SYLLABUS

for

Semester VI

Program: B. Sc.

Course: Physics

Effective from

Academic Year

2026-27

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Solid State Physics and Theory of Relativity
COURSE CODE: PHYMJ-S6P14-2CR26 [CREDITS - 02]

<table>
<tr><td rowspan="2">CC XIV</td><td colspan="2">COURSE CODE: PHYMJ-S6P14-2CR26</td></tr>
<tr><td colspan="2">Course Learning Outcomes</td></tr>
<tr><td colspan="3">At the end of this course, students will be able to
• explain the electronic properties of solids using free electron and band theory models
• analyze electrical and thermal behaviour of metals based on fundamental concepts such as conductivity, Fermi level and energy bands
• differentiate between metals, insulators, and semiconductors using band structure concepts
• derive the time dilation and length contraction formulae
• establish a relation between mass and energy
• establish the Lorentz transformation
• apply the concept of relativity to the electromagnetism.</td></tr>
<tr><td>Unit I</td><td>Solid State Physics</td><td>[15L]</td></tr>
<tr><td colspan="3">Learning Objectives:
This unit is intended to make the learners
• understand the motion and behaviour of conduction electrons in solids
• familiarize with the formation of energy bands and their significance in determining material properties
• develop conceptual clarity about electron dynamics in periodic potentials.</td></tr>
<tr><td colspan="3">Learning Outcomes:
At the end of this unit, learners will be able to
• describe the free electron model and its role in explaining conductivity and thermal properties
• explain the origin of energy bands and classify solids based on band theory
• apply basic concepts of electron dynamics (Hall effect, effective mass) to interpret physical phenomena in solids.</td></tr>
<tr><td>1.1</td><td>Conduction Electrons (4.2), The Free-electron Gas (4.3), Electrical Conductivity (4.4), Electrical Resistivity vs Temperature (4.5), Heat Capacity of Conduction Electrons (4.6), The Fermi Surface (4.7), Electrical conductivity; effects of the Fermi surface (4.8), motion in a magnetic field: cyclotron resonance and the Hall effect (4.10), Failure of the Free Electron Model (4.13).</td><td>[07L]</td></tr>
<tr><td>1.2</td><td>Energy spectra in atoms, molecules, and solids (5.2), Energy bands in solids; the Bloch theorem (5.3), Band symmetry in k-space; Brillouin zones (5.4), Number of states in the band (5.5), The nearly-free-electron model (5.6) The energy gap and the Bragg reflection (5.7), Metals, insulators, and semiconductors (5.10), Density of states (5.11), The Fermi surface (5.12), Velocity of the Bloch electron (5.13), Electron dynamics in an electric field</td><td>[08L]</td></tr>
</table>

	(5.14), The dynamical effective mass (5.15) Momentum, crystal momentum, and physical origin of the effective mass (5.16), The hole (5.17).	

Text Book:
Elementary Solid State Physics by M. Ali Omar, Addison-Wesley 2016.

Unit II	**Theory of Relativity**	**[15L]**

Learning Objectives:
This unit is intended to make the learners
- familiarize the students with postulates of Special Relativity and their implications
- introduce the students the implications of Special Relativity.

Learning Outcomes:
At the end of this unit, learners will be able to
- derive the time dilation and length contraction formulae
- establish a relation between mass and energy
- establish the Lorentz transformation
- apply the concept of relativity to the electromagnetism.

2.1	Special Relativity (1.1), Time dilation (1.2), Doppler Effect (1.3), Length Contraction (1.4), Relativistic Momentum (1.7), Mass and Energy (1.8), Energy and Momentum (1.9), General Relativity (1.10), Appendix 1: The Lorentz Transformation, Appendix 2: Space Time.	**[08L]**
2.2	The interdependence of Electric and Magnetic fields (4.2), The transformation of **E** and **B** (4.3), The field of a uniformly moving point charge (4.4), Forces and fields near a current-carrying wire (4.5), Forces between moving charges (4.6), The invariance of Maxwell's equations (4.7).	**[07L]**

Text book:
1. Introduction to Modern Physics by Arthur Beiser, Shobhit Mahajan and S. Rai Choudhury, 7th Ed. McGraw-Hill Higher Education Reprint 2020
2. Introduction to Special Relativity by Robert Resnick, John Wiley & Sons, Inc 2007.

