical modelling of nanoparticles, Geometric structure, electronic structures, reactivity, fluctuations, magic clusters, Bulk to nano striction

Semiconducting Nanoparticles: Optical properties, photo fragmentation, Coulombic explosion, Photoluminescence, thermo luminescence

MODULE-II

(10 hours)

Carbon nanostructures: Carbon molecules: Nature of the carbon Bond, New carbon structures Small Carbon Clusters, Discovery of C60, Structure of C60 and its crystal, Alkali-doped C_{60}, Larger and Smaller Fullerenes, Other Bucky ball

Carbon nanotubes: Fabrication, Structure, Electrical properties, Vibrational properties, Mechanical properties

Applications of carbon nanotubes: Field emission and shielding, computers, Fuel cells, Chemical Sensors, Catalysis, Mechanical Reinforcement

MODULE-III

(10 hours)

Bulk Nanostructured materials: Solid Disordered Nanostructures: Methods of synthesis, Failure mechanism of Conventional Grain- Sized Materials, Mechanical properties, Nanostructured Multilayers, Electrical properties, other properties, Metal Nanocluster Composite Glasses, Porous Silicon

Nanostructured Crystals: Natural Nanocrystals, Computational Prediction of Cluster Lattices, Arrays of nanoparticles in Zeolites, Crystals of Metal Nanoparticles, Nanoparticle Lattices in Colloidal suspensions, Photonic Crystals

Physical Properties of Nanostructured Materials: Effect of size reduction on magnetic and electric behaviour of materials, Dynamics of nanomagnets, Ferro fluids

Text books:

- Introduction to Nanotechnology: C. P. Poole, (Jr.), F. J. Owens.
- Nanocrystal Quantum dots: Victor I. Klimov (Second Edition).
- Solid State Physics: C. Kittel (Eighth Edition).

References Books:

- Solid State Physics: N. W. Ashcroft and N.D. Mermin.
- Principles of the Theory of Solids: J. M. Ziman, Cambridge University Press.
- Solid State Physics: A. J. Dekker, Macmillan.
- Superconductivity: V. L. Ginzburg and E. A. Andryushin (World Scientific, 1994).
- Introduction to Superconductivity and high-Tc materials: M.l Cyrot and D. Pavuna, (World Scientific, 1992).
- Fundamentals of Crystallography: C. Giacovazzo, H. L. Monaco, D. Viterbo, F. scordari, G. Gilli, G. Zanotti, M. Cattl (Oxford University Press).

Advanced Electronics Laboratory

Marks-100

Course Objective:

- To give knowledge of some basic electronic components and circuits.
- To give handsome train or in electronic instruments and devices.

Course Outcome:

1. Study basic circuits using diodes and transistors.
2. Introduce the basics of diode and transistor circuits.
3. Understand the working of some IC-based circuits.
4. Study logic gates and their usage in digital circuits.
5. Analyse basic AC & DC circuits for voltage, current and power by using KVL, KCL, and network theorems.
6. Use the basic logic gates and various reduction techniques of digital logic circuits in detail.

Experiments List:

1. Study of a basic configuration of OP-AMP (IC-741), simple mathematical operations and its use as comparator and Schmidt trigger
2. Study and design of differentiator, integrator and active filter circuits using OP-AMP (IC-741)
3. Study and design of phase shift oscillator using OP-AMP (IC-741)
4. Study of various logic families (DRL, DTL and TTL)
5. Study of Boolean logic operations using ICs
6. Design and study of full adder and subtractor circuits
7. Study of various stages of digital voltmeter.
8. Design and study of various counter circuits (up, down, ring, mod-n)
9. Design and study of astable multivibrators using IC-555 Timer
10. To design and study a monostable multivibrator of given specifications using 555 Timer.
11. To design a digital-to-analogue converter (DAC) of given specifications
12. Design and performance study of a constant current source
13. Design and performance study of a voltage-controlled oscillator
14. To design a switch (NOT gate) using a transistor.
15. To design and study of Wien bridge oscillator for a given frequency using an op-amp.
16. Study of various stages of the digital frequency counter.

Basic Condensed Matter Physics Laboratory

Marks-100

Course Objective:

- To develop understanding on the properties of matter.
- To give hands-on training in studying different material characteristics.

Course Outcome:

1. Study electrical, and magnetic properties.
2. Analysis mechanical, Optical Properties.

Experiments List:

1. Study of energy gap and resistivity of Germanium by four-probe method.
2. To draw the B-H curve of Fe using Solenoid & determine energy loss from Hysteresis.
3. Verification of Richardson's T3/2 law.
4. Study of Platinum resistance thermometer using Calendar and Griffith's bridge.
5. Determination of Young's modulus of a given specimen by the Coronus method
6. To determine the Coupling Coefficient of Piezoelectric crystal.
7. Determination of Planck's constant by reverse photoelectric effect method.
8. To study the PE Hysteresis loop of a Ferroelectric Crystal.
9. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
10. Dielectric constant at microwave frequency
11. To study the reflection, and refraction of microwaves
12. To study the current vs voltage characteristics of CdS photo-resistor at constant irradiance
13. To measure the photocurrent as a function of the irradiance at constant voltage
14. Determination of reverse saturation current of P-N junction

---

Literature Review and Seminar

Marks-100

Course Objective:

- To learn, practice, and critique effective scientific seminar skills.
- These skills will improve as students respond to critical feedback, and seek to make scientific information. understandable to scientists, peers, and the general public.

