The University of Burdwan

Syllabus for 3-year Degree/ 4-year Honours
in
Physics
Under Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) as per NEP, 2020
with effect from 2023-24

SEMESTER WISE & COURSE WISE CREDIT DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NEP, 2020

Semester	Course Type	Paper Code	Name of the Course	Credit	Lect.	Tuto.	Pract./Viva	Full Marks	Distribution of Marks		
									Theory	Pract./ Tuto./ Vivavoce	Internal Assessment
I	Major/DS Course (Core) Code: PHYS1011	100-199	MATHEMATICAL PHYSICS-I	4	3	0	1	75	40	20	15
	Minor Course Code: PHYS1021	100-199	MATHEMATICAL PHYSICS-I	4	3	0	1	75	40	20	15
	Multi/Inter disciplinary Code: PHYS1031		CNCEPTS OF PHYSICS 1	3	2	1	0	50	40	00	10
	Ability Enhancement Course (AEC) [L_1-1 MIL] Code: …..1041		Arabic/ Bengali/ Hindi/ Sanskrit/ Santali/ Urdu or Equvlnt. Course from SWAYAM /Any other UGC recognized platform	2	2	0	0	50	40	00	10
	Skill Enhancement Course (SEC) Code: PHYS1051		RENEWABLE ENERGY AND ENERGY HARVESTING	3	2	1	0	50	40	00	10
	Common Value Added (CVA) Course Code: CVA1061		Environmental Science/ Education	4	3	0	1	100	60	20	20
	Total			**20**				**400**			

Semester	Course Type	Paper Code	Name of the Course	Credit	Lect.	Tuto.	Pract./Viva	Full Marks	Distribution of Marks		
									Theory	Pract./ Tuto./ Vivavoce	Internal Assessment
II	Major/DS Course (Core) Code: PHYS2011	100-199	MECHANICS	4	3	0	1	75	40	20	15
	Minor Course Code: PHYS2021	100-199	MECHANICS	4	3	0	1	75	40	20	15
	Multi/Interdisciplinary Code: PHYS2031		CNCEPTS OF PHYSICS 2	3	2	1	0	50	40	00	10
	Ability Enhancement Course (AEC)[L_2-1] Code:ENGL2041		English or Equvlnt. Course from SWAYAM/ /Any other UGC-recognized platform	2	2	0	0	50	40	00	10
	Skill Enhancement Course (SEC) Code: PHYS2051		ELECTRICAL CIRCUITS AND NETWORK SKILLS	3	2	1	0	50	40	00	10
	Common Value Added (CVA) Course Code: CVA2061		Understanding India/Digital & Technological Solutions/Health & Wellness,Yoga Education, Sports & Fitness	4	3/3	1/0	0/1	100	80/60	0/20	20
Skill based vocational course (addl. 4 Cr) during summer term for 8 weeks, who will exit the programme after securing 40 cr.											
For UG Certificate 40 cr + Additional 4 cr (work based vocational course) = 44 cr. Students are allowed to re-enter within 3 years and complete the program within the stipulated max. period of 7 years											
	Total			**20**				**400**			

Semester	Course Type	Paper Code	Name of the Course	Credit	Lect.	Tuto.	Pract. /Viva	Full Marks	Distribution of Marks		
									Theory	Pract./ Tuto./ Vivavoce	Internal Assessment
III	Major /DS Course (Core)	PHYS3011	Electricity and Magnetism	5	4		1	75	40	20	15
		PHYS3012	Waves and Optics	5	4		1	75	40	20	15
	Minor Course	…….3021	Voc. Edn. & Trng.	4				75			15
	Multi/Inter disciplinary	PHYS3031	Electricity, Magnetism and Electronics	3	2	1		50	40	0	10
	AEC(MIL): L_1-2	……..3041	Arabic/ Bengali/ Hindi/ Sanskrit/ Santali/ Urdu or Equvlnt. Course from SWAYAM /Any other UGC recognized platform	2	2			50	40	0	10
	Skill Enhancement Course (SEC)	PHYS3051	Basic Instruments and Their Usage	3	2	1		50	40	0	10
Total				**22**				**375**			

Semester	Course Type	Paper Code	Name of the Course	Credit	Lect.	Tuto.	Pract./ Viva	Full Marks	Distribution of Marks		
									Theory	Pract./ Tuto./ Vivavoce	Internal Assessment
IV	Major/ DS Course (Core)	PHYS4011	Heat and Thermodynamics	5	4		1	75	40	20	15
		PHYS4012	Mathematical Physics-II	5	4		1	75	40	20	15
		PHYS4013	Classical Mechanics and Special Theory of Relativity	5	5		0	75	60	0	15
	Minor Course	PHYS4021	Thermal Physics	4	3	0	1	75	40	20	15
	Minor Course (Other than Physics)	……..4021		4				75			
	Ability Enhancement Course (AEC) [L_2-2]	ENGL4041	English	2	2			50	40	0	10
Total				**25**				**425**			

MAJOR-PHYSICS COURSE

Semester I

MAJOR-I: PHYS1011: MATHEMATICAL PHYSICS-I (Credits: Theory-03, Practical - 01)
F.M. = 75 (Theory – 40, Practical – 20, Internal Assessment –15)

COURSE OBJECTIVE: ***The aim of this course is to equip the students with mathematical methods that are important prerequisites for physics courses***.

45 Hours

Calculus

Recapitulation: Limits, Continuity, Average and instantaneous quantities, Differentiation. Plotting functions. Intuitive ideas of continuous, differentiable etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).

3 Hours

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of the existence and the Uniqueness theorem for Initial Value Problems. Particular Integral.

9 Hours

Calculus of functions of more than one variable: Partial derivatives, Exact and inexact differentials.

6 Hours

Vector Calculus

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

5 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.

6 Hours

Vector Integration: Ordinary integrals of vectors, Multiple integrals, Jacobian. Notion of an 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).

10 Hours

Orthogonal Curvilinear Coordinates:

Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

6 Hours

Reference Books

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Vector Analysis, M R Spiegel, Schaums Outline Series.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Higher Engineering Mathematics, B S Grewal, Khanna Publisher.
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, H K Dass and R Verma, S. Chand & Company Pvt. Ltd.
8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley&M.P.Hobson, 2011, Cambridge Univ. Press

MAJOR-I: PHYS1011: MATHEMATICALPHYSICS-I

Practical: 30 Hours

COURSE OBJECTIVE: The aim of this course is to learn computer programming and numerical analysis and to emphasize its role in solving problems in Physics.

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, Memory, Input/Output devices.
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, Algorithms, Sequence, Selection and Repetition, Single and double precision arithmetic, Underflow and overflow, Emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.
Errors and Error-Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming Fundamentals	Introduction to Programming, Constants, Variables, Data types, Operators and expressions, I/O statements, scanf and printf, cin and cout, Manipulators for data formatting, Control statements (Decision making statements: if statement, if else Statement, Nested if structure, else if ladder statement, Ternary Operator, goto statement, switch case statement. Unconditional and conditional looping: while loop, do-while loop, for loop, break and continue statements, Nested loops). Arrays (1D & 2D),

	Strings, User defined functions, Structure and Union, Idea of classes and objects.

Programs:

1. Write and execute a program in C/C++ to compute the factorial of a positive integer including Zero.
2. Write and execute a program in C/C++ to calculate sum of squares of n natural numbers.
3. Write and execute a program in C/C++ to find the area and the volume of a Sphere by varying the radius.
4. Write and execute a program in C/C++ to display Fibonacci series.
5. Write and execute a program in C/C++ to find the value of Sine function using power series (The argument will be given during execution).
6. Write and execute a program in C/C++ to find the value of Cosine function using power series (The argument will be given during execution)
7. Write and execute a program in C/C++ to find the value of ex (x will be given during execution of the program).
8. Write and execute a program in C/C++ to sort elements of an array of elements in ascending/ descending order.
9. Write and execute a program in C/C++ to separate odd and even integers in arrays.
10. Write and execute a program in C/C++ to find the largest and smallest in a given set of numbers.
11. Write and execute a program in C/C++ to calculate value of π.

COURSE OUTCOME: On completion of this course, the student must be able to perform different mathematical operations like calculus and vector operations which are extremely essential to study theoretical and experimental physics.

Reference Books

1. Introduction to Numerical Analysis, S .S.Sastry,5 thEdn., 2012 ,PHI Learning Pvt.Ltd.
2. Schaum's Outline of Programming with C++ .J.Hubbard,2000, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al, 3rd Edn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M. Ascher & C.Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis,K.E.Atkinson, 3rd Edn., 2007, Wiley India Edition.
6. An Introduction to Computational Physics, T.Pang, 2nd Edn., 2006, Cambridge Univ. Press
7. Computational Physics, DarrenWalker, 1st Edn., 2015, Scientific International Pvt. Ltd.
8. Programming in ANSI C, E Balagurusamy, McGraw Hill Education.
9. Object Oriented Programming with C++, E. Balagurusamy, McGraw Hill Education.
10. Let Us C, Y Kanetkar, BPB Publications.

MAJOR-PHYSICS COURSE

Semester II

MAJOR II: PHYS2011: MECHANICS (Credits: Theory - 03, Practical - 01)

F.M. = 75 (Theory- 40, Practical – 20, Internal Assessment –15)

COURSE OBJECTIVE: The objective of this course is to provide an in-depth understanding of the principles of Newtonian mechanics and apply them to solve problems involving the dynamics of classical mechanical systems.

