



**Department of Physics**

**Indian Institute of Engineering Science & Technology, Shibpur**  
(Formerly Bengal Engineering & Science University, Shibpur)

*P.O: Botanic Garden, Howrah – 711103, West Bengal, India*

*Website: <http://www.iiests.ac.in>*

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# **BS-MS in Physics**

**Course Structure for BS-MS in Physics**

Sl. No	Type	Course Name	Course code	Class Load/Week			Credit	Class load/week	Marks	Remarks
				L	T	P				
1	PC	Theory (PH) : Mathematical Physics-I	PH1102N	3	1	0	4	4	100	Major Course
2	PC	Practical (PH) : Phys Major Lab-I (Principles of Measurements)	PH1172N	0	0	2	2	3	50	Major Practical
3	PM	Mathematics - I (MA)		3	1	0	4	4	100	Minor Course
4	VAC	Environmental Science (CE)		3	0	0	3	3	100	Value Added Course
5	MDC	One course from pool of MDC courses offered by Science Depts. (SOCSAT, PH, CH, ES) (Non- Departmental)		3	0	0	3	3	100	Multidisciplinary Course
6	SEC	Introduction to Computing (CST)					3	3	100	Skill Enhancement Course
7	AEC	Language Course (HSS)		3	0	0	3	3	100	Ability Enhancement Course
<b>Total</b>							<b>22</b>			
<b>Second Semester</b>										
Sl. No	Type	Course Name	Course code	Class Load/Week			Credit	Class load/Week	Marks	
				L	T	P				
1	PC	Theory (PH) : Classical Mechanics-I	PH1202N	3	1	0	4	4	100	Major Course
2	PC	Practical (PH) : Phys Major Lab-II (Studies on Mech. Systems)	PH1272N	0	0	2	2	3	50	Major Practical
3	PM	Mathematics - II (MA)		3	1	0	4	4	100	Minor Course
4	VAC	Wellbeing and Happiness (HSS)		3	0	0	3	3	100	Value Added Course



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5	MDC	One course from pool of MDC courses offered by Science Depts. (SOCSAT, PH, CH, ES) (Non-Departmental)		3	0	0	3	3	100	Multidisciplinary Course
6	SEC	Introduction to AI/ML (CST)					3	3	100	Skill Enhancement Course
7	AEC	Language Course		3	0	0	3	3	100	Ability Enhancement Course
<b>Total</b>							<b>22</b>			

### Third Semester

Sl. No	Type	Course Name	Course	Class Load			Credit	Class load/Week	Marks	
				L	T	P				
1	PC	Theory (PH) : Mathematical Physics-II	PH2101N	3	1	0	4	4	100	Major Course
2	PC	Theory (PH) : Thermal Physics	PH2102N	3	1	0	4	4	100	Major Course
3	PC	Practical (PH) : Phys Major Lab-III (Thermal Physics Lab)	PH2171N	0	0	2	2	3	50	Major Practical
5	PM	Mathematics - III (MA)		3	1		4	4	100	Minor Course
6	MDC	One course from pool of MDC courses offered by Science Depts. (SOCSAT, PH, CH, ES) (Non-Departmental)		3	0	0	3	3	100	Multidisciplinary Course
7	SEC	Computational Physics (PH)	PH2172N	1	0	2	3	3	100	Skill Enhancement Course
8	AEC	Departmental Course/Language Course		0	0	2	2	0	50	Ability Enhancement Course
<b>Total</b>							<b>22</b>			



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### Fourth Semester

Sl. No	Type	Course Name	Course	Class Load/Week			Credit	Class load/Week	Marks	
			Code	L	T	P				
1	PC	Theory (PH) : Electromagnetic Theory-I	PH2201N	3	1	0	4	4	100	Major Course
2	PC	Theory (PH) : Optics	PH2202N	3	1	0	4	4	100	Major Course
3	PC	Theory (PH) : Electronics-I	PH2203N	3	1	0	4	4	100	Major Course
4	PC	Practical (PH) : Phys Major Lab-IV (Optics and EMT Lab)	PH2271N	0	0	2	2	3	50	Major Practical
5	PM	Mathematics - IV (MA)		3	1	0	4		100	Minor Course
<b>Total</b>							<b>18</b>			

### Fifth Semester

Sl. No	Type	Course Name	Course	Class Load/Week			Credit	Class load/Week	Marks	
			Code	L	T	P				
1	PC	Theory (Departmental) : Quantum Mechanics- I		3	1	0	4	4	100	Major Course
2	PC	Theory (Departmental) : Classical Mechanics- II		3	1	0	4	4	100	Major Course
3	PC	Theory (Departmental) : Solid State Physics-I		3	1	0	4	4	100	Major Course
4	PC	Practical (Departmental)		0	0	2	2	3	50	Major Practical
5	PM	Physics - I / Chemistry - I					3		100	Minor Course
6	PM	Physics - II / Chemistry - II					3		100	Minor Course
7	PM	Minor Lab-I		0	0	2	2		50	Minor Lab
<b>Total</b>							<b>22</b>			