Reference Books:
- Solid State Physics by N. W. Ashcroft and N. D. Mermin, Cengage Learning 2021
- Introduction to Solid State Physics by C. Kittel, 8th Ed., Wiley 2004
- Solid State Physics by A. J. Dekker, Pearson Education 2008
- Principles of the Theory of Solids by J. M. Ziman, Cambridge University Press 1979
- Oxford Solid State Basics by Steven H. Simon, Oxford University Press 2013
- Quantum Mechanics: Concepts and Applications: Nouredine Zettili, 2nd Ed., John Wiley and Sons Ltd., 2004
- Introduction to Quantum Mechanics: David Griffiths, 2nd Ed., Pearson Education; 2015

Online Learning resources:
- http://www.digimat.in/nptel/courses/video/115106061/115106061.html
- https://nptel.ac.in/courses/115105099
- https://onlinecourses.nptel.ac.in/noc21_ph21/preview

- https://onlinecourses.nptel.ac.in/noc21_ma27/preview
- https://nptel.ac.in/courses/115103036
- https://ocw.mit.edu/courses/8-04-quantum-physics-i-spring-2016/
- https://ocw.mit.edu/courses/8-20-introduction-to-special-relativity-january-iap-2021/

Question Paper Template

Unit	Remembering/ Knowledge (1)	Understanding (2)	Applying (3)	Analysing (4)	Evaluating (5)	Creating (6)	Total
I	-	30%	25%	25%	20%	-	100%
II	-	30%	25%	25%	20%	-	100%

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• explain the electronic properties of solids using free electron and band theory models	√	√	√			√
• analyze electrical and thermal behaviour of metals based on fundamental concepts such as conductivity, Fermi level and energy bands	√	√	√			√
• differentiate between metals, insulators, and semiconductors using band structure concepts	√	√				√
• derive the time dilation and length contraction formulae	√	√		√	√	
• establish a relation between mass and energy	√	√			√	
• establish the Lorentz transformation	√	√			√	
• apply the concept of relativity to the electromagnetism.	√	√				√

Sir P. T. Sarvajanik College of Science (Autonomous)
Athwalines, Surat-395001

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Electrodynamics and Optics
COURSE CODE: PHYMJ-S6P15-2CR26 [CREDITS - 02]

CC XV	Course Code PHYMJ-S6P15-2CR26
	Course Learning Outcomes

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

- understand the behaviour of conductors and dielectrics in the presence of an external electric field
- study polarization of dielectrics and have understanding of displacement field in the dielectric
- study linear dielectrics and their properties
- obtain expressions for energy and forces in the presence of dielectrics
- understand the working principles and applications of optoelectronic devices like photodiodes, LEDs and LASERs.

Unit I	Electrodynamics	[15L]

Learning Objectives:
This unit is intended to make the learners

- get familiarize the students with the Ohm's law, electromagnetic induction, Maxwell's equations and Poynting's theorem
- understand the concept of emf and inductance
- derive continuity equation.

Learning Outcomes:
At the end of this unit, learners will be able to

- study Ohm's law, electromagnetic induction, Maxwell's equations and Poynting's theorem
- derive an expression for energy in a magnetic field and boundary conditions across an interface of two different media
- derive and understand Poynting's theorem
- apply Maxwell's equations in different matters and solve them.

1.1	**Electromotive Force:** Ohm's Law (7.1.1), Electromotive Force (7.1.2), Motional emf (7.1.3).	**[02L]**
1.2	**Electromagnetic Induction:** Faraday's Law (7.2.1), The Induced Electric Field (7.2.2), Inductance (7.2.3), Energy in Magnetic Field (7.2.4).	**[03L]**
1.3	**Maxwell's Equations:** Electrodynamics before Maxwell (7.3.1), How Maxwell fixed Ampere's Law (7.3.2), Maxwell's Equations (7.3.3), Magnetic Charge (7.3.4), Maxwell's Equations in Matter (7.3.5), Boundary Conditions (7.3.6).	**[06L]**
1.4	**Conservation Laws:** The Continuity Equation (8.1.1), Poynting's Theorem (8.1.2), momentum (8.2), Newton's third law in electrodynamics (8.2.1), Maxwell's Stress Tensor (8.2.2), Conservation of Momentum (8.2.3), Angular Momentum (8.2.4)	**[04L]**

Text book:
Introduction to Electrodynamics by David J. Griffiths, Pearson India Education, 4th Ed., 2015.

Unit II	Optics	[15L]

Learning Objectives:
This unit is intended to make the learners
- learn theory and applications of holography
- study multiple reflections from thin films
- understand Fabry-Perot etalon and Fabry-Perot interferometer.

Learning Outcomes:
At the end of this unit, learners will be able to
- study the theory of holography and its applications
- learn the multiple reflections from thin films
- discuss the working of Fabry-Perot etalon and Fabry-Perot interferometer
- obtain the basic idea of resolving power
- understand Lummer-Gehrcke Plate and get introduction of interference filters.