Course Outcome:

1. Communicate scientific discoveries in materials/devices for 30–40-minute oral presentation.
2. Understand and critique scientific presentations.

General Aspects of Oral Presentation: Presented at the level that is appropriate to the audience; clear and informative visual aids (simple, sufficient time); evident that the presenter has practised.
Introduction: Overview of your problem area provided; unfamiliar terms introduced; appropriate literature abstracted and presented clearly; research hypothesis of the study identified.
Methods: Brief overview of the equipment and materials used, and how obtained; a brief overview of the experimental design used and any other parts of the methods employed; materials and/or equipment described; procedures followed to experiment presented
Results: Anticipated and actual results reported; statistics presented.
Discussion: Implications if the hypothesis is supported clearly stated; implications if the hypothesis is not supported clearly stated; limitations of your study discussed; future research addressed
Questions: Demonstrated knowledge of the material; poised and confident, but no bluffing; answered the question(s) asked (asked for clarification or restatement of the question)

TENTH SEMESTER

Atomic and Molecular Physics

Marks-100

Course Objective:

- Describe the atomic emission/absorption spectrophotometry and molecular spectroscopy.
- Explain the rotational, vibrational, electronic and Raman spectra of molecules.

Course Outcome:

1. Describe the function of one electron atom.
2. Explain the Hyperfine structure and calculate the energy spectrum of many-electron atoms.
3. Describe the Molecular electronic state of diatomic molecules and discuss the electronic wave function.
4. The detailed studies of rotational and vibrational spectra of diatomic molecules distinguish between the different spectra of diatomic molecules.
5. Discuss the fine structure and solve the problems.
6. Explain the vibration of a polyatomic molecule using the group theory.

MODULE-I

(10 hours)

One Electron Atom:
Introduction: Quantum States; Atomic orbital; Parity of the wave function; Angular and radial distribution functions.

Hyperfine structure:
Review of Fine structure and relativistic correction, Lamb shift. Hyperfine interaction and isotope shift; Hyperfine splitting of spectral lines; selection rules.

Many electron atoms:
Independent particle model; He atom as an example of central field approximation; Central field approximation for many-electron atoms; Slatter determinant; L-S and j-j coupling; Equivalent and non-equivalent electrons; Energy levels and spectra; Spectroscopic terms; Hunds rule; Lande interval rule; Alkali spectra.

MODULE-II

(10 hours)

Molecular Electronic States:
Concept of molecular potential, Separation of electronic and nuclear wave functions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, Approximation methods for the calculation of electronic Wave function, The LCAO approach, States for Hydrogen molecular ion, Coulomb, Exchange and Overlap integrals, Symmetries of electronic wave functions; Shapes of molecular orbital and bond; Term symbol for simple molecules.

Rotation and Vibration of Molecules:
Solution of nuclear equation; Molecular rotation: Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential.

MODULE-III

(10 hours)

Spectra of Diatomic Molecules:
Transition matrix elements, Vibration-rotation spectra: Pure vibrational transitions, Pure rotational transitions, Vibration-rotation transitions, Electronic transitions: Structure, Franck-Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra.

Vibration of Polyatomic Molecules:
Application of Group Theory, Molecular symmetry; Matrix representation of the symmetry elements of a point group; Reducible and irreducible representations; Character tables for C2v and C3v point groups; Normal coordinates and normal modes; Application of group theory to molecular vibration.

Text books:

- Physics of Atoms and Molecules: B. H. Bransden and C. J. Joachain.
- Fundamentals of Molecular Spectroscopy: C. B. Banwell.

Reference Books:

- Quantum Mechanics vol. 1 and 2: C. Cohen,Tannoudji, B. Dier, and F. Laloe.
- Spectra of Diatomic Molecules: H. Herzberg.
- Molecular Spectroscopy: J. D. Graybeal.
- Principles of Quantum Mechanics: R. Shankar.

- Molecular Spectroscopy: G. M. Barrow.
- Lasers, Theory and Applications: K. Thyagarajan and A. K. Ghatak.
- Principles of Lasers: O. Svelto.
- Quantum Chemistry: B. H. Eyring, J. Walter and G. E. Kimball.
- Molecular Physics: W. Demtroder.
- Atomic and Molecular Spectroscopy: M. C. Gupta.
- Lasers and Non-linear Optics: B. Laud.
- Spectrophysics Thorne: U. Litzen and J. Johnson.

Advanced Condensed Matter Physics

Course Objective:

- The objective of the course is to discuss the basic principles responsible for several properties of solids. Different theories related to electron interaction and magnetism will be discussed in detail.
- In addition to this the students will be familiar with their optical properties and also have insights into the defects in solids.

Course Outcome:

Upon successful completion of this course, students will have/ be able:

1. Explain the basic principles underlying solids scientifically.
2. State and derive different types of magnetism in mathematical forms like the Curie –Weiss law for susceptibility
3. Understand the Landau theory of phase transition
4. Describe the Kramers-kronig relation for dielectric materials
5. Understand the Defects in solids
6. A broad understanding of the optical properties of solids.

Marks-100

MODULE-I

(12 hours)

Magnetism:

Classification of different types of magnetism: Diamagnetism, Paramagnetism, Ferromagnetism, Anti-ferromagnetism, Ferrimagnetism, Helical order. Ferromagnetic domains, Magnetic anisotropy energy, Hysteresis. Heisenberg and Ising Model, Excitations: magnon contribution to specific heat, Bloch's $T^{3/2}$ Law. Frustration, spin glasses, superparamagnetism, 1D and 2D magnets.