### Sixth Semester



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Sl. No	Type	Course Name	Course	Class Load/Week			Credit	Class load/Week	Marks	
			Code	L	T	P				
1	PC	Theory (Departmental) : Quantum Mechanics-II		3	1	0	4	4	100	Major Course
2	PC	Theory (Departmental) : Electromagnetic Theory-II		3	1	0	4	4	100	Major Course
3	PC	Theory (Departmental) : Electronics-II		3	1	0	4	4	100	Major Course
4	PC	Practical (Departmental)		0	0	2	2	3	50	Major Practical
5	PM	Physics - III / Chemistry - III					3		100	Minor Course
6	PM	Physics - IV / Chemistry - IV					3		100	Minor Course
7	PM	Minor Lab-II		0	0	2	2		50	Minor Lab
8	I	Internship					2		50	Other Course
<b>Total</b>							<b>24</b>			

**EXIT: Three years UG Degree**

**Entry: Two Years MS Program for Three years UG degree holders**

## Seventh Semester

### Dissertation Course

Sl. No	Type	Course Name	Course	Class Load/Week			Credit	Class load/Week	Marks	
			Code	L	T	P				
1	PC	Theory (Departmental) : PH401/Nuclear and Particle Physics		3	1	0	4	4	100	Major Course
2	PC	Theory (Departmental) : PH402/Statistical Mechanics-I		3	1	0	4	4	100	Major Course
3	PC	Theory (Departmental) : PH403/Atomic and Molecular Physics-I		3	1	0	4	4	100	Major Course
4	PC	Theory (Departmental) : PH421/Elective1		3	1	0	4	4	100	Major Course



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5	PC	Practical (Departmental)		0	0	2	2	3	50	Major Practical
6	P	Term Paper /Literature Review					2		50	For Four Years UG Honours with Research
7	P	Thesis Progress Report					2		50	For Four Years UG Honours with Research
8	O	Seminar/Viva-voce					2		50	For Four Years UG Honours with Research
<b>Total</b>							<b>24</b>			Total Credit for Four Years UG Honours with Research

### Non-Dissertation Course

8	MAJOR	Theory		3	0	0	3	3	100	Only for Four years UG Honours
9	MAJOR	Practical		0	0	3	2	3	50	Only for Four years UG Honours
<b>Total</b>							<b>23</b>			Total Credit for Four years UG Honours

### Eighth Semester

Sl. No	Type	Course Name	Course	Class Load/Week			Credit	Class load/Week	Marks	
			Code	L	T	P				
1	PC	Theory (Departmental) : Solid State Physics-II		3	1	0	4	4	100	Major Course
2	PC	Theory (Departmental) : Atomic Molecular Physics-II		3	1	0	4	4	100	Major Course
3	PC	Theory (Departmental) : Elective		3	1	0	4	4	100	Major Course
	PC	Practical (Departmental)		0	0	3	2	3	50	Major Practical
5	P	Thesis Final Report/Thesis Progress					4		150	For Four Years UG Honours with



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		Report								Research
6	O	Seminar/Viva-voce					2		50	For Four Years UG Honours with Research
	<b>Total</b>						<b>20</b>			<b>Total Credit for Four Years UG Honours with Research</b>

## Non-Dissertation Course

7	MAJOR	Theory		3	0	0	3	3	100	Only for Four years UG Honours
8	MAJOR	Theory		3	0	0	3	3	100	Only for Four years UG Honours
9	MAJOR	Practical		0	0	3	2	3	50	Only for Four years UG Honours
	<b>Total</b>						<b>22</b>			<b>Total Credit for Four years UG Honours</b>

**Exit: (i) Four Years UG Degree (Honours) -- for CGPA < 8.0 till sixth semester (ii) Four Years UG Degree (Honours with Research) -- for CGPA >= 8.0 till sixth semester**

**Entry: One Year MS Program for Four years UG degree holders**

## Ninth Semester

Sl. No	Type	Course Name	Course	Class Load/Week			Credit	Class load/Week	Marks	
			Code	L	T	P				
1	PC	Theory (Departmental)		3	1	0	4		100	Major Course
2	PC	Theory (Departmental)		3	1	0	4		100	Major Course
3	PC	Theory (Departmental)		3	1	0	4		100	Major Course
4	P	Thesis Progress Report					4		100	
5	O	Project Seminar					2		50	
6	O	Viva-voce					2		50	
	<b>Total</b>						<b>20</b>			

## Tenth Semester



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Sl. No	Type	Course Name	Course	Class Load/Week			Credit	Class load/Week	Marks	
			Code	L	T	P				
1	PC	Theory (Departmental)		3	1	0	4	4	100	Major Course
2	PC	Theory (Departmental)		3	1	0	4	4	100	Major Course
3	P	Project Final Report					6		150	
4	P	Project Final Seminar					4		100	
5	O	Viva Voce					2		50	
	<b>Total</b>						<b>22</b>		<b>500</b>	
<b>Exit: (i) Five Year BS-MS Degree (ii) One Year MS Degree for Four Years UG Degree Holders (iii) Two years MS degree for Three Years UG Degree Holders</b>										

### Acronym for course types:

PC = Program Core			
PM = Program Minor			
VAC = Value Added Course			
MDC = Multidisciplinary Course			
SEC = Skill Enhancement Course			
AEC = Ability Enhancement Course			
I = Internship			
P = Project			
O = Other /Viva Voce			

### Convention of courses codes:

Code: WWXYZZN

where

WW: Department Code ( e.g., CH, PH, GE, etc.)