45 Hours

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

6 **Hours**

Work and Energy: Work-Energy theorem, Conservative and non-conservative forces, Potential energy, Energy diagram, Stable and unstable equilibrium, Force as gradient of potential energy, Work and potential energy, Work done by non-conservative forces, Law of conservation of Energy.

4 **Hours**

Collisions: Elastic and inelastic collisions between particles in Centre of mass and Laboratory frames.

3 **Hours**

Rotational Dynamics: Angular momentum of a particle and a system of particles, Torque and the principle of conservation of angular momentum, Rotation about a fixed axis, Moment of Inertia, Calculation of moments of inertia for regular shaped bodies, Kinetic energy of rotation. Motion involving both translation and rotation.

8 **Hours**

Elasticity: Elastic properties of matter, Hooke's Law, Relation between Elastic constants, Twisting torque on a cylinder or a wire, Bending of Beams: Cantilever, Beam supported near the ends on two knife edges held in the same horizontal plane and a concentrated load W is applied at the midpoint.

4 **Hours**

Gravitation and Central Force Motion: Law of gravitation, Gravitational potential energy, Inertial and gravitational mass, Gravitational potential and the gravitational field due to a spherical shell and a solid sphere.

4 **Hours**

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

6 **Hours**

Oscillations: Simple Harmonic Oscillations: Differential equation of SHM and its solution, Kinetic energy, potential energy, Total energy and their time-averaged values. Damped oscillation, Forced oscillations: Transient and steady states, Resonance, Sharpness of resonance, Power dissipation and Quality Factor, Compound pendulum.

6 **Hours**

Non-Inertial Systems: Non-inertial frames and fictitious forces: Uniformly rotating frame, Laws of Physics in rotating coordinate systems, Centrifugal force, Coriolis force and its applications. Components of velocity and acceleration in cylindrical and spherical coordinate

4 **Hours**

COURSE OUTCOME: This course in Mechanics serves as the foundation for further progress towards the study of physics at graduate or post-graduate level. Upon completion of the course, the student will be able to apply Newton's laws of motion to different force fields for a single particle and for a system of particles.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
4. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
5. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
6. An Introduction to Classical Mechanics, R G Takwale & P S Puranik, TMG Hill.
7. Mechanics, P K Srivastava, New Age International Pvt. Ltd.
8. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.
9. Vibrations, Waves and Acoustics, D Chattopadhyay and P C Rakshit, Books and Allied Pvt. Ltd.
10. Advanced Acoustics, D P Roychaudhuri and P Banerjee, The New Book Stall, 2009

MAJOR-II: PHYS2011: MECHANICS

Practical: 30 Lectures

Practical:

1. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
2. To determine the Moment of Inertia of a Flywheel/regular shaped body.
3. To determine g and velocity for a freely falling body using Digital Timing Technique.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle/dynamical method.
6. To determine the elastic Constants of a wire by Searle's method.
7. To determine the value of g using Bar pendulum/Kater's Pendulum.
8. To determine the value of Young's Modulus by Flexure method.

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna,11thEdn,2011,KitabMahal.
3. Engineering Practical Physics, S.Panigrahi &B.Mallick,2015,CengageLearningIndiaPvt.Ltd.
4. Practical Physics,G.L.Squires,2015, 4thEdition,CambridgeUniversityPress.
5. Practical Physics, D Chattopadhyay, P C Rakshit and B Saha, Books and Allied Pvt. Ltd.
6. Advanced Practical Physics, B Ghosh and K G Mazumdar, Sreedhar Publishers.
7. B. Sc. Practical Physics, Harnam Singh and P S Heme, S Chand and Company Limited.
8. B. Sc. Practical Physics, C L Arora, S Chand and Company Limited.

MINOR-PHYSICS COURSE

Semester I

MINOR-I: PHYS1021: MATHEMATICAL PHYSICS-I (Credits: Theory - 03, Practical - 01)

F.M. = 75 (Theory - 40, Practical - 20, Internal Assessment - 15)

COURSE OBJECTIVE: The aim of this course is to equip the students with mathematical methods that are important prerequisites for physics courses.

45 Hours

Calculus

Recapitulation: Limits, Continuity, Average and instantaneous quantities, Differentiation. Plotting functions. Intuitive ideas of continuous, differentiable etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).

3 Hours

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of the existence and the Uniqueness theorem for Initial Value Problems. Particular Integral.

9 Hours

Calculus of functions of more than one variable: Partial derivatives, Exact and inexact differentials.

6 Hours

Vector Calculus

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

5 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.

6 Hours

Vector Integration: Ordinary integrals of vectors, Multiple integrals, Jacobian. Notion of an 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).

10 Hours

Orthogonal Curvilinear Coordinates:

Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

6 Hours

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
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8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley&M.P.Hobson, 2011, Cambridge Univ. Press

MINOR-I: PHYS1021: MATHEMATICALPHYSICS-I

30 Hours

COURSE OBJECTIVE: The aim of this course is to learn computer programming and numerical analysis and to emphasize its role in solving problems in Physics.

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, Memory, Input/Output devices.
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, Algorithms, Sequence, Selection and Repetition, Single and double precision arithmetic, Underflow and overflow, Emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.
Errors and Error-Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming Fundamentals	Introduction to Programming, Constants, Variables, Data types, Operators and expressions, I/O statements, scanf and printf, cin and cout, Manipulators for data formatting, Control statements (Decision making statements: if statement, if else Statement, Nested if structure, else if ladder statement, Ternary Operator, goto statement, switch case statement. Unconditional and conditional looping: while loop, do-while loop, for loop, break

	and continue statements, Nested loops). Arrays (1D & 2D), Strings, User defined functions, Structure and Union, Idea of classes and objects.

Programs:

1. Write and execute a program in C/C++ to compute the factorial of a positive integer including Zero.
2. Write and execute a program in C/C++ to calculate sum of squares of n natural numbers.
3. Write and execute a program in C/C++ to find the area and the volume of a Sphere by varying the radius.
4. Write and execute a program in C/C++ to display Fibonacci series.
5. Write and execute a program in C/C++ to find the value of Sine function using power series (The argument will be given during execution).
6. Write and execute a program in C/C++ to find the value of Cosine function using power series (The argument will be given during execution)
7. Write and execute a program in C/C++ to find the value of ex (x will be given during execution of the program).
8. Write and execute a program in C/C++ to sort elements of an array of elements in ascending/ descending order.
9. Write and execute a program in C/C++ to separate odd and even integers in arrays.
10. Write and execute a program in C/C++ to find the largest and smallest in a given set of numbers.
11. Write and execute a program in C/C++ to calculate value of π.

COURSE OUTCOME: On completion of this course, the student must be able to perform different mathematical operations like calculus and vector operations which are extremely essential to study theoretical and experimental physics.

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8. Programming in ANSI C, E Balagurusamy, McGraw Hill Education.

9. Object Oriented Programming with C++, E. Balagurusamy, McGraw Hill Education.

10. Let Us C, Y Kanetkar, BPB Publications.

MINOR-PHYSICS COURSE

Semester II

MINOR II : PHYS2021: MECHANICS (Credits: Theory - 03, Practical - 01)

F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment –15)

COURSE OBJECTIVE: The objectives of this course is to provide an in-depth understanding of the principles of Newtonian mechanics and apply them to solve problems involving the dynamics of classical mechanical systems.

45 Hours

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

6 Hours

Work and Energy: Work-Energy theorem, Conservative and non-conservative forces, Potential energy, Energy diagram, Stable and unstable equilibrium, Force as gradient of potential energy, Work and potential energy, Work done by non-conservative forces, Law of conservation of Energy.

4 Hours

Collisions: Elastic and inelastic collisions between particles in Centre of mass and Laboratory frames.

3 Hours

Rotational Dynamics: Angular momentum of a particle and a system of particles, Torque and the principle of conservation of angular momentum, Rotation about a fixed axis, Moment of Inertia, Calculation of moments of inertia for regular shaped bodies, Kinetic energy of rotation. Motion involving both translation and rotation.

8 Hours

Elasticity: Elastic properties of matter, Hooke's Law, Relation between Elastic constants, Twisting torque on a cylinder or a wire, Bending of Beams: Cantilever, Beam supported near the ends on two knife edges held in the same horizontal plane and a concentrated load W is applied at the midpoint.

4 Hours

Gravitation and Central Force Motion: Law of gravitation, Gravitational potential energy, Inertial and gravitational mass, Gravitational potential and the gravitational field due to a spherical shell and a solid sphere.

4 Hours

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

6 Hours

Oscillations: Simple Harmonic Oscillations: Differential equation of SHM and its solution, Kinetic energy, potential energy, Total energy and their time-averaged values. Damped oscillation, Forced oscillations: Transient and steady states, Resonance, Sharpness of resonance, Power dissipation and Quality Factor, Compound pendulum.

6 Hours

Non-Inertial Systems: Non-inertial frames and fictitious forces: Uniformly rotating frame, Laws of Physics in rotating coordinate systems, Centrifugal force, Coriolis force and its applications. Components of velocity and acceleration in cylindrical and spherical coordinate systems.