2.1	**Holography:** Introduction (21.1), Basic Theory (21.2), Requirements (21.3), Some Applications of Holography (21.4).	[05L]
2.2	**Multiple Beam Interferometry:** Introduction (16.1), Multiple Reflections from a Plane Parallel Film (16.2), The Fabry-Perot Etalon (16.3), Flatness of the Coated Surfaces (16.3.1), Modes of the Fabry-Perot Cavity (16.3.2), The Fabry-Perot Interferometer (16.4), Resolving Power (16.5), Resolving Power of a Scanning Fabry-Perot Interferometer (16.5.1), Resolving Power of a Fabry-Perot Etalon (16.5.2), The Lummer-Gehrcke Plate (16.6), Interference Filters (16.7).	[10L]

Text book:
Optics by Ajoy Ghatak, McGraw Hill Edu. (India) Pvt. Ltd., 6th Ed., 2017.

Reference Books:
- Electricity and Magnetism by Rangwala and Mahajan, Tata McGraw-Hill, Reprint 2001
- Electromagnetics by B. B. Laud, New Age International Publishers, 4th Ed., 2022
- Electricity and Magnetism by D. C. Tayal, Himalaya Publishing House, Revised Ed., 2009
- Principles of Optics by Max Born and Emil Wolf, 7th Ed. Cambridge University Press, 2019
- A Textbook of Optics by Subrahamanyam and Brij Lal, S. Chand & Co., 25th Revised Ed., 2006

Online Learning resources:
- https://www.youtube.com/watch?v=gwSbQBo55QI&pp=ygUTZWxlY3Ryb21vdGl2ZSBmb3JjZQ%3D%3D
- https://www.youtube.com/watch?v=k077CwKGiwk&pp=ygUTZWxlY3Ryb21vdGl2ZSBmb3JjZQ%3D%3D

- https://www.youtube.com/watch?v=nGQbA2jwkWI&pp=ygUZRWxlY3Ryb21hZ25ldGljIEluZHVjdGlvbg%3D%3D
- https://www.youtube.com/watch?v=3HyORmBip-w&pp=ygUZRWxlY3Ryb21hZ25ldGljIEluZHVjdGlvbg%3D%3D
- https://www.youtube.com/watch?v=2tMRPuU78GA&pp=ygUZRWxlY3Ryb21hZ25ldGljIEluZHVjdGlvbtIHCQmHCgGHKiGM7w%3D%3D
- https://www.youtube.com/watch?v=yU--8Zk57-Y&pp=ygUZRWxlY3Ryb21hZ25ldGljIEluZHVjdGlvbg%3D%3D
- https://www.youtube.com/watch?v=0jW74lrpeM0&pp=ygUVTWF4d2VsbOKAmXMgRXF1YXRpb25z
- https://www.youtube.com/watch?v=yINtzw63Knc&pp=ygUVTWF4d2VsbOKAmXMgRXF1YXRpb25z0gcJCYcKAYcqIYzv
- https://www.youtube.com/watch?v=EmKQsSDlaa4&pp=ygUKSG9sb2dyYXBoeQ%3D%3D
- https://www.youtube.com/watch?v=okLzzJiqd3g&pp=ygUcTXVsdGlwbGUgQmVhbSBJbnRlcmZlcm9tZXRyeQ%3D%3D
- https://www.youtube.com/watch?v=3bXbWRL_WJc&pp=ygUcTXVsdGlwbGUgQmVhbSBJbnRlcmZlcm9tZXRyeQ%3D%3D

Question Paper Template

Unit	Remembering/ Knowledge (1)	Understanding (2)	Applying (3)	Analysing (4)	Evaluating (5)	Creating (6)	Total marks
I	30%	30%	10%	20%	10%	-	100%
II	30%	30%	10%	20%	10%	-	100%

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• understand the behaviour of conductors and dielectrics in the presence of an external electric field		√	√		√	
• study polarization of dielectrics and have understanding of displacement field in the dielectric	√	√			√	√
• study linear dielectrics and their properties	√	√				
• obtain expressions for energy and forces in the presence of dielectrics	√	√	√		√	
• understand the working principles and applications of optoelectronic devices like photodiodes, LEDs and LASERs	√	√			√	√

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Statistical Mechanics
COURSE CODE: PHYMJ-S6P16-2CR26 [CREDITS - 02]