X: Year (1, 2, 3, 4, 5 for BS-MS 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> year respectively.)

Y: Semester Code -- 1 for odd semester and 2 for even semester

*Theory Courses:*

ZZ: 01-20 -- for Core (Major/PC) Courses

21-60 -- for Dept. Electives

61-70 -- for Open Electives (MDC/Minor/VAC)

*Laboratory / Practical / Project:*



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71-90 -- for Laboratory Courses with weekly class load (Major/Minor/SEC/AEC)

91-99 -- for Thesis/Project/Internship/Viva, etc. without weekly class load

N: To be appended with a N to identify the courses developed following NEP 2020.

### Credit distribution

Course	Total Credit for three years UG degree	Required
PC	64	60
PM	32	24
VAC	6	6 to 8
MDC	9	9
AEC	8	8
SEC	9	9
Internship	2	2 to 4
<b>Total</b>	<b>130</b>	<b>120</b>

Course	Total Credit for four years UG honours with reaserch	Required
PC	96	80
PM	32	32
VAC	6	6 to 8
MDC	9	9
AEC	8	8
SEC	9	9
Research	12	12
Internship	2	2 to 4
<b>Total</b>	<b>174</b>	<b>160</b>

Course	Total Credit for four years UG honours	Required
PC	109	92
PM	32	32
VAC	6	6 to 8
MDC	9	9
AEC	8	8
SEC	9	9
Internship	2	2 to 4



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Total	175	160
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# SYLLABUS

## 5 Year BS-MS Program (Semester I-IV)



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# Department of Physics

# Semester - I



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### Mathematical Physics-I (Semester I)

Course Code	PH1102N	Course Name	Mathematical Physics I	Course Category	PC	L	T	P
						3	1	0
Pre-requisite Courses		Co-requisite Courses		Progressive Courses				
Course Offering Department	Physics			Data Book / Codes/Standards				

Course Objective	<ol style="list-style-type: none"> <li>To equip students with necessary mathematics required for advanced courses in physics.</li> <li>To sketch the ideas and emphasize the relations that are essential to the study of physics and related fields.</li> </ol>
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Module	Syllabus	Duration (class-hour)	Module outcome
1.	<p><b>A. Vectors:</b> Vectors and scalars under rotation; Levi-Civita symbol and summation convention, Gradient, divergence and curl operators; Gauss divergence, Stokes theorem.</p> <p><b>B. Curvilinear Coordinates:</b> Orthogonal curvilinear coordinates, Jacobian of transformation, concept of a metric, spherical and cylindrical coordinates and their unit vectors.</p> <p><b>C. Tensors:</b> Covariant and contravariant tensors, contractions and direct products. Examples: pseudo, dual, isotropic, symmetric and anti-symmetric tensors.</p>	15	This module introduces different vector operations and related differential operators required in different areas of science and engineering. Students will learn about different coordinate systems and related mathematical operations. The concept of tensors will be used in relativity, high energy physics, non-linear optics, etc.
2.	<p><b>Linear vector spaces:</b> Definitions, Properties Cauchy-Schwarz inequality, Definitions of norms, Gram-Schmidt orthonormalization</p> <p><b>Matrices:</b> Similarity transformations, eigenvalues and eigenvectors, commuting</p>	8	Matrices are used to solve differential equations and are the basis for some rapid numerical methods.



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	operators and simultaneous eigenvectors for non-degenerate and degenerate eigenvalues, Cayley-Hamilton Theorem, diagonalization of matrices.		Quantum Mechanics can be described entirely in terms of matrices.
3.	<p><b>A. Fourier Series:</b> Periodic functions, orthogonality of sine and cosine functions, Dirichlet Conditions, Fourier theorem and determination of Fourier coefficients, expansion of non-periodic functions over an interval, even and odd functions and their Fourier expansions</p> <p><b>B. Integral Transforms:</b></p> <p><b>(i) Fourier Transform:</b> Fourier Integral theorem, Fourier Transform (FT) with examples, inverse Fourier transform, properties of FT (translation, change of scale, complex conjugation, etc.). Parseval's identity.</p> <p><b>(ii) Laplace Transform:</b> Definition, Properties and examples of Laplace Transforms, Inverse Transform, Convolution theorem and its applications, transforms of derivatives, Laplace transform method of solving differential equations (ODE and PDE), Differentiation and Integration of transforms, Inverse Transform by Bromwich integral.</p>	14	Integral transform methods will help in solving the differential equations and it is widely used in engineering fields namely, mechanical and electrical engineering, etc. It will help students to understand spectroscopic outcomes, signal processing, etc. Integral transform methods and the momentum representation are useful for problems in quantum mechanics.
4.	<p><b>Probability:</b> Probability for discrete events, and combined probability for uncorrelated events, mean and variance, independent random variables, Sample space and Probability distribution functions, Binomial, Gaussian, and Poisson distribution with examples, central limit theorem, one dimensional random walk.</p>	5	This will help students to apply probability theory in different areas like data analysis, system modelling. This will later be useful in statistical as well as quantum mechanics.