Transport Properties:

The Boltzmann equation electrical conductivity, general transport coefficients, thermal conductivity, thermoelectric effect, Magneto-resistance: Magneto-resistance of ferromagnets, anisotropic magnetoresistance, Giant magneto-resistance and Colossal magnetoresistance, Hall effect, Elementary ideas on Quantum Hall Effect.

MODULE-II

(10 hours)

Electron Interaction:

Perturbation formulation, Hartree Equation, Hartree-Fock Equation, Dielectric function of an interacting electron gas (Lindhard"s expression), Static screening, Thomas-Fermi theory of Screening, Screened impurity, Kohn effect, Friedel Oscillations and sum rule, Dielectric constant of semiconductor, Plasma oscillations.

MODULE-III

(10 hours)

Optical properties of solids:

The dielectric function: the dielectric function for a harmonic oscillator, dielectric losses of electrons, Kramers-Kronig relations, Interaction of phonons and electrons with photons, Interband transition - direct and indirect transition; Absorption in insulators, Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect.

MODULE-IV

(08 hours)

Fermi Surface:

Experimental methods of study of Fermi surface, Cyclotron Resonance, de Hass van Alphen effect.

Defects in Crystals:

Lattice defects, Frenkel and Schottky defects. Line defects, edge and screw dislocations – Burger"s vector, planner (stacking) faults-twin planes and grain boundaries, dislocation densities, dislocation multiplication and slip strength of crystal, color centers, polarons and excitons.

Text books:

- Magnetism in Condensed Matter: Stephen Blundell, Oxford University Press.
- Magnetism and Magnetic Materials: J. M. D. Coey, Cambridge University Press.
- Introduction to Magnetic Materials: B. D. Cullity, Wiley.
- Introduction to Solid State Physics: C. Kittel, Wiley.
- Solid State Physics: N. W. Ashcroft and N.D. Mermin, Brooks/Cole.
- Principles of the Theory of Solids: J.M. Ziman, Cambridge University Press.
- Advanced Solid-State Physics: P. Phillips, Overseas Press, India Pvt. Ltd.

- Solid State Physics: A. K. Saxena, Trinity Publication.

Reference Books:

- Introduction to Modern Solid-State Physics: Y. M. Galperin.
- Introduction to Solids: N.W. Ashcroft, N.D. Mermin.
- Elementary Solid-State Physics: A. Omar.
- Solid state physics: A.J. Dekkar Macmillan, London.
- Solid State Physics: H.E. Hall.
- Introduction to Modern Solid-State Physics: Y. M. Galperin.
- Principles of Condensed Matter Physics: P.M. Chaikin and T.C. Lubensky.
- Solid State Physics, Essential Concepts: D. W. Snoke, Pearson Education (2009).

Advanced Particle Physics

Mark-100

Course Objective:

- Understand the mathematical formalism of field theory and use them for elementary particles.
- Understand various phenomena discovered in particle physics in projection to discovery.

Course Outcome:

1. Explain the properties of various elementary particles.
2. Derivation of relevant mathematical formalism (group theoretical/ integral) for the different processes associated with elementary particles.

MODULE-I (10 hours)

Symmetry: Different types of symmetries and conservation laws. Noethers' theorem.
Symmetry groups and Quark model: SU(2) and SU(3): quark model, colour, heavy quarks and their hadrons.

MODULE-II (10 hours)

Lorentz Group: Continuous and discrete transformations, Group structure, Proper and improper Lorentz Transformations, SL(2, C) representations, Poincare group.
Interacting fields: Interaction picture, covariant perturbation theory, S-matrix, Wicks theorem, Feynman diagrams.

MODULE-III (10 hours)

QED: Feynman rules, Example of actual calculations: Rutherford, Bhabha, Moeller, Compton, e+ e-⟶ μ+ μ -. Decay and scattering kinematics. Mandelstam variables and use of crossing symmetry.
Gauge theories: Gauge invariance in QED, non-abelian gauge theories, QCD (introduction), Spontaneous symmetry breaking, Higgs mechanism.

MODULE-IV (10 hours)

Weak Theory: Classification of weak interactions, Parity violation, Elementary notions of leptonic decay of strange particles. Cabibbo-angle and Cabibbo hypothesis.
Electroweak Theory: Weak Isospin and hypercharge. Basic electro-weak interaction. Spontaneous symmetry breaking. Standard Model, Gauge boson and fermion masses.

Text books:

- Introduction to elementary particles: David J Griffith.
- Quantum Field Theory: M. Peskin and F. Schroeder:

Reference Books:

- Quantum Field Theory: A Modern Introduction: M. Kaku.
- Relativistic Quantum Fields: J. D. Bjorken and S. D. Drell.
- Introduction to Gauge Field Theory: D. Bailin and A. Love.
- A First Book of Quantum Field Theory: A. Lahiri and P. B. Pal.
- A Modern Primer Quantum Field Theory: F. Mandl and G. Shaw.
- Field Theory: P. Ramond.
- Quantum Field Theory: C. Itzykson and J. B. Zuber.
- Quarks and Leptons: F. Halzen and A. D. Martin.
- Dynamics of the Standard Model: J. Donoghue, E. Golowich and B. Holstein.
- Gauge Theories in Particle Physics: T. -P. Cheng and L. -F. Li.
- An Introduction to Gauge Theories and Modern Particle Physics: E. Leader and E. Predazzi.
- An Introduction to Quarks and Partons: F. E. Close.