CC XVI	COURSE CODE: PHYMJ-S6P16-2CR26	
	Course Learning Outcomes	
At the end of this course, students will be able to • apply Boltzmann factor and partition function to physical systems • analyze classical and quantum distribution functions • calculate thermodynamic quantities from microscopic models • explain physical phenomena using statistical mechanics		
Unit I	**Boltzmann Statistics**	**[15L]**
Learning Objectives: This unit is intended to make the learners • understand Boltzmann factor and partition function • compute thermodynamic quantities • apply classical statistics to gases and molecules.		
Learning Outcomes: At the end of this unit, learners will be able to • use partition function to find probabilities and averages • calculate energy, entropy, and free energy • explain Maxwell distribution and equipartition theorem.		
1.1	The Boltzmann Factor, The Partition Function, Thermal Excitation of atoms; Average Values; Paramagnetism; Rotation of Diatomic Molecules, The Equipartition Theorem, The Maxwell Speed Distribution, Partition Function and Free Energy, Partition functions for Composite Systems, Ideal gas Revisited; The Partition Function; Predictions.	**[15L]**
Text book: An Introduction to Thermal Physics by Daniel V. Schroeder, Oxford University Press, 2^{nd} Ed., 2021.		
Unit II	**Quantum Statistics**	**[15L]**
Learning Objectives: This unit is intended to help learners • understand quantum statistics • study fermions and bosons • relate theory to physical systems.		
Learning Outcomes: At the end of this unit, learners will be able to • apply Fermi–Dirac and Bose–Einstein distributions • analyze Fermi gases and photon gases • explain blackbody radiation and Bose–Einstein condensation.		
2.1	The Gibbs factor; An example: Carbon Monoxide Poisoning, Boson and Fermions; The Distribution Functions, Degenerate Fermi Gases; Zero	**[15L]**

	Temperature; Small Nonzero Temperatures; The Density States; The Sommerfeld Expansion, Blackbody Radiation; The Ultraviolet Catastrophe; The Planck Distribution; Photons; Summing over Modes; The Planck Spectrum; The Total Energy; Entropy of a Photon Gas; The Cosmic Background Radiation; Photons Escaping through a Hole; Radiation from other Objects; The Sun and The Earth, Debye Theory of Solids; Bose-Einstein Condensation; Real-World examples; Why Does it Happen?	

Text book:

An Introduction to Thermal Physics by Daniel V. Schroeder, Oxford University Press, 2nd Ed., 2021.

Reference Books:

- Thermal Physics Kinetic Theory Thermodynamics and Statistical Mechanics by S.C. Garg, R.M. Bansal and C.K. Ghosh, 2nd Ed., McGraw Hill 2017.
- An Introduction to Thermal Physics by C. J. Adkins, 2nd Ed., Cambridge University Press, 1987.
- Thermal Physics by Rollen Frantz, Discovery Publishing House, 2024.

Online Learning resources:

- https://onlinecourses.nptel.ac.in/noc24_me63/preview
- https://www.youtube.com/watch?v=OjhZYx1FbhI
- https://www.youtube.com/watch?v=DPjMPeU5OeM
- https://www.youtube.com/watch?v=huKBuShAa1w

Question Paper Template

Unit	Remembering/ Knowledge (1)	Understanding (2)	Applying (3)	Analysing (4)	Evaluating (5)	Creating (6)	Total
I	30%	30%	10%	20%	10%	-	100%
II	30%	30%	10%	20%	10%	-	100%

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• apply Boltzmann factor and partition function to physical systems.	√	√				
• analyze classical and quantum distribution functions.	√	√				
• calculate thermodynamic quantities from microscopic models.	√	√	√			
• explain physical phenomena using statistical mechanics.	√	√		√		√

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Physics Practical - XII
COURSE CODE: PHYMJ-S6PR12-2CR26 [CREDITS - 02]

Practical XII	Course Code: PHYMJ-S6PR12-2CR26
	Course Learning Outcomes

After the successful completion of the course, learners will be able to

- demonstrate practical skills
- correlate the Physics theory concepts through practical

1	To determine the electrical resistivity of a semiconductor sample using four-probe method.
2	To study Hall effect in a semiconductor sample and to determine the Hall coefficient (R_H), the type of charge carriers (n-type or p-type) and the carrier concentration.
3	To solve problems based on postulates of special theory of relativity.
4	To solve problems based on time dilation.
5	To solve problems based on Doppler effect.
6	To solve problems based on length contraction.
7	To solve problems based on twin paradox.
8	To solve problems based on relativistic momentum.
9	To solve problems based on mass and energy.
10	To solve problems based on energy and momentum.

Reference Books:

- Elementary Solid State Physics by M. Ali Omar, Addison-Wesley 2016.
- Introduction to Special Relativity by Robert Resnick, John Wiley & Sons, Inc 2007.
- Introduction to Modern Physics by Arthur Beiser, Shobhit Mahajan and S. Rai Choudhury, 7th Ed. McGraw-Hill Higher Education Reprint 2020.