<b>Course Outcome</b>	<ol style="list-style-type: none"> <li>1. This course helps students to acquire necessary mathematical skills to grasp the concepts of advanced physics.</li> <li>2. The course contents are designed to gear up active learning and enhance problem-solving skills of physics students.</li> <li>3. The mathematical methods given herewith are not quoted under most general assumptions, but are customized to the more restricted</li> </ol>
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applications required in almost all areas of physics.

### Learning Resources

1. Mathematical Methods for Physicists, G.B. Arfken and H.J. Weber, 2005, Harris, Elsevier.
2. Theory and Problems of Vector Analysis (Schaum's Outline Series), M.R. Spiegel
3. Fourier Analysis, M.R. Spiegel, 2004, Tata McGraw-Hill
4. Fourier Series and Boundary Value Problems, J.W. Brown and R.V. Churchill, 2017, McGraw Hill Education
5. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
6. Mathematical Physics: P. K. Chattopadhyay, 2014, New Academic Science.
7. Mathematical Methods in Physical Sciences; M. L. Boas, 2006, Wiley India Pvt Ltd.



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### Physics Major Lab-1 (Semester - I)

Course Code	PH1172N	Course Name	Physics Major Lab-I	Course Category	PC	L	T	P
						0	0	2

#### Principles of measurements (accompanying theory course: Mathematical Physics-I)

1. Understanding least count, significant figures and order of accuracy (using basic measurement devices like slide calipers, screw gauge, spherometer, travelling microscope etc.)
2. Significance of number of observational data and its impact in final calculations.
3. Limitation of measurement devices, error estimation and methods of minimising them.
4. Graph plotting and error calculation from graph.
5. Simple circuit analysis using a voltage source and a digital multimeter.
6. Use of a Oscilloscope and Photoconductor/Photodiode
7. To determine the focal length of a combination of lenses.
8. To determine acceleration due to gravity by studying videos of a projectile.
9. Verification of Malus' Law (polarization).
10. Verification of Newton's second law.
11. To study collision and hence conservation of energy by video tracking
12. Photoelectric Effect: To study the Photoelectric effect and to determine Planck's constant.
13. To determine the resistance per unit length and an unknown resistance using the Carey Foster Bridge.
14. To study the forward/reverse characteristics of the PN junction diode.
15. To study the input and output characteristics of a P-N-P transistor.



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# Semester - II



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### Classical Mechanics-I (Semester II)

Course Code	PH1202N	Course Name	Classical Mechanics-I	Course Category	PC	L	T	P
						3	1	0
Pre-requisite Courses	None	Co-requisite Courses	None	Progressive Courses				
Course Offering Department		Physics		Data Book / Codes/Standards				

Course Objective	The aim of this course is to provide physics students the basics tools to solve problems related to the mechanics of classical bodies. This course also introduces some advanced tools that are more versatile than the Newtonian methods.
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Module	Syllabus	Duration (class-hour)	Module outcome
	<b>History of Classical Mechanics</b>	1	
1.	<p>A. <b>Inertial Frames:</b> Concepts of Inertial frames, force and mass. Galilean transformations and Galilean invariance.</p> <p>B. <b>Motion of a particle:</b> Newton's laws of motion, work energy theorem, conservative and non-conservative forces, work done by a non-conservative force, concept of potential and potential energy, other equivalent definitions of a conservative force, law of conservation of energy, qualitative study of one-dimensional motion from potential energy curves, stable and unstable equilibrium; Rotational motion, Centrifugal and Coriolis force, Effect of centrifugal and Coriolis force due to earth rotation.</p>	10	This module introduces the basics to study the motion of a particle under external force. At the end of this unit, students will be able to deal with the mechanics of bodies in non-inertial frames too. In particular, the motion of objects in rotating frames such as earth.
2.	<p>A. <b>Dynamics of a system of particles:</b> The problem of solving equation of motion; Action-reaction kind of forces and the two body problem; Reduced mass and centre of mass; Properties of the centre of mass;</p>	6	Describe the dynamics of particle systems, center of mass, and conservation laws, and solve problems



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	Effect of torque; Linear momentum, angular momentum and total energy of a system of particles. B. <b>Scattering:</b> Two body collision and scattering.		involving collisions.
3.	<b>Central force:</b> Newton's Law of Gravitation; Kepler's Laws; Conservation of angular momentum, Gauss's law for Gravitation (integral form); Gravitational potential and intensity due to uniform spherical shell, solid sphere of uniform density and infinite flat sheet. Differential equation for the path in a central force field. Motion under an inverse square force, calculation of orbits.	8	At the end of this module, students will be able to comprehend gravitational forces, potentials, and fields in different contexts and its application in explaining the out-of-scattering experiments.
4.	<b>Rigid Body Dynamics:</b> Constraints defining the rigid body, degrees of freedom for a rigid body; relation between angular momentum and angular velocity: moment of inertia tensor, calculation for rectangular, cylindrical and spherical bodies, equation of motion (EOM) for rotation about a fixed axis, principal axes transformation, transformation to a body fixed frame. EOM for the rigid body with one point fixed (Euler's equations of motion). Torque-free motion. Kinetic energy of rotation.	10	This module will help to understand the exact representation of the orientation of an arbitrary rigid body using Euler angles and its application in understanding the motion of heavy tops.
5.	<b>Fluid Mechanics:</b> Bernoulli's theorem, equation of continuity, streamline and turbulent flow (Reynolds number), surface tension and surface energy, viscosity and Poiseuille's Equation, Navier-Stoke's theorem.	8	This module will help to understand the basics of fluid mechanics