4 Hours

COURSE OUTCOME: This course in Mechanics serves as the foundation for further progress towards the study of physics at graduate or post-graduate level. Upon completion of the course, the student will be able to apply Newton's laws of motion to different force fields for a single particle and for a system of particles.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
4. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
5. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
6. An Introduction to Classical Mechanics, R G Takwale & P S Puranik, TMG Hill.
7. Mechanics, P K Srivastava, New Age International Pvt. Ltd.
8. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.
9. Vibrations, Waves and Acoustics, D Chattopadhyay and P C Rakshit, Books and Allied Pvt. Ltd.
10. Advanced Acoustics, D P Roychaudhuri and P Banerjee, The New Book Stall, 2009

MINOR II: PHYS2021: MECHANICS

Practical: 30 Hours

1. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
2. To determine the Moment of Inertia of a Flywheel/regular shaped body.
3. To determine g and velocity for a freely falling body using Digital Timing Technique.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle/dynamical method.
6. To determine the elastic Constants of a wire by Searle's method.
7. To determine the value of g using Bar pendulum/Kater's Pendulum.
8. To determine the value of Young's Modulus by Flexure method.

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna,11thEdn,2011,KitabMahal.
3. Engineering Practical Physics, S.Panigrahi &B.Mallick,2015,CengageLearningIndiaPvt.Ltd.
4. Practical Physics,G.L.Squires,2015, 4thEdition,CambridgeUniversityPress.
5. Practical Physics, D Chattopadhyay, P C Rakshit and B Saha, Books and Allied Pvt. Ltd.
6. Advanced Practical Physics, B Ghosh and K G Mazumdar, Sreedhar Publishers.
7. B. Sc. Practical Physics, Harnam Singh and P S Heme, S Chand and Company Limited.
8. B. Sc. Practical Physics, C L Arora, S Chand and Company Limited.

MULTI-DISCIPLINARY COURSE (PHYSICS)
Semester I

MULTI-DISCIPLINARY-1: PHYS1031: CNCEPTS OF PHYSICS 1 (Credits: 03)

F.M. = 50 (Theory- 40, Internal Assessment – 10)

COURSE OBJECTIVE: The aim of the course is to enable the students to be familiar with basic Physics.

Theory: 45 Hours

Unit, Dimensions and Measurement of Physical Quantities

Need for a measurement, Units of measurement, Systems of units, SI units, Fundamental and derived units. Length, mass and time measurements, Accuracy and precision of measuring instruments, Errors in measurements, Significant figures. Dimensions of physical quantities, Dimensional analysis and its applications.

4 Hours

Kinematics

Motion in a Straight Line, Uniform and non-uniform rectilinear motion, Average speed and instantaneous velocity, Uniformly accelerated motion, Velocity-time and position-time graphs, Kinematic equations for uniformly accelerated motion (graphical treatment).

3 Hours

Scalar and vector quantities

Unit vector, Position and displacement vectors, Equality of vectors, Multiplication of vectors by a real number, Addition and subtraction of vectors, Relative velocity, Resolution of a vector in a plane, Rectangular components, Scalar and vector product of two vectors.

3 Hours

Motion in a plane

Uniform circular motion, projectile motion.

2 Hours

Laws of Motion

Intuitive concept of force, Inertia, Newton's first law of motion, Momentum and Newton's second law of motion, Impulse, Newton's third law of motion. Law of conservation of linear momentum and its applications. Static and kinetic friction, Laws of friction, Rolling friction, Lubrication. Dynamics of uniform circular motion, Centripetal force, Examples of circular motion (vehicle on a leveled circular road, vehicle on a banked road).

8 Hours

Work, Energy and Power

Work done by a constant force and a variable force, Kinetic energy, Work-energy theorem, power. Notion of potential energy, Potential energy of a spring, Conservative forces, Conservation of mechanical energy (Sum of kinetic and potential energies), Non-conservative forces, Motion in a

vertical circle, Elastic and inelastic collisions in one and two dimensions.

8 Hours

System of Particles and Rotational Motion

Centre of mass of a two-particle system, Momentum conservation and Motion of centre of mass. Centre of mass of a rigid body, Centre of mass of a uniform rod. Moment of a force, Angular momentum, Law of conservation of angular momentum and its applications. Equilibrium of rigid bodies, Rigid body rotation and equations of rotational motion, Comparison of linear and rotational motion. Moment of inertia, Radius of gyration, Values of moments of inertia for simple geometrical objects (no derivation).

12 Hours

Gravitation

Universal law of gravitation, Acceleration due to gravity and its variation with altitude and depth. Gravitational potential energy and gravitational potential, Escape velocity, Orbital velocity of a satellite, Geo-stationary satellites.

5 Hours

COURSE OUTCOME: Students will develop the problem-solving capability and also learn the applications of Newtonian mechanics in daily life.

Reference Books:

1. Vector analysis, M.R. Spiegel, Tata McGraw Hill.
2. An introduction to Mechanics, D. Kleppner, R.J. Kolenkow, McGraw-Hill.
3. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. Tata McGraw-Hill.
4. Concepts of Physics, H C Verma, Vol 1 & 2, BharatiBhawan.
5. Mechanics, D.S. Mathur, S. Chand and Company Limited,
6. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, Addison Wesley
7. Theoretical Mechanics, M.R. Spiegel, Tata McGraw Hill.
8. New Simplified Physics, S L Arora, Dhanpat RaI & Co. Pvt. Ltd, Vol.1, 2020

MULTI-DISCIPLINARY COURSE (PHYSICS)

Semester II

MULTI-DISCIPLINARY-2: PHYS2031 CNCEPTS OF PHYSICS 2 (Credits: 03)

F.M.= 50 (Theory-40, Internal Assessment–10)

COURSE OBJECTIVE: ***The aim of the course is to enable the students to be familiar with basic Physics.***

Theory: 45 Hours

General Properties of Matter

Mechanical properties of solids, Stress-strain relationship, Hooke's law, Elastic moduli. Mechanical properties of fluids, Pressure due to a fluid column, Pascal's law and its applications (hydraulic lift and hydraulic brakes).

Viscosity, Stokes' law, Terminal velocity, Streamline and turbulent flow, Critical velocity, Bernoulli's theorem and its applications.

Surface energy and surface tension, Angle of contact, Excess-pressure across a curved surface, Effects of surface tension to drops, bubbles and capillary rise.

13 Hours

Thermal Properties of Matter

Heat, Temperature, Thermal expansion, Thermal expansion of solids, liquids and gases, Anomalous expansion of water, Specific heat capacity, C_p, C_v – Calorimetry, Change of state, Latent heat capacity.

Processes of heat transfer: Conduction, Convection and Radiation, Thermal conductivity. Blackbody radiation, Planck’s distribution law (qualitative discussion), Wien's displacement Law, Stefan's law.

8 Hours

Behavior of Perfect Gases and Kinetic Theory of Gases

Equation of state of a perfect gas, Work done in compressing a gas, Kinetic theory of gases: Postulates, Concept of pressure, Kinetic interpretation of temperature, RMS speed of gas molecules, Degrees of freedom, the law of equi-partition of energy (statement only) and its application to specific heat capacities of gases, Concept of mean free path, Avogadro's number.

8 Hours

Thermodynamics

Zeroth law of thermodynamics, Heat, work and internal energy, First law of thermodynamics, Isothermal and adiabatic processes, Second law of thermodynamics: Reversible and irreversible processes, Concept of entropy.

8 Hours

Oscillations and Waves

Oscillations: Periodic motion, Time period, Frequency, Displacement as a function of time, Simple harmonic motion (S.H.M): Differential equation, Phase, Oscillations of a loaded spring, Restoring force and force constant, Energy in S.H.M., Kinetic and potential energies, Derivation of the expression for the time period of a simple pendulum. Free, Forced and Damped oscillations (qualitative ideas only), Resonance.

8 Hours

COURSE OUTCOME: ***Students will develop the problem-solving capability and also learn the applications of Newtonian mechanics in daily life.***

Reference Books

1. Thermal Physics, S.Garg, R.Bansal and C.Ghosh,1993,Tata McGraw-Hill.
2. New Simplified Physics, S L Arora, Dhanpat RaI & Co. Pvt. Ltd, Vol.1, 2020
3. Concepts of Physics, H C Verma, Vol 1 & 2, Bharati Bhawan.
4. Waves: Berkeley Physics Course,vol.3,FrancisCrawford,2007,TataMcGraw-Hill.
5. Heat Thermodynamics and Statistical Physics, Brijlal, Subrahmanyam, Heme, S Chand.
6. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears & G.L.Salinger. 1988, Narosa.
7. A Treatise on Heat, Meghnad Saha and B.N.Srivastava, 1969, Indian Press.

SEC-PHYSICS

Semester-I

SEC-1:PHYS1051: RENEWABLE ENERGY AND ENERGY HARVESTING (Credits: 03)

F.M. = 50 (Theory - 40, Internal Assessment - 10)

COURSE OBJECTIVE: ***To impart knowledge and hands on learning about various alternative energy sources like Wind, Solar, Mechanical, Ocean, Geothermal etc. To review the working of various energy harvesting systems which are installed worldwide.***

Theory: 45 Hours

Fossil Fuels and Alternate Sources of Energy: Fossil fuels and nuclear energy, Their limitation, Need of renewable energy, Non-conventional energy sources. An overview of the developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, Solar energy, Biomass, Biochemical conversion, Biogas generation, Geothermal energy, Tidal energy, Hydroelectricity.

8 Hours

Solar energy: Solar energy and its importance, Storage of solar energy, Solar pond, Non-convective solar pond, Applications of solar pond and solar energy, Solar water heater, Flat plate collector, Solar distillation, Solar cooker, Solar green houses, Solar cell, Absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits and sun tracking systems.

8 Hours

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces and grid interconnection topologies.

5 Hours

Ocean Energy: Ocean Energy, Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

5 Hours

Geothermal Energy: Geothermal resources, Geothermal technologies.