Vacuum Technology and Cryogenics

Marks-100

Course Objective:

- Understand the concepts of pressure and vacuum.
- Understand the need for a vacuum for certain applications.
- Understand the procedure for creating a vacuum with related instruments.

Course Outcome:

1. Application of vacuum at various instruments (specific pumps).
2. Use of vacuum pumps in sequences. (i.e. in sputtering, TEM, etc..).
3. Know the use of gas cylinders, gas flow, clamps and valves.

MODULE-I (10 hours)

Behaviour of gases; Gas Transport phenomenon, Viscous, molecular and transition flow regimes, measurement of pressure, Residual gas analyses.

MODULE-II (10 hours)

Production of vacuum-mechanical pumps, Diffusion pumps, Getter and ion pumps, cryopumps, the material used in a vacuum; high vacuum and ultra-high vacuum systems; Leak detection, Vacuum gauges

MODULE-III (10 hours)

Properties of engineering material at low temperature; cryogenic fluids-Hydrogen, Helium3, Helium4, superfluidity, experimental method at low temperature: closed cycle, Refrigerators, single and double cycle He 3 refrigerator, He4 refrigerator, He3-He4 dilution refrigerator, pomeranchuk cooling, pulsed refrigerator system, magnetic refrigerator, Thermoelectric coolers; Cryostat Design: Cryogenic level sensors, Handling of cryogenic liquids, Cryogenic thermometry.

Text book:

- Handbook of Vacuum Science and Technology Edited by: Dorothy M. Hoffman, Bawa Singh, John H. Thomas III and John H. Thomas III, ISBN: 978-0-12-352065-4.
- The Art of Cryogenics, 1st Edition, Low-Temperature Experimental Techniques, Guglielmo Ventura Lara Risegari.

Reference Book:

- Vacuum Science and Technology: V.V. Rao, T.B. Gosh, K.L. Chopra.
- Vacuum Science, Technology and Applications: Pramod K. Naik.

Material Science

Marks-100

Course Objective:

- Understand the mechanical, thermal, dielectric, magnetic and optical properties of various materials.
- Understand the broad classification of advanced materials.

Course Outcome:

1. Identify mechanical, thermal properties of materials and their optical phenomena.
2. Discuss various properties of dielectric materials, plasmons, polarons, polaritons .
3. Demonstrate fundamentals on magnetic materials properties and their application.
4. Classify advanced materials and their properties.

MODULE-I (12 hours)

Mechanical Properties: Tensile Strength, stress-strain behavior, ductile and brittle material, toughness, hardness, fatigue, creep and fracture.

Thermal properties: Thermal conductivity, thermoelectric effects, heat capacity, thermal stress.

Application to optical phenomena: Luminescence, photoconductivity, LED materials, optical fibers in communication. Lasers: Basic elements of a laser, population inversion, optical resonators, Q-switching and mode locking, three and four-level laser system: Ruby, He- Ne and semiconductor diode laser.

MODULE-II (12 hours)

Dielectrics, Plasmons, polarons, and Polaritons:

Fundamental of dielectrics: Dielectric constant and polarizability, mechanism of polarization, kinds of polarization, molecular field in a dielectric, Clausius-Mossotti equation, classical theory of electronic polarizability, frequency dependent polarization, dielectric loss, dielectric relaxation, dielectric breakdown. Ferroelectricity: Theory, types and properties of ferroelectrics, domains, imperfections and polarization reversals, Polarization catastrophe, Soft optical phonons, Landau theory of phase transition-second and first-order transition, antiferroelectricity, piezoelectricity and pyroelectricity. Metal plasma, plasmon excitation, electron-phonon interaction in ionic crystals (polarons). Ionic polarization: Application to long wavelength optical modes of ionic crystals, condition for transverse optical mode, the interaction of electromagnetic waves with optical modes (polaritons).

Magnetic properties: Exchange interactions: direct and indirect interactions, magnetic anisotropy, hard and soft magnetic materials, magnetic bubbles, spin waves (magnons), magnetoresistance, GMR materials, dilute magnetic semiconductor (DMS) materials, technological application in memory devices, sensors.

MODULE-III (6 hours)

Soft condensed matter: Polymeric materials: Thermosetting and thermoplastics.

Composite materials: Fibre reinforced composites, Polymer matrix composites, Metal-matrix composites, Ceramic-matrix composite, Carbon-carbon composites.

Ceramic materials: Properties and applications of ceramic materials.

Advanced materials: Brief description of corrosion resistant materials, nanophase materials, metallic glasses**,** smart materials, piezoelectric, magnetostrictive, electrostrictive materials, shape memory alloys, rheological fluids, CCD device materials.

Text book:

- Material Science and Engineering: W. D. Callister, Jr. D. G. Rethwisch, Wiley.
- Materials Science: M Vijaya, Rangarajan G, McGraw Hill Education.

Reference Book:

- Materials Science of Thin Films, Deposition and Structure: M. Ohring.
- Elements of Material Science and Engineering: V. Vlack.
- Introduction to Polymer Science and Technology: N. B. Singh, S. S. Das.
- Polymer Science and Technology: J. R. Fried.
- Ceramic Materials: Synthesis, Performance and Applications: J. Perez.
- Advanced Structural Ceramics: B. Basu, K. Balani.
- Introduction to Laser Technology: C. B. Hitz, J. J. Ewing, J. Hecht.
- Laser System and Applications: V. Saluja,Satya Prakash.
- Lasers and Optoelectronics: Fundamentals, Devices and Applications: A. K. Maini.
- Materials Science and Engineering: V. Raghavan.