Online Learning resources:

- https://www.olabs.edu.in/
- https://vlab.amrita.edu/index.php?sub=1
- https://alllabexperiments.com/physics_practical_files/
- https://ep2-iitb.vlabs.ac.in/

Note:

- ➢ The duration of each experiment is of 2 hours. Two such experiments are to be performed by each student per week.
- ➢ In the external exam, a student will have to perform two experiments, one from each group. The experiment will be of 2-hour duration.
- ➢ There should be two examiners, one for each group, in the external examination.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• demonstrate practical skills	√	√		√	√	√
• utilize Physics theory concepts with appropriate practical	√	√			√	

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Physics Practical - XIII
COURSE CODE: PHYMJ-S6PR13-2CR26 [CREDITS - 02]

Practical XIII	Course Code: PHYMJ-S6PR13-2CR26
	Course Learning Outcomes

After the successful completion of the course, learners will be able to

- demonstrate practical skills
- correlate the Physics theory concepts through practical

1	To determine e/m by Helical method.
2	To measure dielectric constant of a material at room temperature using capacitor for different dielectric samples.
3	To study variation in resistance with temperature in a thermistor and find its energy band gap.
4	To determine the resistance and the resistivity of a metallic conductor using a meter bridge.
5	To determine e/k_B for CE configuration of transistor.
6	To determine separation between plates of a Fabry-Perot Etalon.
7	To determine cardinal points of a lens system by Searle's Goniometer.
8	To determine the wavelength of sodium light with the help of a Fresnel's biprism.
9	To study variation in refractive index of a transparent liquid with temperature using a hollow prism.
10	To study Hartmann's formula.

Reference Books:

- Advanced Practical Physics by B. L. Worsnop and H. T. Flint, 3rd Ed., Asia Publishing House, New Delhi, 2021
- B. Sc. Practical Physics by C. L. Arora, S. Chand & Co., Reprint Ed., 2010
- University Practical Physics by D. C. Tayal, Edited by Ila Agarwal, 1st Ed., Himalayan Publishing House, 2000.
- A Laboratory Manual of Physics for Undergraduate Classes by D. P. Khandelwal, 1st Ed., Vani Publication House, New Delhi, 1985.
- B. Sc. Practical Physics by Geeta Sanon, 1st Ed., R. Chand & Co., 2007.

Online Learning resources:

- https://www.olabs.edu.in/
- https://vlab.amrita.edu/index.php?sub=1
- https://alllabexperiments.com/physics_practical_files/

Note:

- The duration of each experiment is of 2 hours. Two such experiments are to be performed by each student per week.
- In the external exam, a student will have to perform two experiments, one from each group. The experiment will be of 2-hour duration.
- There should be two examiners, one for each group, in the external examination.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• demonstrate practical skills	√	√	√	√	√	√
• utilize Physics theory concepts with appropriate practical	√	√			√	

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Physics Practical - XIV
COURSE CODE: PHYMJ-S6PR14-2CR26 [CREDITS - 02]

Practical XIV	Course Code: PHYMJ-S6PR14-2CR26
	Course Learning Outcomes

After the successful completion of the course, learners will be able to

- demonstrate practical skills
- correlate the Physics theory concepts through practical

1	Use Microsoft Excel to plot the graph of probability of various macro-states in coin-tossing experiment (two level system) versus number of heads with 4, 8, 16 coins etc.
2	Use Microsoft to plot the graph of Maxwell speed distribution function at different temperatures in a 3-dimension system. Calculate average speed, root mean square and most probable speed of the particles.
3	Use Microsoft Excel to study a) Dulong-Petit law b) Einstein distribution function c) Debye distribution function.
4	Use Microsoft Excel to plot the graph for the following functions: a) Maxwell-Boltzmann distribution b) Fermi-Dirac distribution and c) Bose-Einstein distribution.
5	Use Microsoft Excel to study Planck's law of Black body radiation with respect to wavelength/ frequency at different temperatures. Compare it with Rayleigh-Jeans Law and Wien's distribution law for a given temperature.
6	Generation and analysis of the Maxwell-Boltzmann speed and velocity distribution using computational methods.
7	Numerical simulation of Joule's free expansion to study entropy changes in an isolated system.
8	Simulation of a first-order phase transition to study its various applications.
9	Simulation of a second-order phase transition to study its various applications.
10	Simulation of the 1D Ising model to analyze magnetic phase transitions and susceptibility.

Reference Books:

- An Introduction to Thermal Physics by Daniel V. Schroeder, Oxford University Press, 2nd Ed., 2021
- Understanding Molecular Simulation: From Algorithms to Applications by Daan Frenkel and Berend Smit, 2nd Ed., Academic Press, San Diego, 2002
- Advanced Practical Physics by B. L. Worsnop and H. T. Flint, 3rd Ed., Asia Publishing House, New Delhi, 2021
- B. Sc. Practical Physics by C. L. Arora, S. Chand & Co., Reprint Ed., 2010

- University Practical Physics by D. C. Tayal, Edited by Ila Agarwal, 1st Ed., Himalayan Publishing House, 2000.
- B. Sc. Practical Physics by Geeta Sanon, 1st Ed., R. Chand & Co., 2007.