4 Hours

Hydro Energy: Hydropower resources, Hydropower technologies, Environmental impact of hydro power sources.

5 Hours

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modelling piezoelectric generators, Piezoelectric energy harvesting applications, Human power.

5 Hours

Electromagnetic Energy Harvesting: Linear generators, Related Physics, Mathematical models, Recent applications, Carbon captured technologies, cell, Batteries, Power consumption, Environmental issues and Renewable sources of energy, Sustainability.

5 Hours

COURSE OUTCOME: The students are expected to learn not only the theories of the renewable sources of energy, but also to have hands-on experiences on them wherever possible.

Reference Books:

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
2. Solar energy - M P Agarwal - S Chand and Co. Ltd.
3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
4. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
5. Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
6. J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
7. http://en.wikipedia.org/wiki/Renewable_energy
8. Snatak Padartha Vigyan, Renewable Energy Sources, A M Rudra, A Bhattacharya and A Dan, The New Book Stall, 2018.

SEC-PHYSICS

Semester-II

SEC-2: PHYS2051: ELECTRICAL CIRCUITS AND NETWORK SKILLS (Credits: 03)

F.M.= 50 (Theory - 40, Internal Assessment - 10)

COURSE OBJECTIVE*: The aim of this course is to enable the students to understand the basics of electronic circuits. Practical design and trouble shoot of electronic instrument is also a major objective of this Couse.*

Theory: 45 Hours

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

5 Hours

Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

8 Hours

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.
(5 Lectures)

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

5 Hours

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.

5 Hours

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources

5 Hours

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)

5 Hours

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit Cable trays. Splices: wire nuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.
(7 Lectures)

COURSE OUTCOME: After the completion of the course the student will acquire necessary skills/ hands on experience /working knowledge on Multimeter, voltmeters, ammeters, electric circuit elements, dc power sources. With the knowledge of basic electronics a student can able to detect troubleshoot and repair some of the electronic instruments used in our daily life.

Reference Books:

1. A Text book in Electrical Technology - B L Theraja - S Chand & Co.
2. A Text book of Electrical Technology - A K Theraja
3. Performance and design of AC machines - M G Say ELBS Edn.

MAJOR-PHYSICS COURSE
Semester III

MAJOR-III: PHYS3011: Electricity and Magnetism (Credits: Theory - 04, Practical - 01)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)

Course Objective: ***The objective of this paper is to give the basic concept as well as an in-depth understanding of the principles of electricity and magnetism and apply them to solve the problems related.***

60 Hours

Electrostatics

Unit I Quantization of electric charge, Coulomb's law, Principle of superposition, Electric field (Physical concept, quantitative definition and its source), Electric field of a point charge, Electric field lines and their properties, Charge density, Volume charge density, Surface charge density, Line charge density, Electric fields due to continuous charge distributions, Electric field due to a uniformly charged non-conducting rod at an axial point and at a point on the perpendicular bisector of that rod, Electric field due to a circular disc on the axial point.

5 Hours

Unit 2 Electric flux, Gauss' law, Differential form of Gauss' law, Equivalence of Coulomb's law and Gauss' law, Gaussian surface, Application of Gauss' law to evaluate the electric field at a point for charge distributions with spherical (A thin spherical shell of radius R with a charge +Q evenly distributed over its surface, thick shell, and a solid sphere of radius R with uniform volume charge density), planar (Infinitely large non-conducting plane with uniform surface charge density) and cylindrical symmetry (Infinitely long non-conducting rod of uniform line charge density).

6 Hours

Unit 3 Conservative nature of electrostatic field, Electric scalar potential, Relation between the electric field and the electric potential, Electric potential of a point charge and a group of point charges, Electric potential due to a continuous charge distribution, Electric potential and field due to an electric dipole, Force and torque acting on an electric dipole in a uniform electric field, Laplace's and Poisson's equations, The Uniqueness theorem (Proof required).

5 Hours

Unit 4 Electrostatic potential energy, Electrostatic potential energy of a collection of point charges, Electrostatic potential energy of a continuous charge distribution (general expression and a charged sphere as an example), Self energy, Classical electron radius, Electrostatic potential energy of an electric dipole in a non-uniform electric field.

4 Hours

Unit 5 Equipotential surfaces, Electrostatic equilibrium properties (regarding electric charge, electric field and electric potential) of a conductor in a uniform electric field, Surface charge and force on a conductor, Boundary conditions on the electric field at the interface between a vacuum and a conductor, Capacitor as a charge storing device, Capacitance and the energy stored in a capacitor, Capacitance of a system of charged conductors, Parallel-plate capacitor, Capacitance of an isolated conductor, Method of Images and its application to: (1) Plane infinite sheet and (2) Sphere.

6 Hours

Unit 6 Dielectric properties of matter**:** Electric field inside a matter, Polarization, Polarization charges, Electrical susceptibility and dielectric Constant, Capacitor (parallel-plate, spherical, cylindrical) filled with dielectric, Displacement vector $\vec{D}$, Relations between $\vec{E}$, $\vec{P}$ and $\vec{D}$, Gauss' Law

in dielectrics, Boundary conditions between two dielectric interfaces.

4 Hours

Steady Electric Current

Electric current, Current density, Continuity equation, Conductivity, Ohm's law, Electromotive force, Kirchhoff's first and second law- statement and applications, Thevenin′s, Norton′s and maximum power transfer theorems and their applications.

2 Hours

Magneto-statics

Unit 1 Electric current as a source of magnetic field, Definition and units (SI) of: Magnetic flux density $\vec{B}$, Magnetic field strength $\vec{H}$ and Magnetization vector ($\vec{M}$), Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$, Magnetic susceptibility and magnetic permeability, Boundary conditions between two magnetic media, Force (Lorentz force) on a moving charge in the simultaneous presence of both electric and magnetic fields, Trajectory of a charged particle in a crossed uniform electric and magnetic fields.

3 Hours

Unit 2 Biot Savart's Law and its applications: $\vec{B}$ due to current in (i) a long straight conductor, (ii) a circular loop, (iii) a solenoid, Current loop as a magnetic dipole and its dipole moment.

3 Hours

Unit 3 -Ampere's circuital law and its applications: $\vec{B}$ due to current in (i) a long straight conductor, (ii) a solenoid and (iii) a toroid.

2 Hours

Unit 4 Magnetic force on (i) a current element, (ii) a line current, Force between two current elements, Divergence and Curl of B (Gauss and Ampere's laws), Physical significance of the nature of the divergence and curl of B, Magnetic vector potential.

3 Hours

Transient current

Growth and decay of currents in LR, CR and LCR circuits, Time constant.

2 Hours

Alternating Current

Source of alternating current, Mean value, Peak value and RMS value of alternating voltage and current, Inductive and capacitive reactance, Real power, Reactive power and apparent power, Power triangle, Power factor, Series LCR circuit analysis, Phasor diagrams (AC voltage from a source (V), Current through the resistor R (i_R) and the voltage across R (V_R), Current through the capacitor C (i_c) and the voltage across C (V_c), Current through the inductor L(i_L) and the voltage across L (V_L), Calculation of total impedance of a series LCR circuit using the phasor diagram of V, V_R, V_L and V_c, Parallel LCR circuit analysis, Resonance in LCR circuits (series and parallel), LC oscillations.

7 Hours

Electromagnetic Induction

Faraday's law, Lenz's law and conservation of energy, Motional EMF, Eddy current, Principle of power generation, Self-inductance and mutual inductance, Induction oven, Induction brake, Reciprocity theorem, Energy stored in a magnetic Field, Introduction to Maxwell's equations, Continuity equation.

4 Hours

Electrical equipment

Moving coil ballistic and dead beat galvanometers: Working principle, Derivation of the equation relating between the charge flowing through the coil and the ballistic throw of the galvanometer, Damping correction, Current, charge and voltage sensitivities of a moving coil galvanometer, Equation of motion of the coil, Non-oscillatory, aperiodic or dead beat motion, Critical damping, Light damping: Ballistic motion, Uses.

4 Hours

Course Outcome: *At the end of this course, students will be able to comprehend the concept of electric field, electric flux, magnetic field and their origin. They will learn to apply the Gauss's theorem to find the electric fields for different types of charge distribution. The students will develop a sound perception about Electrostatics, Magneto-statics, Electric current and electromagnetic induction.*

Reference Books

- Electricity and Magnetism, Purcell, M. Edward, David J. Morin, 2013, Cambridge University Press, 3rd edition.
- Electricity and Magnetism, R. Murugeshan, 2019, S. Chand Publishing, 10th Edition.
- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw-Hill.
- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
- Introduction to Electrodynamics, D.J. Griffiths, 1998, Benjamin Cummings, 3rd Edn.
- Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education.
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism Volume I, J.H. Fewkes & J. Yarwood, 1991, Oxford Univ. Press.

MAJOR-III: PHYS3011: Electricity and Magnetism
Practical: 30 Hours

List of Experiments

1. ***To verify the Thevenin's, Norton's and Maximum Power transfer theorems***
2. ***To determine the Self-inductance of a coil using Anderson's bridge***
3. ***To study the response curve of a series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor and (d) Band width***
4. ***To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor***
5. ***Measurement of Charge Sensitivity and CDR of a Ballistic Galvanometer***
6. ***Determination of a Ballistic Galvanometer Constant by Capacitor Charging-Discharging method***

7. ***Construction of a One Ohm coil***
8. ***Determination of a Ballistic Galvanometer Constant by the Solenoid method***
9. ***Determination of Mutual Inductance of two coils by Carey-Foster's method***

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani.
- B.Sc. Practical Physics, Harnam Singh, Dr. P.S. Hemne, 2018, S. Chand.
- Advanced Practical Physics, B. Ghosh and K. G. Majumdar, Shreedhar Publishers.
- Advanced Course in Practical Physics, D Chattopadhyay, P C Rakshit, New Central Book Agency.