Modern Physics Laboratory

Marks-100

Course Objective:

- To introduce students to the principles and operations of modern physics experiments.

Course Outcome:

1. Express the energy and Balmar series of the Hydrogen spectrum.
2. Know about the Millikan oil drop experiments.
3. Demonstrate the energy spectrum of the Normal Zeman effect.
4. Explain the change in intensity as polarized light passes through a polarizing filter.
5. Explain the working principle of lasers
6. Calculate the Rydberg constant of the hydrogen spectrum.

Experiments List:

1. To study the different spectra (up to 3rd order of Balmer series of Hydrogen spectra and estimate the Rydberg constant.
2. To set up the Millikan oil drop apparatus and determine the charge of an electron.
3. To demonstrate the quantum nature of charge using the Millikan oil drop apparatus
4. Existence of discrete energy level by Frank Hertz experiment.
5. To study the effect of filament voltage and anode plate voltage on the Frank-Hertz characteristic curve for neon
6. Study of polarization using Malus Law.
7. Determination of Brewster's angle.
8. To analyze elliptically polarized Light by using a Babinets compensator.
9. To study damping oscillations in various mediums.
10. Rectification by junction Diode using various filters.
11. Study of junction capacitance of P-N junction
12. To study the Normal and Anomalous Zeeman effect
13. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece

---

Project

Marks-100

Course Objective:

- To carry out research on a certain topic given by the supervisor.
- To do literature survey

Course Outcome:

1. To present research outcome in the seminar.
2. Submit a project thesis
3. Able to answer the question of the examiner.

Project evaluation guidelines:

Every student will have to complete the project in the Semester with 100 marks. Students can take one long project (especially for SSP / SSE / Material Sc. / Nanotechnology / Nuclear /Particle physics etc). However, for the project students have to submit a dissertation consisting of the problem definition, literature survey and status, objectives, methodology, experimental work, results and analysis. The project can be theoretical or experimental, related to advanced topics, electronic circuits, models, industrial projects, training in a research institute, training in handling sophisticated equipment etc. A maximum of three students can do a joint project. Each one of them will submit a separate project report with details/parts only he/she has done. However, he/she can in brief (on page one or two) mention in the Introduction section what other group members have done. In the case of electronic projects, the use of readymade electronic kits available in the market should be avoided. The electronics project/models should be demonstrated during the presentation of the project. In case a student takes training in a research institute/training of handling sophisticated equipment, he/she should mention in a report what training he/she has got, which instruments he/she handled and their principle and operation etc.

Each project will be 100 marks by internal evaluation.

The project report should be le bound/spiral bound/hardbound and should have the following format

- Title Page/Cover page
- Certificate endorsed by Project Supervisor and Head of Department
- Declaration
- Abstract of the project
- Table of Contents
- List of Figures
- List of Table

Chapters of Content:

- Introduction and Objectives of the Project Experimental/Theoretical
- Methodology/Circuit/Model etc. details Results and Discussion if any
- Conclusions
- References

Evaluation by the Internal examiner will be based on the following criteria:

Criteria	**Maximum Marks**
Literature Survey	10
Objectives/Plan of the project	10
Experimental/Theoretical methodology/Working condition of project or model	20
Significance and originality of the study/Society application and Inclusion of recent References	10
Depth of knowledge in the subject / Results and Discussions	20
Presentation	30
Total marks	100

Advanced Condensed Matter Physics Laboratory

Marks-100

Course Objective:

- To introduce students to advanced condensed matter physics experiments
- To get knowledge on the characteristics of different materials

Course Outcome:

1. Explain Lande's g factor using ESR
2. Analyze magnetic susceptibility by Gacoy-ballance
3. Study the characteristics of MOSFET, Thermo-EMF of a thermocouple
4. Study various techniques ; XRD, SEM, and UV visible spectroscopy.

Experiments List:

1. Determination of magnetic susceptibility by Guoy-balance.
2. Measurement of Lande's g factor of DPPII by ESR at Microwave frequency.
3. To observe the Meissner effect and determine the transition temperature of a given superconductor.
4. To study MOSFET characteristics.
5. Determination of Thermo-EMF of a thermocouple
6. Determination of Magnetoresistance of Bismuth.
7. To characterize Solar cells and find out their power conversion efficiency.
8. To determine the Dielectric constant of solid (wax) by Lecher Wire
9. To study lattice vibrations in mono- and di-atomic lattice using a lattice dynamics kit.
10. Preparation of thin film using spin coating techniques
11. Study of the lattice parameter of a given material using X-ray diffraction technique
12. To determine the magnetic moment of an electron using ESR equipment 1
13. To study the dielectric properties of a given substance using an Impedance analyzer
14. Characterization of a given nanomaterial by Scanning electron microscope
15. To verify the Beer-Lambert law using a UV-visible spectrometer.

Advanced Particle Physics Laboratory

Marks-100

Course Objective:

- To understand the detection principles and mechanism of various detectors.

Course Outcome:

1. Calibrate the detectors and obtain the data
2. Analyze the data obtained from various detectors.
3. Carry out error analysis and need for improvement.

Experiments List:

1. Calibration of the x-ray spectrometer and determination of x-ray energy of unknown sources.
2. Determination of resolving power of x-ray spectrometers.
3. Study of β spectrum.
4. Determination of absorption coefficient of Aluminum using G. M Counter.
5. X-test and operating point determination using G-N tube.
6. Characteristics of G. M. counter.
7. Study of surface barrier detector.
8. Study of counter technique.
9. Study of single channel analyzer.
10. Study of the photodetector and photomultiplier.
11. Study of wide-band amplifier.
12. Emulsion photograph studies

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

Pass Syllabus

First Semester

PHYSICS-I (Mechanics and Waves)

Marks-100

Course Objective:

This course enables the student

- To know central, conservative forces and mathematically understand the conservative theorems of energy, linear momentum and angular Momentum.
- To know about various types of oscillation undamped, damped and forced oscillations.