Online Learning resources:

- https://www.olabs.edu.in/
- https://vlab.amrita.edu/index.php?sub=1
- https://alllabexperiments.com/physics_practical_files/

Note:

- The duration of each experiment is of 2 hours. Two such experiments are to be performed by each student per week.
- In the external exam, a student will have to perform two experiments, one from each group. The experiment will be of 2-hour duration.
- There should be two examiners, one for each group, in the external examination.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• demonstrate practical skills	√	√	√	√	√	√
• utilize Physics theory concepts with appropriate practical	√	√			√	

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Nuclear Physics
COURSE CODE: PHYMN-S6P6-2CR26 [CREDITS - 02]

MN VI	COURSE CODE: PHYMN-S6P6-2CR26
	Course Learning Outcomes

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

- understand the fundamental concepts of radioactivity, radioactive decay law, half-life, mean life, and radioactive series
- apply the laws of disintegration and successive disintegration to solve numerical problems related to decay constant and radioactive equilibrium
- explain the mechanisms of alpha, beta, and gamma decay and compare their properties and penetration power
- analyze different types of radiation detectors and their working principles
- describe the construction, operation, and characteristics of gas-filled detectors such as ionization chamber, proportional counter, and GM counter
- explain advanced detectors including scintillation, semiconductor, Cerenkov counters, and particle detection chambers
- evaluate and select appropriate radiation detectors for scientific, medical, and industrial applications.

Unit-I	Radioactivity	[15L]

Learning Objectives:

This unit is intended to make the learners

- understand the basic concepts and nature of radioactivity, including types of radioactive decay and fundamental radioactive properties
- study the laws governing radioactive disintegration, such as decay constant, half-life, mean life, and exponential decay law
- analyze radioactive series and successive disintegration laws, including parent–daughter relationships and equilibrium conditions
- examine the mechanisms of nuclear decay, focusing on alpha emission, beta decay, and gamma decay processes.

Learning Outcomes:

At the end of this unit, learners will be able to

- explain the phenomenon of radioactivity and the laws of radioactive decay with appropriate mathematical expressions
- apply the laws of disintegration and successive decay to solve numerical problems related to radioactive series and equilibrium
- differentiate between alpha, beta, and gamma decay based on energy, penetration power, and interaction with matter
- describe the structure and decay schemes of radioactive series, and interpret their significance in nuclear physics and applications.

1.1	**Radioactivity:** Introduction (3.1), Laws of Disintegration (3.2), Activity and its units (3.2.1), Half-life (3.2.2), Average (Mean) life (3.2.3), Radioactive Series (3.3), Laws of Successive Disintegration (3.4), Radioactive equilibrium (3.4.1), Alpha Emission (3.5), Properties of alpha particles (3.5.1), Alpha spectrum (3.5.2), Range of Alpha particles (3.5.3), Geiger-Nuttal Law (3.5.4), Gamow theory of alpha decay (3.5.5), Beta Decay (3.6), Conditions for Spontaneous Emission of β^- decay (3.6.1), Conditions for Spontaneous Emission of β^+ decay (3.6.2), Beta-Particle Spectrum (3.6.3), Electron Capture (3.6.4), Neutrino and Antineutrino (3.6.5), Detection of Antineutrino (3.6.6), Detection of neutrino (3.6.7), Gamma Decay (3.7), Gamma Decay (3.7.1), Internal Conversion (3.7.2), Internal Pair Conversion (3.7.2).	**[15L]**

Text book:
Introduction to Nuclear and Particle Physics, By V. K. Mittal, R. C. Verma and S. C. Gupta, 3rd Ed., PHI Learning Pvt. Ltd. 2017.

Unit II	**Radiation Detectors**	**[15L]**

Learning Objectives:
This unit is intended to make the learners

- understand the fundamental principles of radiation detection, including interaction of radiation with matter and signal formation in different detector systems
- study the working, construction, and operating characteristics of gas-filled detectors, such as ionization chambers, proportional counters, and Geiger–Müller counters
- analyze solid-state and scintillation detectors, focusing on scintillation mechanisms, semiconductor junctions, energy resolution, and efficiency
- familiarize with particle visualization and specialized detectors, including cloud, bubble, spark chambers, nuclear emulsions, and Cerenkov counters.

Learning Outcomes:
At the end of this unit, learners will be able to

- explain the operating principles and classification of radiation detectors based on detection mechanism and application
- differentiate between various gas-filled detectors (ionization chamber, proportional counter, GM counter) in terms of operation, advantages, and limitations
- describe the working and applications of scintillation and semiconductor detectors in radiation measurement and nuclear experiments
- identify and explain track-detecting and threshold detectors, such as cloud chambers, bubble chambers, spark chambers, nuclear emulsions, and Cerenkov counters, for particle detection and analysis.