MAJOR-PHYSICS COURSE
Semester III

MAJOR-III: PHYS3012: Waves and Optics (Credits: Theory - 04, Practical - 01)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)

Course Objective: ***The objective of this course is to provide an in-depth understanding of the nature of waves in general, sound wave as an example of mechanical wave and light as an electromagnetic wave. It is also intended to provide a comprehensive idea of some phenomena like interference, diffraction and polarisation and their physical explanation in terms of the wave theory of light.***

60 Hours

Superposition of Collinear Harmonic Oscillations

Simple harmonic motion as a projection of a uniformly rotating vector on a reference axis, Linearity and superposition principle, Superposition of two collinear simple harmonic vibrations with different amplitudes, different initial phases and with: (1) same frequencies using both the analytical method and the vector method, (2) slightly different frequencies, Beats (graphical representation of beats), Superposition of a large number (N) of simple harmonic vibrations of equal amplitude and frequency but with (a) equal successive initial phase differences and (b) random phases by the vector method,

Superposition of a large number (N) of simple harmonic vibrations of equal amplitude and same initial phase but with equal successive frequency differences by the analytical method.

5 Hours

Superposition of two Perpendicular Harmonic Oscillations

Superposition of two perpendicular simple harmonic oscillations having (1) equal frequencies, different amplitudes and an initial phase difference δ (graphical representation for δ varying between 0 and 2π), and (2) two different frequencies, different amplitudes and an initial phase difference δ (Lissajous Figures) using the analytical method as well as the graphical method.

2 Hours

Coupled Oscillations

Stiffness coupled oscillators: two identical pendulums (each a light rigid rod of length l supporting a mass m) coupled by a weightless spring of stiffness ***s***, Normal coordinates, Degrees of freedom, Normal modes of vibration, A large number (N) of coupled oscillators *e.g.*, a light string fixed at both ends, supporting N equal masses spaced at equal distance along its length (Qualitative discussion without any mathematical details).

3 Hours

One Dimensional Waves

Unit I Transverse oscillations (in a plane) of a slightly extensible, uniform string of mass per unit length ρ under a constant tension (T) with free ends: Equation of motion - $\frac{\partial^2 y}{\partial x^2} = \frac{T}{\rho}\frac{\partial^2 y}{\partial t^2}$ ~ the one dimensional wave equation representing a travelling wave of velocity (*c*) equal to $\sqrt{\frac{T}{\rho}}$, $y = A\,sin\frac{2\pi}{\lambda}(ct \pm x)$ or $A\,cos\frac{2\pi}{\lambda}(ct \pm x)$ - a solution of the wave equation, $\frac{2\pi}{\lambda}(ct \pm x)$ - a dimensionless quantity for λ representing a length, Harmonic waves, Wavelength (λ), Wave or phase velocity ($c = \frac{\partial x}{\partial t}$), Frequency ($\nu = \frac{c}{\lambda}$), Oscillator or particle velocity ($\frac{\partial y}{\partial t}$).

4 Hours

Unit II Oscillations of a string of fixed length *l* under a constant tension (*T*) with both ends rigidly clamped: Equation of motion $\frac{\partial^2 y}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 y}{\partial t^2}$ (same) with the boundary conditions $y = 0$ at $x = 0$ and $x = l$ for all t, General solution $y = A\,sin\frac{2\pi}{\lambda}(ct - x) + Bsin\frac{2\pi}{\lambda}(ct + x)$, The boundary condition $y = 0$ at $x = 0$ for all t implies $A = -B \rightarrow y = 2A\,sin\frac{2\pi}{\lambda}ct\,cos\,\frac{2\pi}{\lambda}x$ – superposition of a wave moving along positive or negative *x*-axis and the wave reflected at either fixed end (discontinuity) with a π phase change in amplitude, Nature of oscillations: (a) All particles of the string execute simple harmonic oscillation about their equilibrium positions (points on the string at rest) at the same frequency, (b) The amplitude varies along the length of the string, (c) Nodes with zero amplitude and antinodes with a peak amplitude, (d) The positions of the nodes and antinodes do not change with time, The boundary condition $y = 0$ at $x = l$ for all t gives $\frac{2\pi}{\lambda} = \frac{n\pi}{l}$ or $\nu_n = \frac{nc}{2l}$, the general solution

$$y(x,t) = \sum_{n=1}^{\infty}\left(a_n\,sin\,\frac{n\pi ct}{l}cos\,\frac{n\pi}{l}x\right) = \sum_{n=1}^{\infty}(a_n \sin\omega_n t\,cos\frac{\omega_n}{c}x)$$

Additional characteristics: $y(x,t)$ - superposition of an infinite number normal modes of different frequencies ($\nu_n = \frac{nc}{2l}$), The total energy of the vibrating string (derivation required) (E) = $\sum E_n$,

$E_n = \frac{1}{2}m\omega_n^2 a_n^2$, Wave group with a number of components of different frequencies, dispersive medium, Group velocity = $\frac{d\omega}{dk}$, Doppler Effect.

6 Hours

Sound Waves in Gases

Longitudinal disturbances in the pressure and density causing compressions and rarefactions of small volume elements of the gases, Deduction of the wave equation $\frac{\partial^2 y}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 y}{\partial t^2}$, Velocity of sound waves $c = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{\gamma P}{\rho}}$, The energy (kinetic, potential, total) distribution in space for a sound wave in a gas (qualitative idea), Intensity of sound waves and units.

3 Hours

Elastic Waves in Bulk Solids

Longitudinal and transverse modes, The wave equations for each mode, Velocity of waves in each mode.

2 Hours

Three Dimensional Waves

Wavefront-a surface of constant phase at a given instant of time, A plane wave $\psi(\vec{r}, t) = Ae^{i(\vec{k}\cdot\vec{r}-\omega t)}$ with a wavefront defined by $\vec{k}\cdot\vec{r}$ = constant, A spherical wave $\psi(r, t) = \frac{A}{r}e^{i(kr-\omega t)}$ with a wavefront defined by kr = constant, A cylindrical wave $\psi(\vec{r}, t) = \psi(r, \theta, z, t) = \frac{A}{\sqrt{r}}e^{i(kr-\omega t)}$ is θ-independent and z-independent and the wavefront is a right circular cylinder centered on the z-axis and having infinite length.

Light propagation explained as rays in geometrical optics (deals with an image formation in different optical instruments) whereas electromagnetic waves in physical optics (deals with different phenomena as interference, diffraction and polarization).

2 Hours

Superposition of Harmonic Waves

The wave equation supports the superposition principle, Superposition of electromagnetic waves treating the fields as scalar, Superposition of (a) Two harmonic plane waves of the same frequency – Idea of coherent sources and interference, (b) N harmonic waves with identical frequencies: (i) randomly phased sources of equal amplitudes, (ii) Coherent (constant phase relationship) sources of the same type) and in phase.

3 Hours

Interference

Unit 1 Conditions of interference, Spatial and temporal coherence, Realization of coherent sources by division of a wavefront: Young's double slit experiment, Fresnel's Bi-prism, Lloyd's Mirror.

Unit 2 Phase change on reflection: Stokes' treatment, Realization of coherent sources by division of amplitude, 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.

Unit 3 Michelson interferometer, Formation of the fringes, (No theory required), Applications: Determination of the (1) wavelength and (2) wavelength difference, (3) Refractive Index, Visibility of fringes.

Unit 4 Fabry-Perot interferometer, Formation of the fringes, Intensity distribution, Resolving Power, Superiority over Michelson interferometer.

10 Hours

Diffraction

The Huygens–Fresnel principle, Diffraction and interference, Fresnel diffraction and Fraunhofer diffraction.

Fraunhofer diffraction: Single slit diffraction, Double slit diffraction, N-slits diffraction or a diffraction grating, Rayleigh criterion for resolution, Resolving power of a grating, Grating spectra versus Prism spectra.

Fresnel Diffraction: Fresnel's assumptions, Fresnel's half-period zones for plane wave, Explanation of rectilinear propagation of light, Theory of a zone plate: Multiple foci of a zone plate, Fresnel's integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

10 Hours

Polarisation of Light

Types of polarized light: Plane polarized light, Circularly polarized light, Elliptically polarized light,

Production of polarized light (a) by reflection, Brewster angle, Malus law, (b) by dichroism, Pollaroids, (c) by double refraction, Doubly refracting crystals, Negative crystals, Positive crystals, Optic axis, Nicol prism, Huygen's theory of double refraction, Phase retardation plate: 1) Quarter wave plate 2) Half wave plate,

Detection of plane, circularly and elliptically polarized light.

Optical activity and its origin, Two types of optically active substance, Fresnel's theory of optical rotation, Polarimeter.

10 Hours

Course Outcome: ***The outcome of the paper includes the knowledge of vibrations, propagation of waves, vibrations of air column, and harmonics of the strings. The paper has another outcome of offering knowledge of wave properties of light & corresponding phenomena.***

Reference Books

- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N K Bajaj, 1984, Tata McGraw-Hill.
- Waves and Oscillations, N. Subramanyam and Brij Lal, 2010, Vikas Publishing House Pvt. Ltd.
- Waves and Optics: As per CBCS, M. N. Avadhanulu & TVS Arun Murthy, S. Chand Publishing.
- Optics, Eugene Hecht, 2019, Pearson.