Course Outcome:

1. State the conservation principles involving momentum, angular momentum and energy and understand that they follow from the fundamental equations of motion
2. Have a deep understanding of Newton's laws, and properties of matter.
3. Solve for the solutions and describe the behaviour of a damped and driven harmonic oscillator in both time and frequency domains
4. Describe the behaviour of waves at interfaces **(**reflection, transmission, impedance**)** and their behaviour in dissipative media **(**damping**)**

MODULE-I

(12 hours)

The motion of a system of particles: centre of mass, velocity, acceleration, momentum, Equation of motion, Kinetic energy and angular momentum of centre of mass. Conservation of linear momentum and angular momentum for a system of particles, the moment of inertia, parallel axis theorem perpendicular axis theorem. Moment of inertia of cylinder and sphere. Rotational kinetic energy and power, g by a compound pendulum **(**bar pendulum**)**. Gravitational force, field potential energy and potential, gravitational potential and field at a point due to a thin spherical shell and a solid sphere.

Central force motion, reduction of two body problems into an equivalent one-body problem, general characteristics of central force motion. Derivation of Kepler's laws of planetary motion from gravitational force.

MODULE-II

(8 hours)

Relation between elastic constants. Torsion of a cylinder, bending of beams, expression for bending moment, equation for bending, depression occurring at the free ends of a light, heavy cantilever.

The viscosity of liquids, laminar flow through a narrow tube and Poisseuille's formula surface tension-pressure difference across the curved membrane.

MODULE-III

(10 hours)

Oscillation and Waves

Simple harmonic oscillator, damped harmonic oscillator, power loss, Q-factor, overdamped motion, critical damping, forced vibration, resonance, sharpness of resonance. Mathematical description of traveling waves, wave equation. Transverse waves in a stretched string longitudinal waves in a gaseous medium.

Text Books:

- Classical Mechanics: H Goldstein **(**Narosa**)**.
- Mechanics: D. S Mathur **(**S. Chand**)**.
- Classical Mechanics: M. Das, P.K Jena **(**Sri Krishna Publication**).**

Reference Books:

- Classical Mechanics: N. Rana And P. Joag **(**TMH**)**.
- Introduction to Classical Mechanics: R. Takwale & P. Purnaik **(**TMH**)**.
- Mechanics: K.R Simon **(**Addison Wesley**).**
- Properties of matter: V.H.L. Searle and F.H. Neaman **(**Arnold Publication**)**.
- Classical Mechanics: T. Kibble, F.H. Berkshire.

PHYSICS LABORATORY-I (Mechanics, Thermal Physics Laboratory)

Marks-100

Course Objective:

- To introduce different experiments to test the basic understanding of physics concepts.

Course Outcome:

1. The hands-on exercises undergone by the students will help them to apply physics principles.

Experiments List:

1. Determination of accurate weight of a body using balance by Gauss method.
2. Error analysis using a vernier calliper, screw gauge and spherometer.
3. Determination of velocity of sound by resonance column method.
4. To determine the acceleration due to gravity by bar pendulum and study the effect of amplitude on time period.
5. To determine the acceleration due to gravity by Kater's pendulum.
6. Verification of laws of vibration of string using sonometer.
7. Determination of Young's modulus of wire by Searle's method.
8. Determination of rigidity modulus of the rod by static method.
9. Determination of surface tension of water by using capillary rise method.
10. Determination of viscosity of liquid by Poisuelies method.
11. Determination of specific heat of solid/liquid applying radiation correction.
12. To study the velocity of sound by Kundt's tube.
13. Calculate the surface tension of mercury by using the capillary rise method.
14. To determine the moment of inertia of a flywheel about its axis of rotation.
15. To determine the Young's modulus of a wire using the optical lever method.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

Second Semester

PHYSICS-II (Electricity, Magnetism and Electronics)

Marks-100

Course Objective:

- To study the close connection between electricity and magnetism led to the discovery of electromagnetic waves.
- To have basic knowledge on electronic components like diode, transistor, Oscillators and switching circuits.

Course Outcome:

1. Learn Coulomb's law and Gauss' law for the electrostatic force
2. Understand the relationship between electrostatic field and electrostatic potential
3. Use Ampere's law to calculate magnetic fields
4. Use Faraday's law in induction problems
5. Understand the basic laws that underlie the properties of electric circuit elements

MODULE-I

(8 hours)

Scalar and vector triple product, Differentiation of a vector, The gradient operator, The divergence and curl of vector, Gauss divergence theorem, Stokes theorem. Gauss law in electrostatics and application, Computation of field due to linear spherical and plane charge distribution, Differential form of Gauss law, the energy of a point charge, discrete and continuous distribution, energy density of the electrostatic field.

MODULE-II

(12 hours)

Magnetic field B, Lorentz force law, The Biot Savart law B due to straight, circular, and solenoidal currents. The vector potential, Ampere circuital law & its differential form. Differential form of electromagnetic induction.

Maxwell equation and physical significance, Wave equation, Electromagnetic waves, Wave properties, speed, growth and decay current in RC and LR circuits, impedance, Power in AC circuit, power factor, series and parallel resonant circuits, Sharpness of resonance, Bandwidth and Q-factor.