2.1	**Radiation Detectors:** Introduction (7.1), Gas Filled Detectors (7.2), Ionization Chamber (7.3), Proportional Counters (7.4), Geiger-Muller (GM) Counters (7.5), Scintillation Detectors (7.6), Semiconductor Radiation Detectors (7.7), Cloud Chamber (7.8), Bubble Chamber (7.9),	**[15L]**

	Spark Chamber (7.10), Nuclear Emulsions (7.11), Cerenkov Counters (7.12)	

Text book:
Nuclear Physics by D. C. Tayal, 5th Ed., Himalaya Publishing House 2021.

Reference Books:

- Atomic and Nuclear Physics by Shatendra K. Sharma, Pearson Education 2008
- Nuclear and Particle Physics by Brian R. Martin, Graham Shaw 2019
- Nuclear Physics: An Introduction by S. B. Patel, New Age International Publisher 2021
- Concept of Nuclear Physics Vol I by Dr. A. B. Sharma. Notion Press 2024.

Online Resources:

- https://nptel.ac.in/courses/115104043
- https://ocw.mit.edu/courses/22-02-introduction-to-applied-nuclear-physics-spring-2012/
- https://nptel.ac.in/courses/115103101

Question Paper Template

Unit	Remembering/ Knowledge (1)	Understanding (2)	Applying (3)	Analysing (4)	Evaluating (5)	Creating (6)	Total marks
I	30%	30%	20%	20%	-	-	100%
II	30%	30%	20%	20%	-	-	100%

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• understand the fundamental concepts of radioactivity, radioactive decay law, half-life, mean life, and radioactive series.	√	√			√	√
• apply the laws of disintegration and successive disintegration to solve numerical problems related to decay constant and radioactive equilibrium.					√	√
• explain the mechanisms of alpha, beta, and gamma decay and compare their properties and penetration power.	√	√		√	√	
• analyze different types of radiation detectors and their working principles.	√	√	√	√		
• describe the construction, operation, and characteristics of gas-filled detectors such as ionization chamber, proportional counter, and GM counter.					√	√
• explain advanced detectors including scintillation, semiconductor, Cerenkov counters, and particle detection chambers.	√	√	√			
• evaluate and select appropriate radiation detectors for scientific, medical, and industrial applications					√	√

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Physics Practical - VI
COURSE CODE: PHYMN-S6PR6-2CR26 [CREDITS - 02]

MN Practical VI	Course Code: PHYMN-S6PR6-2CR26
	Course Learning Outcomes

After the successful completion of the course, learners will be able to

- demonstrate practical skills
- utilize Physics theory concepts through practical

1	To study characteristics of a GM tube and determine its operating voltage, plateau length and slope.
2	To verify inverse square law for γ-rays using a GM detector.
3	To study nuclear counting statistics using a GM detector.
4	To find the dead time of a GM detector using single source method.
5	To measure the half-value thickness and evaluate mass-absorption coefficient.
6	To estimate the efficiency of a GM detector using γ-source.
7	To study Cs-137 spectrum, and calculate FWHM and resolution for a Scintillation detector.
8	To calibrate spectrometer to establish linearity between energy and channel number using a single channel analyser.
9	To determine the energy of an unknown γ-source using a Scintillation detector.
10	To determine the energy of an unknown gamma source with the help of a scintillation detector using an MCA.
11	To calculate the binding energy per nucleon using liquid drop model.

Reference Books:

- Nuclear Physics Experiments by Jagdish Varma. New Age International Pvt Ltd, 2025
- Techniques for Nuclear and Particle Physics Experiments by William R. Leo, 2nd Ed., Springer-Verlag Berlin Heidelberg GmbH, 1994
- Practical Approach to Nuclear Physics, A by K. Muraleedhara Varier, Narosa 2019.
- Advanced Practical Physics by B. L. Worsnop and H. T. Flint, 3rd Ed., Asia Publishing House, New Delhi, 2021
- B. Sc. Practical Physics by C. L. Arora, S. Chand & Co., Reprint Ed., 2010
- University Practical Physics by D. C. Tayal, Edited by Ila Agarwal, 1st Ed., Himalayan Publishing House, 2000.
- A Laboratory Manual of Physics for Undergraduate Classes by D. P. Khandelwal, 1st Ed., Vani Publication House, New Delhi, 1985.
- B. Sc. Practical Physics by Geeta Sanon, 1st Ed., R. Chand & Co., 2007.