<b>Course Outcome</b>	Upon completion of this course, students will - 1) Have a broad understanding of the mechanics of classical objects. 2) Develop analytical skills and understanding of physical principles governing natural phenomena. 3) Be able to describe classical systems using the Lagrangian and Hamiltonian approach. 4) Be able to appreciate the limitations of classical mechanics.
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### Learning Resources

1. Introduction to Classical Mechanics, R. G. Takwale and P.S.Puranik, Tata McGraw-Hill Publishing Company Ltd.
2. Classical Mechanics and General Properties of Matter. S.N. Maiti and D.P. Raychaudhuri, New Age
3. Theory and Problems of Theoretical Mechanics, M. R. Spiegel, McGraw Hill Education
4. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
5. Mechanics, Resnick, Halliday and Walker 8/e. 2008, Wiley
6. Classical Mechanics, Goldstein, Poole and Safko, 2011, Pearson Education
7. Classical Mechanics , N.C. Rana and P. Joag, 2017, McGraw Hill Education
8. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education



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### Physics Major Lab-2 (Semester - II)

Course Code	PH1272N	Course Name	Physics Major Lab-II	Course Category	PC	L	T	P
						0	0	2

#### Studies on Mechanical Systems (*accompanying theory course: Classical Mechanics-I*)

1. Determination of surface tension of a liquid using capillary tube.
2. Determination of coefficient of viscosity of a liquid using Stoke's law.
3. Determination of Young's modulus of a metal bar using the flexure method.
4. Pohl's Pendulum: To study forced oscillations and to plot resonance curves for different damping.
5. Coupled Pendula: To study normal modes, normal frequencies and resonance of coupled pendula.
6. To determine the moment of inertia of a gyroscope and of masses of different shapes.
7. Torsional pendulum and determination of rigidity modulus.
8. To determine the acceleration due to gravity using a compound pendulum.
9. To study (a) the phase-space trajectory (p-x plot) of a simple harmonic oscillator, (b) forced vibration and resonance, and (c) effect of damping (underdamped, critically damped, and overdamped) using video tracking.
10. Determination of group velocity by studying the wave phenomena of ripples/surface waves.
11. Determination of coefficient of restitution using sound analysis.







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	application.		with constant coefficients, including applications to simple harmonic motion.
3	<b>Special Functions:</b> Special functions (Hermite, Bessel, Laguerre and Legendre functions). Partial differential equations (Laplace, wave and heat equations in two and three dimensions,	8	To understand and apply special functions (Hermite, Bessel, Laguerre, and Legendre) and to formulate and solve partial differential equations (Laplace, wave, and heat equations) in two and three dimensions using Green's function methods.
4	<b>Partial Differential Equations:</b> Solution of PDEs using the method of separation of variables. Laplace's equation in Cartesian and spherically symmetric cases. Wave equation: vibrational modes of a stretched string. Diffusion (heat) equation in one dimension.	8	To solve partial differential equations using the method of separation of variables, analyze Laplace's equation in Cartesian and spherical symmetry, and apply wave and diffusion equations to physical systems such as vibrating strings and heat flow in one dimension.
5	<b>Group Theory:</b> Basics of group theory relevant to physics, SU(2) group: properties and representations, O(3) group: properties and physical significance, generators and their algebra.	8	Understand the structure and physical relevance of SU(2) and O(3) groups and their basic representations.





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### Thermal Physics (Semester III)

Course Code	PH2102N	Course Name	Thermal Physics	Course Category	PC	L	T	P
						3	1	0
Pre-requisite Courses		Co-requisite Courses		Progressive Courses				
Course Offering Department	Physics			Data Book / Codes/Standards				

Course Objective	<p><b>Develop conceptual understanding</b> of the laws of thermodynamics and their implications for physical systems in equilibrium and non-equilibrium settings.</p> <p><b>Apply statistical mechanics principles</b> to relate microscopic states to macroscopic thermodynamic quantities, including entropy, temperature, and free energies.</p>
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Module	Syllabus	Duration (class-hour)	Module outcome
1.	<b>Kinetic Theory of gases:</b> Brownian motion, Maxwell-Boltzmann distribution law, collision parameters and its experimental determination; transport phenomena: diffusion, effusion, thermal conduction; viscosity, relaxation time, principle of equipartition of energy, specific heat capacity of solids and gases, classical theory of specific heat of solids.	12	At the end of this unit students will learn to use kinetic theory of gases to calculate macroscopic observables like temperature.
2.	<b>Laws of thermodynamics:</b> zeroth, first, second & third; Entropy, free energy, enthalpy, and their implications and applications, Maxwell's thermodynamic relations. Heat engines, Carnot engine, thermodynamic phase transitions, Clausius-Clapeyron equation, phase equilibrium and Gibbs phase rule, blackbody radiation (Stefans	22	Thermodynamical laws and its consequences, concept of entropy, working principles of thermal engines.