MODULE-III

(10 hours)

Rectifier:

Half wave & full wave rectifier **(**semiconductor devices**)** Principle, circuit, operation & theory. Use of L & π filters in rectifier circuits **(**qualitative idea**)**

Amplifier:

Classification of amplifier, comparison, Voltage & power gain in CB, CE & CC configuration and characteristics studies, RC coupled amplifier, Class B Push/pull amplifier **(**principle of amplification circuit description operation, theory and frequency response curve**)**, feedback Amplifier: Basic circuit, operation, advantage of negative feedback.

Oscillator

Necessary feedback, positive & negative feedback, criteria for sustained oscillation, Hartly and Colpitt's oscillator **(**principle, circuit, operation, theory and use**)**,

Modulation & demodulation:

Principle of modulation, A.M & F.M **(**Theory and differences between them**)**, Principle of demodulation.

Text Books:

- Introduction to Electrodynamics : D. J Griffiths **(**PHI**)**
- Electronics : Chattopadhyay & Rakshit **(**New Age**)**
- Electronics : B. B Swain
- Electricity and magnetism : D. C Tayal
- Electricity and magnetism : Satyaprakash

Reference Books:

- Foundation of electromagnetic theory : Ritz and Milford **(**Narosa**)**
- Electricity and magnetism : E. Purcell **(**Berkeley Physics Course**)** TMH

PHYSICS LABORATORY-II (Electricity, Magnetism and Optics Laboratory)

Marks-100

Course Objective:

To introduce different experiments to test the basic understanding of physics concepts.

Course Outcome:

1. The hands-on exercises undergone by the students will help them to apply physics principles.

Experiments List:

1. Determination of wavelength of sodium light by using Newton's ring method.
2. Determination of grating element of grating spectra.
3. Determination of wavelength of Laser using diffraction grating.
4. Determination of the magnifying power of a microscope.
5. Determination of the magnifying power of a telescope.
6. Figure of merit of a Galvanometer.
7. Resistance of a resistor using a meter bridge **(**applying end correction**)**.
8. Study the charging and discharging process of a capacitor through a resistor.
9. LCR impedance apparatus.
10. Calibration of CRO.
11. To determine the self-inductance of a coil by Rayleigh's method.
12. To determine the mutual inductance of two coils by absolute method.
13. To determine the self-inductance of a coil by Anderson's bridge.
14. Conversion of the voltmeter to ammeter and vice-versa.
15. To study the force experienced by a current-carrying conductor placed in a magnetic field **(**Lorentz's force**)** using a mechanical balance.

School of Basic Sciences & Humanities
Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

Third Semester

PHYSICS-III (Optics and Quantum Mechanics)

Marks: 100

Course Objective:
This course enables the student
- To provide an in-depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.
- To understand the role of uncertainty in quantum mechanics and knowledge of behavior of microscopic particles.

Course Outcome:
1. Fermat's Principle can be used to establish laws of reflection and refraction at spherical surfaces.
2. The interference chapter gives the concept of light wave and its equation, meaning of coherence, interference fringes etc.
3. The diffraction chapter explains various types of diffractions in detail, knowledge of grating and its resolving power.
4. To study time-dependent and independent Schrodinger's equations with solutions in simple potentials.

.

MODULE-I

(12 hours)

Fermat's principle, reflection and refraction at plane interference, cardinal points of a coaxial optical system, cardinal points of the combination of two thin lenses, elementary ideas of monochromatic aberrations and remedies, chromatic aberration, achromatic combination, Ramsden's and Huygens's eyepieces,
Wave theory of light, Huygens principle, condition of interference, division of wavefront, biprism, the colour of thin films, Newton's ring, and determination of the wavelength of monochromatic light by Newton's ring.

MODULE-II

(8 hours)

Diffraction of light, Fresnel and Fraunhofer diffraction, Fresnel's half-period zones, Zone plate act as a convex lens. Fraunhoffer diffraction by a single slit,
Electromagnetic nature of light, Polarized and unpolarized light. Plane polarized, circularly polarized and elliptically polarized light. Polarization by reflection and refraction, Brewster's law, Malus's law. Double refraction, ordinary and extraordinary rays, construction, working and uses of Nicol prism. Half wave plate and quarter wave plate.

MODULE-III

(10 hours)

Inadequacy of classical physics: review of black body radiation. Particle nature of wave, photoelectric effect, Compton effect, dual nature of radiation. Wave nature of particle-De Broglie hypothesis and wave-particle duality. Superposition of two waves, group velocity and phase velocity, wave packet. Experimental confirmation of matter waves **(**Davisson-Germer experiment**)**. Heisenberg's uncertainty principle and applications **(**Ground state energy of the harmonic oscillator, Time-dependent Schrodinger equation in one and three dimensions. The wave function, equation of continuity, probability current density and probability density. Normalization of the wave function, Expectation value of an observable. **(**6**)**

Text Books:
- Optics : A.K. Ghatak.
- Introduction to Quantum Mechanics : M. Das, P.K.Jena **(**Srikrishna Prakashan**)**.

Reference Books:
- Principle of optics : B.K.Mathur.
- Optics : P.K. Chakravarty.
- Physics for degree students : M. Das, P.K.Jena, VOL III and IV **(**Srikrishna Prakashan**)**.
- Quantum mechanics : J.L. Powell, B. Crasemann.