- OPTICS at Graduate Level, Prof. Devanarayanan Sankara, 2019, Independently published.
- Optics An Introduction, Sarhan M. Musa, 2017, Mercury Learning and Information.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 2017, McGraw-Hill Education Ltd.
- Principles of Optics, Max Born and Emil Wolf, 1999, Pergamon Press.

MAJOR-III: PHYS3012: Waves and Optics
Practical: 30 Lectures

List of Experiments

1. ***To draw n-l curve with the help of a sonometer and hence find the frequency of an unknown fork***
2. ***Determination of the frequency of ac mains with a sonometer using a magnetic wire***
3. ***Determination of the velocity of ultrasonic waves in a given liquid***
4. ***To determine the refractive index of the material of a prism using sodium source***
5. ***To determine the dispersive power and Cauchy constants of the material of a prism***
6. ***To determine the wavelength of sodium light using Fresnel Biprism***
7. ***To determine the wavelength of sodium light using Newton's Rings***
8. ***Determination of the width of a single slit producing a Fraunhofer diffraction pattern***
9. ***To determine wavelength of (1) Na source and (2) spectral lines of Hg source using a plane diffraction grating***
10. ***Calibration of a polarimeter and determination of the concentration of an active solution***
11. ***To determine the resolving power of a plane diffraction grating***

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani.
- B.Sc. Practical Physics, Harnam Singh, Dr. P.S. Hemne, 2018, S. Chand.
- Advanced Practical Physics, B. Ghosh and K. G. Majumdar, Shreedhar Publishers.

- Advanced Course in Practical Physics, D Chattopadhyay, P C Rakshit, New Central Book Agency.

MULTIDISCIPLINARY COURSE-PHYSICS
Semester III

MULTI-DISCIPLINARY: PHYS3031: Electricity, Magnetism and Electronics (Credits: 03)
F.M. = 50 (Theory - 40, Practical – 0, Internal Assessment – 10)

Course Objective: ***This course is designed to give the students a basic understanding of electricity, magnetism and electronics. The student will also gain a preliminary knowledge of some electrical and electronic instruments.***

45 Hours

Basic Concepts of Electrostatics

Electric charge, Coulomb's law, Electric field, Electric field of a point charge, Electric potential, Electric potential of a point charge.

6 Hours

Dielectric, Capacitor and Capacitance

A dielectric or dielectric material, Dielectric polarization, Electric dipole moment (SI unit), Permittivity, Static dielectric constant, Capacitor and capacitance, Potential energy stored in a capacitor, Capacitance of a parallel plate capacitor, SI unit of capacitance, Relation between the dielectric constant and the capacitance of a dielectric, Types of capacitors: Aluminum electrolytic capacitor, Tantalum capacitor, Electric double layer capacitor, Ceramic capacitor, Film capacitor, Mica Capacitor.

9 Hours

Electrical Conductor

A conductor, Electric current, Resistance and conductance of a conductor and their units, Characteristics of good electrical conductor with examples, Ohm's law, Direct current and its sources, Uses of battery in electronic circuits: Cell phones, laptops, radios, flashlights, automobiles and other electronic gadgets, Alternating current and its sources, Uses in electrical/ electronic circuits.

7 Hours

Magneto-statics

Biot Savert law, Magnetic field and its SI unit, Magnetic flux and force, Ampere's circuital law.

8 Hours

Electromagnetic Induction and Inductors

Electromagnetic induction, Faraday's law of electromagnetic induction, Lenz's law and conservation of energy, Inductance and its SI unit, Principle of operation of an AC generator, Inductor as a component that allows DC current to flow but not AC current.

8 Hours

Basic Electrical/ Electronic Components and Devices

Resistors, Capacitors, Diodes, Light emitting diode (LED), Transistors, Inductors, Integrated circuit (IC), Fuse, Transformer, Electrical versus electronic devices, Working principle of a tube light, Working principle of an electric fan, Electronic circuits: Amplifier, Rectifier, Filter.

7 Hours

Reference Books

- Electricity & Magnetism, Sehgal D. L., Chopra K.L., Sehgal N.K., 2020, Sultan Chand & Sons.
- Electricity and Magnetism, S.P. Taneja, 2022, R. Chand and Company.
- Electricity and Magnetism, R Murugeshan, 2017, S. Chand Publishing.
- Basic Electrical and Electronics Engineering, S. K. Bhattacharya, 2011, Pearson Education India.
- Basic Electronics, McGraw Hill Education, (2017).

Course Outcome: ***After successful completion of this paper students of other disciplines will be able to comprehend the basics of electricity, magnetism and electronics. The students will be acquainted with basic electrical and electronic devices.***

SEC-PHYSICS
Semester-III

SEC-3:PHYS3051: Basic Instruments and their Usage (Credits: 03)
F.M. = 50 (Theory - 40, Internal Assessment – 10)

Course Objective: ***This course is designed to give the students an exposure with various aspects of electrical and optical instruments and their applications in experimental physics.***

Electrical/ Electronic Instruments

Unit 1 Voltage and current sources, Principles of measurement of dc voltage & current, ac voltage & current and a resistance, Specifications of an electronic voltmeter/ multi-meter and their significance, Advantages of electronic voltmeter over conventional multi-meter for the measurement of voltage, Instrumental accuracy, Precision, Sensitivity, Resolution, Range *etc*., Errors in measurements and loading effects.

Unit 2 Cathode Ray Oscilloscope: Block diagram of basic CRO, Time base operation, Synchronization, Front panel controls, Specifications of a CRO and their significance, Use of CRO for the measurement of voltage (dc and ac), frequency, Special feature of dual trace.

Unit 3 Signal Generators: Block diagram, Explanation and specifications of low frequency signal generators, Pulse generators and function generators.

Unit 4 Digital Instruments: Principle and function of a digital meter, Characteristics of a digital meter, Comparison of analog & digital instruments.

Optical Instruments

Unit 1 Optical microscope: Simple microscope, Compound microscope, Electron microscope: Principal components, Working principle and uses.

Unit 2 Telescope: Principal components, Working principle and uses of different types of telescopes (Astronomical telescope, Terrestrial telescope, Reflecting telescope).

Unit 3 An objective lens and an eyepiece or ocular lens: Elements, Angular magnification of a telescope, Angular magnification of a microscope, Huygens eyepiece, Ramsden eyepiece.

Unit 4 Spectrometer: Principal components, Role of individual components, Uses, Ultraviolet-Visible (UV-VIS), Near-infrared (NIR) and Raman spectrometers.

Suggested Activities

1. To realize the importance of grounding, earthing and the methods for earthing
2. To know about the telescopes used at different observatories in and outside India

Demonstration Experiments

1. Use of an oscilloscope for the measurement of voltage, frequency, time period and phase angle
2. An experiment for the determination of magnifying power of a microscope
3. Use of a digital multi-meter for measuring voltages (dc and ac), currents (dc and ac), resistances and its limitation for measuring high frequency voltage and current

Reference Books

- Modern electronic instrumentation and measurement techniques India, Albert D Helfrick & William D Cooper 1992, Prentice Hall India Learning Private Limited.
- Basic Electrical and Electronics Engineering, S. K. Bhattacharya, 2011, Pearson Education India.
- The Theory of Optical Instruments, E T Whittaker, 2023, Mjp Publishers

Course Outcome ***After completion of this course, the students will gain knowledge the in setting up electrical and optical experiments.***

MAJOR-PHYSICS COURSE
Semester IV

MAJOR-IV: PHYS4011: Heat and Thermodynamics (Credits: Theory-04, Practicals-01)
F.M. = 75 (Theory-40, Practical–20, Internal Assessment–15)

Course Objectives***: The objective of the course is to infuse ideas of thermodynamic systems, thermodynamic variables, thermodynamic processes, and allied phenomena. It is designed to familiarize students with thermodynamic potentials, the kinetic theory of gases, and the theory of radiation.***

60 Hours

The Kinetic Theory of Gases

Unit 1 Objective of the theory (Knowledge of a macroscopic system from its microscopic constituents), Classical ideal gas and the ideal gas law, A microscopic view of an ideal gas and the basic postulates of the kinetic theory, The justifications and implications of the postulates, Mean free path, Collision probability, Estimates of mean free path, The kinetic interpretation of pressure P, Relation between pressure and translational kinetic energy of the molecules, Kinetic interpretation of temperature - the average molecular kinetic energy is proportional to the absolute temperature.

4 Hours

Unit 2 The equipartition theorem (statement only), Kinetic degrees of freedom (*f*), Thermal energy and specific heat of gases ($\boldsymbol{C_p}$ and $\boldsymbol{C_v}$), $\boldsymbol{\gamma}$ - the ratio of $\boldsymbol{C_p}$ and C_v, Relation between $\boldsymbol{\gamma}$ and $\boldsymbol{f}$, Specific heat of a monatomic, a diatomic gas (N_2) gas: the experimental value and its interpretation in terms of quantum effects restricting the active modes, Brownian motion and its significance.