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	law), thermodynamic description of magnetism, superconductivity and ionic phenomena, Joule-Thomson effect.		
3.	<b>Elementary Concepts of Statistical Mechanics:</b> Concept of ensemble and Ergodic Hypothesis, Postulate of equal a priori probability. Boltzmann hypothesis: Entropy and thermodynamic probability.	8	At the end of this unit student will learn to represent a system of large numbers of particles with minimum as a point in phase space along with the time evolution of the system.

<b>Course Outcome</b>	After the completion of the course students will-  <b>Explain and apply</b> the laws of thermodynamics to analyze energy exchange, entropy, and equilibrium in physical systems.  <b>Solve quantitative problems</b> involving thermodynamic potentials and statistical ensembles for idealized physical systems.
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<b>Learning Resources</b>	<ol style="list-style-type: none"> <li>1. “Heat and Thermodynamics” (7th edition) M. W. Zeemansky and R. H. Ditman- Mc Graw Hill</li> <li>2. “Statistical Mechanics”, (2nd Ed.), K. Huang- Wiley</li> <li>3. Fundamentals of Statistical and Thermal Physics, F. Reif, McGraw Hill</li> </ol>
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### Physics Major Lab-3 (Semester - III)

Course Code	PH2171N	Course Name	Physics Major Lab-III	Course Category	PC	L	T	P
						0	0	2

**Thermal Physics Lab** (*accompanying theory course: Mathematical Physics-II, Thermal Physics*)

1. To determine the thermal conductivity of a bad conductor using Lee's disc method.
2. Determination of the coefficient of thermal conductivity of a good conductor (metal rod) using Searle's method.
3. Study of linear thermal expansion in metal rods.
4. To determine the volume expansion of liquid (including water) as a function of temperature using the pycnometer
5. Studies on temperature sensor (Thermocouple/ Thermistor) and its application.
6. Studies on the molar specific heat of metals and Dulong-Petit's law.
7. Verification of the equation of state of gases.
8. Verification of Stefan's Law of Radiation
9. Study of the mechanical equivalence of heat.



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### Computational Physics (Semester - III) Skill Enhancement Course

Course Code	PH2172N	Course Name	Physics Major Lab-III	Course Category	SEC	L	T	P
						1	0	2

<b>Course Objective</b>	To learn numerical methods and techniques in order to solve physics-related problems, especially the ones that defy analytical solutions.
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#### Syllabus

1. Data Analysis (Random Variables, Random number Generator, Moment calculations)
2. Polynomial data fitting
3. Root finding
4. Numerical Differentiation and Interpolation
5. Numerical Integration
6. Differential Equations
7. Partial differential Equations
8. Random Processes: Monte Carlo Integration, Random Walk, Metropolis algorithm
9. Linear Algebra: Eigen value Problems

<b>Course Outcome</b>	Students will learn to solve complex problems using computers for which analytical solutions are hard to obtain.
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<b>Learning Resources</b>	<ol style="list-style-type: none"><li>1. Computational Physics by Mark Newman (Create Space Independent Publishing Platform)</li><li>2. Numerical Methods in Physics with Python, Alex Gezerlis, (Cambridge University Press)</li></ol>
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# Semester - IV



**Electromagnetic Theory I (Semester IV)**

<b>Course Code</b>	PH2201N	<b>Course Name</b>	Electromagnetic Theory I	<b>Course Category</b>	PC	L	T	P
						3	1	0

<b>Pre-requisite Courses</b>		<b>Co-requisite Courses</b>	<i>Mathematical Physics</i>	<b>Progressive Courses</b>	
<b>Course Offering Department</b>	<i>Physics</i>		<b>Data Book / Codes/Standards</b>		

<b>Course Objective</b>	<ol style="list-style-type: none"> <li>1. Understand the fundamental principles of electric and magnetic fields in electrical systems.</li> <li>2. Develop the idea of electromagnetic fields.</li> <li>3. Apply electromagnetic concepts to practical systems.</li> </ol>
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<b>Module</b>	<b>Syllabus</b>	<b>Duration (class-hour)</b>	<b>Module outcome</b>
1	<b>Electrostatics:</b> Coulomb's law, Superposition principle, Gauss's law and its applications, Field, potential and energy, energy stored in electrostatic field, Multipole expansion of potential, Dipole and quadrupole moment	8	Students will be able to compute and analyze electric fields, potentials, and energy using Coulomb's law, superposition, Gauss's law, and multipole expansion, including evaluation of dipole and





			energy stored in inductive systems.
6	Maxwell's equations, boundary conditions on the fields at interfaces. Dielectrics and conductors. Electromagnetic waves in free space and material medium. Scalar and vector potentials, gauge invariance. Poynting Theorem and Poynting vector. Electromagnetic (EM) Energy Density Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction.	8	Students will be able to interpret Maxwell's equations in free space and linear media and apply the corresponding boundary conditions at dielectric and conductor interfaces.