PHYSICS LABORATORY-III (Optics and Electricity Laboratory)

Marks: 100

Course Objective:

This course enables the student

- To demonstrate various phenomena related to the wave nature of light.
- To have a basic idea on electrical circuits: LCR circuit.

Course Outcome:

1. To know and handle optical instruments: spectrometer, telescope, traveling microscope etc.
2. To find electrical parameters using electrical circuits.

Experiments List:

1. The angle of minimum deviation **(**I-D curve**)** using the spectrometer.
2. Determination of resolving power of a telescope
3. The optical rotation of sugar solution by polarimeter.
4. The refractive index of a glass slab using a traveling microscope.
5. The refractive index of water using a traveling microscope.
6. Determination of radius of curvature of a spherical mirror by Kohlrausch's method.
7. Determination of dispersive power of the material of the prism.
8. To measure the voltage and Frequency of a sinusoidal waveform using a CRO and to find unknown frequencies by producing a Lissajous figure.
9. To study parallel resonant LCR circuits.
10. To study series resonant LCR circuits.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Effective from 2023-24)

School of Basic Sciences & Humanities

Course: Integrated M. Sc., Programme: Physics, Duration: 5 years (Ten Semesters)

Fourth Semester

PHYSICS-IV (Thermodynamics, Atomic Physics & Nuclear Physics)

Marks: 100

Course Objective:

This course enables the student

- To understand the concept of thermodynamics and their laws and also to learn about concepts of nuclear physics, nuclear energies.

Course Outcome:

1. To analyze the thermodynamic function and their relations.
2. To visualize the emission spectra associated with particular temperatures and to understand how Planck's law can be used to plot blackbody curves of objects with different temperatures.
3. To learn the fundamentals of atomic structure.

MODULE-I

(12 hours)

Thermodynamic system and thermodynamic equilibrium, Reversible and irreversible process, internal energy, the first law of thermodynamics, the difference between molar specific heat of an ideal gas, Derivation of relation PV^{γ} =constant for adiabatic process, work done in isothermal and adiabatic process. Entropy changes in various processes. T-S diagram, Carnot cycle, Carnot engine and its efficiency, Carnot theorem, the second law of thermodynamics-Kelvin plank and Clausius formulation, their equivalence, the thermodynamic scale of temperature.

Thermodynamics coordinates P.V.T and 1st Tds equation, 2nd Tds equation. Clausius-Clapeyron equation, effect of pressure on melting point and boiling point, thermal conductivity, differential equation of heat flow in one-dimension, experimental determination of thermal conductivity by Ingen-Haus and Searl's method. Vandewall's equation of state for real gases, critical constants, reduced equation of state.

MODULE-II

(10 hours)

Black body radiation, Stefan's law, energy distribution in the blackbody spectrum. Wien's displacement law, Wein's formula and Rayleigh-jeans formula **(**only statement and discussion**)**.Planck's radiation formula, the derivative of Rayleigh-jeans formula. Wein's formula and Stefan Boltzmann's law using Planck's formula.

Rutherford's atomic model and its shortcomings, Bohr's theory of hydrogen atom. Energy levels, explanation of spectra, correction for nuclear motion, Bohr's correspondence principle. Frank-Hertz experiment, critical potential.

MODULE-III

(8 hours)

The atomic nucleus: its size, mass, charge, spin, magnetic moment, Mass defect, binding energy, stability of nuclear force - its characteristics, Radioactive decay law, activity decay law, activity, half-life, average life, elementary idea of nuclear fission and fusion. Linear accelerator, cyclotron.

Text Books:

- Heat and Thermodynamics : A. B.Gupta & H. B. Ray **(**New Central**)**
- Physics for degree students-vol-I, II : M. Das.
- Modern Physics : R.Murugeshan.
- Atomic and nuclear physics : Satyapraksh.

Reference Books:

- Sound : M.Ghosh **(**S.Chand**)**
- Introduction To Modern Physics : H.S. Mani, G.K. Mehta **(**Affiliated East West**)**
- Atomic physics : G.P.Harnwell & W.E. Stephens , Mc Graw-HILL Book Company, Inc.
- Atomic and nuclear physics : Shatendra Sharma **(**Pearson publication**)**
- Atomic and nuclear physics : Gupta Ghosha.

PHYSICS LABORATORY-IV (Properties of Matter and Heat Laboratory)

Marks: 100

Course Objective:

This course enables the student

- To demonstrate various physical properties of materials.
- To demonstrate phenomena related to heat

Course Outcome:

1. To learn about properties of liquid like viscosity, surface tension etc.
2. To find physical properties of solids such as modulus of elasticity, thermal conductivity, latent heat etc.

Experiments List:

1	To determine the coefficient of viscosity by viscometer.
2	Determination of rigidity modulus of a wire by dynamic method.
3	Determination of surface tension of soap solution.
4	Determination of Young's modulus, modulus of rigidity, and Poisson's ratio of material of a wire using Searle's method.
5	Calculation of Mechanical equivalent of heat by Joule's calorimeter.
6	To find the Specific heat of a liquid by method of cooling.
7	To determine the specific resistance of a given wire using the Carey-Foster bridge.
8	Calculate the thermal conductivity of a bad conductor by Lee's method.
9	Calculation of velocity of sound by resonance column method.
10	Determine Young's modulus by bending the beam by the cantilever.
11	Determination of thermal conductivity of metal by Searle's apparatus.
12	Determination of latent heat of fusion of ice by applying radiation correction.
13	Determination of vapour density of a volatile liquid by Victor Meyer's method.
14	To determine the coefficient of viscosity of air by Rankin's Method.

Contents

Contents