3 Hours

Unit 3 Speeds of the molecules of an ideal gas in thermal equilibrium, Maxwell–Boltzmann distribution law (statement only): Probability density $\boldsymbol{\rho}(c)$ as a function of speed c and its graphical representation, Important features of the graph and their significances: (a) Asymmetric, single peaked nature of the curve, (b) Changes in $\boldsymbol{\rho}(c)$ with (i) increasing temperature, and (ii) increasing mass of the single molecule of a gas *e.g.*, in the cases for He, Ne, Ar, Number of molecules (dN) of an ideal gas moving with a speed lying between c and $c + dc$, Important conclusions: (a) Heavy molecules are unlikely to have very high speeds, (b) Number of molecules with high speeds increases with the increasing temperature, (c) Area under the curve, equal to the total number of molecules does not change with changing temperature (T), Estimation of the fraction of molecules with speeds greater than c, Average or mean speed ($\boldsymbol{C_{av}}$), Root mean square velocity ($\boldsymbol{C_{rms}}$), Most probable speed ($\boldsymbol{C_{mp}}$) from the distribution law, Comparison of $\boldsymbol{C_{av}}$, $\boldsymbol{C_{rms}}$ and $\boldsymbol{C_{mp}}$ at a fixed temperature (T), Maxwell-Boltzmann distribution law of molecular energies from that of the speeds, Average kinetic energy.

8 Hours

Unit 4 Non equilibrium state and transport phenomenon in ideal gases: (1) Viscosity: Transport of momentum, Coefficient of viscosity ($\boldsymbol{\eta}$) in terms of the mean free path (λ), (2) Thermal conductivity: Transport of thermal energy, Thermal conductivity ($\boldsymbol{K}$) in terms of the mean free path (λ), Effect of temperature (T) on $\boldsymbol{K}$, (3) Diffusion: Transport of mass, Coefficient of diffusion ($\boldsymbol{D}$) in terms of the mean free path (λ), Effect of temperature (T) and pressure on $\boldsymbol{D}$.

4 Hours

Unit 5 Real gases, Andrew's experiment on carbon dioxide: Principle, Result as isothermals (plots of the pressure versus the volume at different temperatures), Interpretation of the isothermals, Inferences from the experiment, Critical constants, Van der waals' equation of state: Correction for finite size of the molecule, Correction for intermolecular attraction, Comparison between the nature of the isothermals obtained from Andrew's experiment and plots of the pressure versus the volume of a gas obeying Van der waals' equation of state at different temperatures (similarities and differences), Expression for critical constants ($\boldsymbol{T_c}$, $\boldsymbol{p_c}$, and $\boldsymbol{V_c}$) and critical coefficient ($\boldsymbol{p_cV_c/RT_c}$), Limitations of the Van der waals' equation, Virial expansion: Concept, the Van der waals' equation of state in terms of a virial expansion, the Boyle temperature in terms of $\boldsymbol{T_c}$.

5 Hours

Heat Conduction

Thermal conductivity (***K***), Diffusivity (***D***), Fourier's equation of heat conduction and its solution for the rectilinear flow of heat. Ingen Hausz's Experimen

3 Hours

Radiation

Blackbody radiation and its spectral distribution, Concept of the energy density, Derivation of the Planck's law, Deduction of the Stefan-Boltzmann law, the Rayleigh-Jean's law and the Wien's displacement law from Planck's law.

4 Hours

Thermodynamics

Unit 1 Definitions: A thermodynamic system and its surroundings, Open, closed, adiabatic and isolated systems, Thermodynamic variables: extensive and intensive, Steady state of a thermodynamic system, Thermodynamic equilibrium, Thermodynamic path, Thermodynamic processes: Cyclic, Quasi-static, Reversible and irreversible processes, Isothermal, Isobaric and Isochoric processes, Minimum number of state variables for a single and a multi component system, Equation of state, Functions of state and functions of path (Examples), Exact and inexact Differentials, Heat and Work, Standard temperature and pressure, Internal energy of a system (***U***).

3 Hours

Unit 2 The zeroth law of thermodynamics and the concept of temperature, The first law of thermodynamics (differential form $\boldsymbol{dU = dQ - dW}$), $\boldsymbol{dU}$ - an exact differential, $\boldsymbol{dQ}$ and $\boldsymbol{dW}$ - inexact differentials, Heat capacity: $\boldsymbol{C_V}$ and $\boldsymbol{C_p}$**.** Molar heat capacity $\boldsymbol{c_v}$ and $\boldsymbol{c_p}$, Ideal gas: Isothermal expansion, adiabatic transformation.

3 Hours

Unit 3 A heat engine, A heat reservoir, The second law of thermodynamics: Clausius' statement of the second law of thermodynamics, Kelvin's statement of the second law of thermodynamics, the efficiency ($\boldsymbol{\eta}$) of an engine and the coefficient of refrigeration ($\boldsymbol{\kappa}$), A Carnot engine, Carnot's theorem, Working substance, The Carnot cycle in a $\boldsymbol{p\text{-}V}$ diagram with an ideal gas as working substance and four stages: isothermal expansion, adiabatic expansion, isothermal compression, adiabatic compression, the work done and the heat exchange in each stage, The efficiency of a Carnot engine ($\boldsymbol{\eta}$) in terms of the ratio of $\boldsymbol{T_1}$ (temperature of the hot reservoir) and $\boldsymbol{T_2}$ (temperature of the cold reservoir), Equivalence of Clausius' and Kelvin's statements, A refrigerator and a heat engine, Clausius' theorem and Clausius inequality.

10 Hours

Unit 4 Definition of entropy, Change in entropy ($\boldsymbol{dS}$) for a thermally isolated system for a reversible change and an irreversible change, Application to the Universe, The first law revisited: $\boldsymbol{dU = TdS - pdV}$, $\boldsymbol{dU = dQ + dW}$ (always true), $\boldsymbol{dQ = TdS}$ (only true for reversible changes), $\boldsymbol{dW = -pdV}$ (only true for reversible changes), $\boldsymbol{dU = TdS - p\,dV}$ (always true), For irreversible changes: $\boldsymbol{dQ \leq T\,dS}$, $\boldsymbol{dW \geq - pdV}$, Second law of thermodynamics in terms of entropy, The change of entropy in the gas, surroundings and the universe during Joule expansion of an ideal gas.

3 Hours

Unit 5 Thermodynamic potentials: Internal Energy (***U***), Enthalpy (***H***), Helmholtz Free Energy (***F***), Gibb's Free Energy (***G***), $\boldsymbol{dU = TdS - pdV}$, $\boldsymbol{dH = TdS + V\,dp}$, $\boldsymbol{dF = -SdT - pdV}$, $\boldsymbol{dG = -SdT + V\,dp}$,

Maxwell's relations: Derivation and applications of expressions: (1) $(\partial C_p/\partial p)_T$ and $(\partial C_V/\partial V)_T$ in terms of p, V, T, (2) $C_p - C_V = VT\beta^2 p/\kappa T$, (3) $S = C_V \ln T + R \ln V +$ constant, $= Cp \ln T - R \ln p +$ constant for 1 mole of an ideal gas, Isothermal (κ_T) and adiabatic (κ_S) compressibilities, Ratio of κ_T and κ_S equal to C_p / C_V.

4 Hours

Unit 6 Free adiabatic expansion of a perfect gas, Joule-Thomson porous plug experiment. Joule-Thomson effect for real and Van der Waals' gases. Temperature of inversion. Joule-Thomson Cooling.

3 Hours

Unit 7 Third law of thermodynamics: Nernst's statement, Planck's statement, Simon's statement, Consequences: (a) Heat capacities tend to zero as T → 0, (b) Thermal expansion stops, (c) No gases remain ideal as T → 0, (d) Impossible to attain T = 0 in a finite number of steps.

3 Hours

Reference Books

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 198`McGraw-Hill.
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 1993, Tata McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger, 1988, Narosa.
- An Introduction to Thermal Physics, Daniel V Schroeder, 2020, Oxford University Press.
- Thermal Physics, A. B. Gupta and H. P. Roy, Books and Allied Ltd.

Course Outcome: ***On completion of this course, the students will learn the kinetic theory of gases, the basic laws of thermodynamics, the applications of the well-known Maxwell's relations, the underlying Physics behind the Joule Thompson effect and the spectral distribution of the blackbody radiation.***

MAJOR-IV: PHYS4011: Heat and Thermodynamics
Practical: 30 Hours

List of Experiments

1. ***To determine the coefficient of thermal conductivity of copper using Searle's apparatus***
2. ***To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method***
3. ***Determination of the value of the Stefan's constant***

4. ***To study the variation of thermo-emf across two junctions of a thermocouple with temperature***
5. ***To determine the temperature coefficient of resistance and the boiling point of a given liquid using Platinum resistance thermometer***
6. ***To calibrate a thermocouple for measuring the temperature in a specified range using i) null method, ii) direct measurement using OP AMP difference amplifiers***
7. ***To determine the coefficient of thermal expansion of a metallic rod using an optical lever***
8. ***To determine the temperature coefficient of resistance using the Carry Foster bridge***
9. ***To determine the coefficient of thermal expansion of a metallic rod using travelling microscope***
10. ***To determine the pressure coefficient of air by constant volume method***

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani.
- B.Sc. Practical Physics, Harnam Singh, Dr. P.S. Hemne, 2018, S. Chand.
- Advanced Practical Physics, B. Ghosh and K. G. Majumdar, Shreedhar Publishers.
- Advanced Course in Practical Physics, D Chattopadhyay, P C Rakshit, New Central Book Agency.

MAJOR PHYSICS COURSE
Semester IV

MAJOR IV: PHYS4012: Mathematical Physics-II (Credits: Theory-04, Practicals-01)
F.M. = 75 (Theory-40, Practical–20, Internal Assessment–15)

Course Objectives: ***The emphasis of this course is on applications of mathematical techniques in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.***

60 Hours

Fourier Series

Unit 1 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 the determination of Fourier coefficients, Complex representation of a Fourier series, Expansion of functions with arbitrary period, Expansion of non-periodic functions over an interval, Even and odd functions and their Fourier expansions.