<b>Course Outcome</b>	<ol style="list-style-type: none"> <li>1. Estimate field intensities, distributions, and related electromagnetic properties.</li> <li>2. Determine boundary conditions and interface characteristics of electromagnetic fields.</li> <li>3. Recognize basic electromagnetic wave phenomena.</li> </ol>
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<b>Learning Resources</b>	<ol style="list-style-type: none"> <li>1. Introduction to Electrodynamics, D.J. Griffiths, 4th Edn., 2015, Pearson Education.</li> <li>2. Classical Electrodynamics, J D Jackson, John Wiley &amp; Sons.</li> <li>3. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education.</li> </ol>
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### Optics (Semester IV)

<b>Course Code</b>	PH2202N	<b>Course Name</b>	Optics	<b>Course Category</b>	PC	<b>L</b>	<b>T</b>	<b>P</b>
						3	1	0

<b>Pre-requisite Courses</b>	Basic standard Physics	<b>Co-requisite Courses</b>		<b>Progressive Courses</b>	
<b>Course Offering Department</b>	<i>Physics</i>		<b>Data Book / Codes/Standards</b>		

<b>Course Objective</b>	The objective of the course is to develop basic understanding of Interference, Diffraction and Polarization among students. They also learn about the theory and applications of LASER and fibre optics. Students will be equipped with knowledge to measure wavelength, refractive index and other related parameters, which will act as a strong background if he/she chooses to pursue physics as a career.
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<b>Module</b>	<b>Syllabus</b>	<b>Duration (class-hour)</b>	<b>Module outcome</b>
1	Elementary geometrical optics in the paraxial approximation. Fermat's principle, refraction at a spherical surface, image formation by thick lenses, lens formula. Combination of thin lenses, equivalent focal length. Dispersion and dispersive power. Use of Matrix methods, Reflection and refraction at a plane boundary from Huygens' principle, Snell's Law, refractive index.	8	Students will be able to apply paraxial geometrical optics and Fermat's principle to analyze image formation, lens systems, dispersion, and reflection/refraction using Huygens' principle and Snell's law.



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2	Simple two-slit interference: Division of amplitude and wavefront. Young's double slit experiment. Intensity distribution, conditions of interference, 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, Interference with broadband light(nonmonochromatic)	10	Students will be able to analyze interference phenomena—including two-slit patterns, thin-film fringes, and Newton's rings—to determine intensity distributions, wavelengths, and refractive indices.
3	Fraunhofer diffraction: Single slit, double slit and diffraction grating. Resolving power of grating, its experimental arrangement, and conditions for proper illumination. The dispersive and resolving features of a diffraction grating. Diffraction through circular aperture, Fresnel diffraction: Fresnel's half-period zones for plane waves. Zone Plate: Multiple foci of a Zone Plate.	8	Students will be able to evaluate Fraunhofer and Fresnel diffraction patterns for various apertures and gratings, and determine their dispersive and resolving properties, including zone-plate focusing behavior.
4	Description of linear, circular and elliptical polarization. Jones vector and Jones matrix, Propagation of electromagnetic waves in birefringent medium, polarization in uniaxial crystals. Double refraction. Polarization by double refraction. Ordinary and extraordinary refractive indices. Phase Retardation plates: Quarter-wave and Half-wave plates. Rotatory polarization, Biot's laws for rotatory polarization. Specific rotation.	10	Students will be able to analyze different states of polarization and describe wave propagation in birefringent media, including double refraction, retardation plates, and rotatory polarization.
5	Elementary Fourier optics and Fibre optics	6	Basic principles of fourier optics





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### Electronics I (Semester IV)

Course Code	PH2203N	Course Name	Electronics - I	Course Category	PC	L	T	P
						3	1	0
Pre-requisite Courses	None	Co-requisite Courses	None	Progressive Courses				
Course Offering Department	Physics			Data Book / Codes/Standards				

Course Objective	<ol style="list-style-type: none"> <li>Understand the principles and characteristics of semiconductor and opto-electronic devices.</li> <li>Learn the operation and applications of operational amplifiers and digital circuits.</li> </ol>
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Module	Syllabus	Duration (class-hour)	Module outcome
1	<b>Circuits and network (DC)</b> Discrete components, active and passive components, ideal constant voltage and constant current sources. Network analysis: Kirchhoff's laws, Thevenin's and Norton's theorem, Superposition theorem. Maximum power transfer theorem.	4	To understand and analyze DC circuits, including active and passive components, apply Kirchhoff's laws, and use Thevenin's, Norton's, and Superposition theorems, as well as the maximum power transfer theorem.
2	<b>Semiconductor diodes and applications</b> P and N-type semiconductors. Energy level diagram. Conductivity and mobility, concept of drift velocity. PN junction fabrication (simple idea only). Barrier formation in a PN junction diode. Static and dynamic resistance. Current flow mechanism in a forward and reverse-biased diode. Drift velocity. Rectifier diode, Calculation of Ripple Factor and	9	To understand P–N junction formation, diode characteristics, and current flow mechanisms, and to analyze diode applications including rectifiers, filters, clippers, clampers,