Online Learning resources:

- https://www.olabs.edu.in/
- https://vlab.amrita.edu/index.php?sub=1
- https://alllabexperiments.com/physics_practical_files/

Note:

- The duration of each experiment is of 2 hours. Two such experiments are to be performed by each student per week.
- In the external exam, a student will have to perform two experiments, one from each group. The experiment will be of 2-hour duration.
- There should be two examiners, one for each group, in the external examination.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• demonstrate practical skills	√	√	√	√	√	√
• utilize Physics theory concepts with appropriate practical	√	√			√	

B. Sc. (Physics) SEMESTER VI
COURSE NAME: Internship
COURSE CODE: PHYINT-S6P1-4CR26 [CREDITS - 04]

<table>
<tr><th rowspan="2">Internship</th><th colspan="2">Course Code: PHYINT-S6P1-4CR26</th></tr>
<tr><th colspan="2">Course Learning Outcomes</th></tr>
<tr><td colspan="3">At the end of this course, learners will be able to
• apply principles, concepts, and methodologies of Physics to investigate a selected scientific problem or practical application
• collect, analyze, interpret, and present experimental or computational data using appropriate scientific tools and techniques
• prepare a technical report and effectively communicate internship findings through oral presentation, demonstrating professional and ethical practices.</td></tr>
<tr><th>Unit</th><th>Internship</th><th>[120 hrs]</th></tr>
<tr><td colspan="3">Learning Objectives:
This unit is intended to
• provide students with hands-on experience in applying theoretical concepts of Physics to experimental, computational, industrial, or research-oriented problems.
• develop scientific inquiry, analytical thinking, data interpretation, and problem-solving skills through independent project work under faculty supervision.
• enhance professional competencies such as technical communication, report writing, ethical conduct, teamwork, and presentation skills required for higher studies and employment.</td></tr>
<tr><td colspan="3">Learning Outcomes:
At the end of this unit, learners will be able to
• apply principles, concepts, and methodologies of Physics to investigate a selected scientific problem or practical application
• collect, analyze, interpret, and present experimental or computational data using appropriate scientific tools and techniques
• prepare a technical report and effectively communicate internship findings through oral presentation, demonstrating professional and ethical practices.</td></tr>
<tr><td colspan="3">(As per UGC Guidelines, NEP-2020, NHEQF and CCFUP Framework)
1. Duration and Credits
• The internship shall carry 4 Credits equivalent to 120 hours of engagement.
• The internship may be completed during Semester VI or as notified by the institution.
• Students shall maintain a detailed record of activities performed during the internship period.
2. Nature of Internship
Students may undertake any one of the following:
• Experimental Physics Project
• Computational Physics Project
• Electronics and Instrumentation Project
• Renewable Energy Studies
• Material Science Project</td></tr>
</table>

- Astronomy and Astrophysics Studies
- Medical Physics Applications
- Industry-Based Physics Applications
- Research Internship in Universities, Research Laboratories, or Scientific Institutions

3. Selection of Topic

- The topic should be relevant to Physics and approved by the departmental internship committee.
- The work should involve substantial learning, experimentation, simulation, data analysis, literature review or field investigation.
- Interdisciplinary topics involving Physics applications are encouraged.

4. Internship Supervision

- Each student shall be assigned a Faculty Mentor/Supervisor.
- External experts, industry personnel, or research scientists may act as co-mentors where applicable.
- Regular progress monitoring shall be conducted by the supervisor.

5. Student Responsibilities

Students shall:

- Attend all scheduled meetings with the supervisor.
- Maintain an internship diary/logbook.
- Follow ethical and safety practices during experimental work.
- Submit progress reports as prescribed.
- Complete the assigned work within the stipulated period.

6. Internship Deliverables

Each student shall submit:

1. Internship Completion Certificate (where applicable)
2. Internship Logbook/Work Diary
3. Project Report (approximately 25–40 pages)
4. Presentation (PowerPoint)

7. Evaluation Scheme

Course Name	Course Code	Credits	Hour	Module	Lectures per module (1 Hr)	Examination		
						Internal Marks	External Marks	Total Marks
Internship	PHYINT-S6P1-4CR26	4	120	-	-	50	50	100

Internal Evaluation					
Evaluation component	**Attendance & Discipline**	**Viva Voce**	**Internship Report**	**Presentation**	**Total**
Marks	10	10	20	10	50

External Evaluation			
Evaluation component	**Attendance & Discipline**	**Skill**	**Total**
Marks	20	30	50

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes					
	1	2	3	4	5	6
• apply principles, concepts, and methodologies of Physics to investigate a selected scientific problem or practical application	√	√		√	√	
• collect, analyze, interpret, and present experimental or computational data using appropriate scientific tools and techniques	√	√		√	√	
• prepare a technical report and effectively communicate internship findings through oral presentation, demonstrating professional and ethical practices	√		√		√	√