Applications: Summing of infinite series, Term-by-term differentiation and integration of a Fourier series, Parseval identity.

12 Hours

Frobenius Method and Special Functions

Singular points of the second order linear equations and their importance, Frobenius method and its applications to differential equations, Legendre, Bessel, Hermite and Laguerre differential equations.

Properties of Legendre polynomials: Rodrigues formula, Generating function, Orthogonality, Simple recurrence relations, Expansion of function in a series of Legendre Polynomials.

Bessel functions of the First kind: Generating function, Simple recurrence relations, Zeros of Bessel functions and orthogonality.

14 Hours

Dirac Delta Function

Definition, Representation as a limit of a Gaussian function and a rectangular function, Properties of the Dirac delta function.

2 Hours

Some Special Integrals

Beta and Gamma functions and the relation between them, Expression of integrals in terms of Gamma functions, Error function (Probability integral).

4 Hours

Theory of Errors

Systematic and random errors, Propagation of errors, Normal law of errors, Standard and probable error.

2 Hours

Partial Differential Equations

Solutions to partial differential equations using the method of separation of variables: (1) the Laplace's equation in problems of rectangular, cylindrical and spherical symmetries, (2) the wave equation related to the vibration of a stretched string and the oscillations of membranes (rectangular and circular).

8 Hours

Introduction to Probability

Random experiments, Sample space, Events, Probability, Random variables and probability distributions: (1) Discrete distributions, Binomial distribution as an example (2) Continuous distributions Gaussian, and Poisson distribution as examples, Mean and Variance.

4 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.

14 Hours

Course Outcome: ***After successful completion of this course, students will be able to formulate problems of Physics in the language of Mathematics.***

Reference Books

- Mathematical Methods for Physicists, Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis, M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- An Introduction to Ordinary Differential Equations, E.A Coddington, 1961, PHI Learning.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Publications.
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books.

MAJOR IV: PHYS4012: Mathematical Physics-II
Practical: 30 Lectures

SCILAB

Course Objective: ***The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem***

List of Assignments

30 Hours

1. Introduction to Numerical Computation Software

Introduction to Scilab/ Mathematica/ Matlab/ Python, Advantages and disadvantages, Scilab/ Mathematica/ Matlab/ Python environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab/ Mathematica/ Matlab/ Python, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab/ Mathematica/Matlab/Python functions, Introduction to 2D and 3D plotting.

Ohms law to calculate the resistance, Hooke's law to calculate the spring constant.

2. Inverse of a Matrix, Eigen Vctors and Eigen Values

Solution of mesh equations of electric circuits (3 meshes), Solution of coupled spring mass systems (3 masses), Generation of Special functions using user defined functions in Scilab/ Mathematica/ Matlab/ Python, Generating and plotting Legendre polynomials, Generating and plotting Bessel function.

3. ***Solution of Ordinary Differential Equations***

Unit 1 First order differential equation: Radioactive decay, Current in RC, LC circuits with DC sources, Newton's law of cooling, Classical equations of motion.

Unit 2 Second order differential Equation: Harmonic oscillators (no friction), Damped harmonic oscillators (Over damped, Critically damped, Oscillatory), Forced harmonic oscillators (Transient and steady state solutions), Solution of the equation $x^2\frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x) = x^3$ with the boundary conditions at $x = 1$, $y = \frac{1}{2}e^2$, $\frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$, in the range $1 \leq x \leq 3$, Plot y and against $\frac{dy}{dx}$ in the given range on the same graph.

4. XCOS

Generating signals, Beat phenomenon, Superposition of two perpendicular SHMs.

Course Outcome: ***The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.***

Reference Books

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 2006, Cambridge University Press.
- Computational Physics, D.Walker, 2015, Scientific International Pvt. Ltd.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, Cambridge University Press.
- Simulation of ODE/ PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández, 2014, Springer.

- Scilab (A Free Software to MATLAB) Er. Hema Ramchandran, Dr. Achuthsankar, S. Nair , S. Chand.
- Scilab: A Beginner's Approach, A. K. Verma, CENAGE, First Edition.

MAJOR-PHYSICS COURSE

Semester IV

MAJOR-IV:PHYS4013: Classical Mechanics and Special Theory of Relativity (Credits: Theory-05, Practicals-00)

F.M. = 75 (Theory-60, Practical–00, Internal Assessment–15)

Course Objectives: ***This course covers the Lagrangian and the Hamiltonian formulation of mechanics in systems with constraints, rigid body dynamics, Generating functions for canonical transformations, invariants. The course also covers the Special theory of relativity.***

Lagrangian Mechanics

Constraints and their classifications with examples**,** Inconvenience of Newtonian formulation in practice, The principle of virtual work, D′ Alambert's principle, Generalized coordinates and momenta, Lagrangian function, Lagrange's equations of motion, Advantages of Lagrangian formulation over Newtonian one, Cyclic Coordinates, Hamilton's variational principle, Applications of Lagrangian formulation to simple systems.

20 Hours

Hamiltonian Formulation

Hamiltonian function and its physical significance, Hamilton's canonical equations of motion, Advantages of Hamiton's formalism over the Lagrangian formulation, Conservation of Energy, Applications of Hamilton's equations to simple systems, Poisson brackets, Canonical transformations, Generating functions.

15 Hours

Rigid Body Dynamics

Generalized coordinates of rigid body, body and space reference systems, Angular momentum and moment of inertia tensor of simple rigid body (cube, sphere, cylinder), Principle axes and principle moments of inertia, Kinetic energy of a rigid body, Euler equations of motion of rigid body.

15 Hours

Special Theory of Relativity

Unit 1 Michelson-Morley experiment and its outcome, Two events in two different inertial frames and its correspondence, Simultaneity and order of events, Postulates of special theory of relativity, Lorentz transformations, Lorentz contraction, Time dilation, Twin paradox, Proper time and Proper length Relativistic transformation of velocity and frequency, Time like, space like and light like intervals, Causality.

Unit 2 Addition of velocities and Lorentz transformations, Variation of mass with velocity, Massless particles and Mass-energy equivalence.

Unit 3 Four vector formalism, Minkowski diagram**,** The four velocity, Four acceleration, Four force/ four momentum, Conservation of four momentum, Energy conservation.

Unit 4 Relativistic Doppler effect, Longitudinal and transverse Doppler effect and aberration, Decay proceses

Unit 5 Transformation of E and B fields, Invariance of Maxwell equations.

Course Objectives: ***On successful completion of this course the students will have in-depth understanding of Lagrangian and the Hamiltonian formulation of mechanics rigid body dynamics, and Special theory of relativity.***

Reference Books

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
3. Classical Electrodynamics, J.D. Jackson, 3rd Edn. 1998, Wiley.
4. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn. 2003, Elsevier.
5. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
6. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
7. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press.

MINOR-PHYSICS COURSE
Semester IV

MINOR IV: PHYS4021: Thermal Physics Credit: 4(3 + 0 + 1)
F. M. = 75 [Theory-40, Practical-20, Internal assessment-15]

45 Hours

Course Objective: ***The objective of the first part of the course is to infuse ideas of the Kinetic theory of gases, Thermodynamic laws, Thermodynamic potentials, and the Theory of radiation.*** **T*he second part is devoted to giving a basic introduction to Statistical Mechanics.***

Kinetic Theory of Gases

Objective of the theory (Knowledge of a macroscopic system from its microscopic constituents), Classical ideal gas and the ideal gas law, The basic postulates of the kinetic theory, Mean free path, Collision probability, The kinetic interpretation of pressure P, Relation between pressure and translational kinetic energy of the molecules, Kinetic interpretation of temperature - the average molecular kinetic energy is proportional to the absolute temperature, Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport

Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

10 Hours

Laws of Thermodynamics

Thermodynamic Description of a system, Zeroth Law of thermodynamics and temperature, First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work done during isothermal and adiabatic processes, Compressibility and expansion Coefficients, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

20 Hours

Thermodynamic Potentials

Enthalpy, Gibbs free energy, Helmholtz free energy and Internal energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (C_P- C_V),C_P/C_V, TdS equations.

5 Hours

Theory of Radiation

Blackbody radiation, Spectral distribution, Concept of energy density, Derivation of Planck's law, Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

5 Hours

Statistical Mechanics

Maxwell-Boltzmann law - distribution of velocity – Quantum statistics - Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics.

5 Hours

Course Outcome: ***Upon completion of this course, the students will grasp the idea of laws of thermodynamics, the Blackbody the basics of Statistical mechanics.***

Reference Books

- Thermal Physics, A. B. Gupta, Haripada Roy, Books & Allied Ltd.
- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw- Hill.
- A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press.
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw- Hill.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford

University Press.

MINOR-IV: PHYS4021: Thermal Physics

Practical: 30 Hours

List of Experiments

1. ***To determine the Stefan's Constant***
2. ***To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus***
3. ***To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method***
4. ***To determine the temperature co-efficient of resistance by Platinum resistance thermometer***
5. ***To study the variation of thermo- emf across two junctions of a thermocouple with temperature***
6. ***To determine the coefficient of thermal expansion of a metallic rod using optical lever***
7. ***To determine the coefficient of thermal expansion of a metallic rod by travelling microscope***
8. ***To determine the pressure coefficient of air by constant volume air thermometer***
9. ***To determine the temperature coefficient of resistance using Carry Foster Bridge***

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