	Rectification Efficiency, L and C filter. Circuit and operation of clipping and clamping circuit; principle and structure of LEDs, photodiode, solar cell.		LEDs, photodiodes, and solar cells.
3	<b>Bipolar junction transistors (BJT) and Field Effect transistors (FET)</b> n-p-n and p-n-p transistors. Characteristics of CB, CE, and CC configurations. Physical mechanism of current flow. The relations between the current gains of the three modes. Active, cut-off, and saturation regions. DC load line and Q-point; Transistor biasing and stabilization circuits. Fixed bias, collector to base bias, emitter or self bias, voltage divider bias. Input and output impedance. JFET and MOSFET (both depletion and enhancement type) as a part of MISFET. Basic structure and principle of operations and their characteristics. Pinch-off, threshold voltage, and short-channel effect.	10	To understand the structure, operation, and characteristics of BJTs and FETs, analyze different transistor configurations, operating regions, biasing methods, and Q-point, and explain the principles and behavior of JFETs and MOSFETs including pinch-off and threshold voltage.
4.	<b>Regulated power supply</b> Load regulation and line regulation. Zener diode as a voltage regulator. Problem with the Zener regulator circuit. Requirement of feedback and error amplifier. Study of series regulated power supply using pass and error transistor assisted by Zener diode as a reference voltage supplier.	3	To understand load and line regulation, analyze Zener diode voltage regulator circuits, and study series regulated power supplies with feedback and error amplification using Zener and transistors.
5.	<b>Amplifiers, Feedback amplifiers and OPAMP</b> Transistor amplifier; CB, CE, and emitter follower circuit and their uses. Load Line analysis of a transistor amplifier. Classification of class A, B, and C amplifiers with respect to the placement of the Q point. Frequency response of a CE amplifier. Role of series and parallel capacitors for cut-off frequencies. Effects of positive and negative feedback. Voltage series, current series,	8	To analyze transistor amplifiers and their frequency response, understand the effects of positive and negative feedback, and apply OP-AMPs in DC and AC applications, including amplifiers, adders, differentiators, integrators,



	voltage shunt, and current shunt feedback, and uses for specific amplifiers. Estimation of input impedance, output impedance, gain, stability; Open-loop and closed-loop voltage gain. Frequency response. CMRR. Slew rate and concept of virtual ground. Application of OP-AMP: DC application — inverting and non-inverting amplifiers, inverting and non-inverting adder, differentiator as subtractor, error amplifier, comparator, Schmidt trigger. AC applications: differentiator, integrator.		comparators, and Schmitt triggers.
6.	<b>Multivibrator and Oscillators</b> Transistor as a switch, Explanation using CE output characteristics. Construction and operation using wave shapes of a collector coupled Bistable, Monostable, and Astable multivibrator circuits, Expression for the time period. Sinusoidal oscillators: Barkhausen's criterion for self-sustained oscillations. RC phase shift oscillator, Wien bridge oscillator, determination of feedback factor, and frequency of oscillation. Relaxation oscillator using OP-AMP.	8	To understand the use of transistors as switches, analyze bistable, monostable, and astable multivibrator circuits, and study sinusoidal and relaxation oscillators, including design principles, feedback factors, and frequency of oscillation.

<b>Course Outcome</b>	<ul style="list-style-type: none"> <li>Analyze semiconductor and opto-electronic devices and their applications.</li> <li>Apply op-amp and digital circuit concepts in practical systems.</li> </ul>
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<b>Learning Resources</b>	<ol style="list-style-type: none"> <li>Circuits and Networks: Analysis and Synthesis, A. Sudhakar and S. P. Shyammohan, Tata McGraw-Hill Education Private Ltd., 2017.</li> <li>Solid State Electronic Devices, B. G. Streetman and S. K. Banerjee, 6th Edition, PHI Private Ltd., 2009.</li> <li>Fundamental Principles of Electronics, B. Ghosh, 2nd Edition, Books &amp; Allied (P) Ltd., 2008.</li> <li>Integrated Electronics, J. Millman and C. C. Halkias, Tata McGraw-Hill.</li> </ol>
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### Physics Major Lab-4 (Semester - IV)

Course Code	PH2271N	Course Name	Physics Major Lab-IV	Course Category	PC	L	T	P
						0	0	2

**Optics and EMT Lab** (*accompanying theory course: Optics, Electromagnetic Theory-I, Electronics-I*)

1. Diffraction Grating: To study the multi-slit Fraunhofer diffraction and to determine the wavelengths of Mercury spectral lines
2. Single Slit and Double Diffraction: To study the single slit Fraunhofer diffraction and to plot the intensity distribution of the diffraction pattern by a slit.
3. Newton's Rings: To study the interference fringes of equal thickness to determine the wavelength of Sodium light.
4. Michelson Interferometer: To study the interference fringes of equal inclination and to determine the wavelength of He-Ne laser light.
5. Determination of specific rotation of cane sugar using a polarimeter.
6. To determine the grating element of a two-dimensional grating by using fourier optics and image analysis (using intensity profile).
7. To study the (a) emission and (b) absorption spectra from iodine vapour using image analysis.
8. To study (a) Rayleigh scattering, (b) Mie scattering, and (c) Raman scattering (Stoke's shift).
9. To map the equipotential lines and electrostatic field lines.
10. Study of the magnetic field in Helmholtz coils.
11. To determine the mutual inductance of a pair of coils using a ballistic galvanometer
12. Study of resonance in a series LCR AC circuit.
13. To study the effect of radiation from an accelerated charge.