



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

SEM-2



M. Sc. (Physics) SEMESTER II

COURSE TITLE: Classical Electrodynamics

COURSE CODE: PHYMSC-S2P4-4CR24 [CREDITS - 04]

CC IV	Course Code: PHYMSC-S2P4-4CR24	
Course Learning Outcomes		
<p>After the successful completion of the course, the learner will be able to</p> <ul style="list-style-type: none"> perform multipole expansion of potential due to localized charge distributions solve the problems of scalar and vector potential under different gauges analyse the behaviour of electromagnetic wave to different waveguides apply the concepts of electromagnetic waves to real life problems explain power radiated by a point charge, electric dipole radiation, magnetic dipole radiation design different antenna using the theory of radiations. 		
Unit I	Multipole Expansion, Potentials and Fields	[15L]
<p>Learning Objective This unit is intended to</p> <ul style="list-style-type: none"> establish the method of multipole expansions of scalar potential develop the theoretical backgrounds of gauge transformation, retarded potential and Lienard-Wiechert potentials. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> analyse the physical effects due to localized charge distributions implement the methods of different gauges. 		
1.1	Multipole expansions for a localised charge distribution in free space, linear quadrupole potential and field, static electric and magnetic fields in material media, Boundary conditions.	[9L]
1.2	Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz gauge, Retarded potentials and Lienard-Wiechert potentials.	[6L]
Unit II	Electromagnetic Waves 1	[15L]
<p>Learning Objective This unit is intended to</p> <ul style="list-style-type: none"> develop the basic knowledge of waves familiarize the students with the basic terms associated an electromagnetic wave, such as velocity, energy and momentum etc. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> apply the wave theory to longitudinal and transverse waves 		



<ul style="list-style-type: none"> implement wave theory to electromagnetic waves. 		
2.1	Waves in one dimension: the wave equation, sinusoidal waves, boundary conditions: reflection and transmission, polarization.	[8L]
2.2	electromagnetic waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves.	[7L]
Unit III	Electromagnetic Waves 2	[15L]
<p>Learning Objective This unit is intended to</p> <ul style="list-style-type: none"> explain the nature of electromagnetic field travelling in different media. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> investigate the nature of electromagnetic field travelling in different media in terms of various physical aspects apply the concepts of electromagnetic wave to different waveguides. 		
3.1	Electromagnetic waves in matter: propagation in linear media, reflection and transmission at normal incidence, reflection and transmission at oblique incidence.	[7L]
3.2	Absorption and dispersion: electromagnetic waves in conductors, reflection at a conducting surface, the frequency dependence of permittivity, wave guides: waves in a rectangular wave guide.	[8L]
Unit IV	Radiation	[15L]
<p>Learning Objective This unit is intended to</p> <ul style="list-style-type: none"> give the students the basics of radiation theory. 		
<p>Learning Outcomes: At the end of this unit, the learners will be able to</p> <ul style="list-style-type: none"> explain power radiated by a point charge, electric dipole radiation, magnetic dipole radiation. design different antenna using the theory of radiations. 		
4.1	What is radiation? electric dipole radiation, magnetic dipole radiation, radiation from an arbitrary source, power radiated by a point charge, radiation reaction.	[6L]
4.2	Radiation from external sources, electric dipole radiations, magnetic dipole and electrical quadrupole radiation, center-fed linear antenna, Hertzian dipole antenna, Rayleigh scattering at long wavelength and blueness of sky, scalar diffraction theory.	[9L]
References:		



- Classical electrodynamics by J. D. Jackson, 3rd Ed., Wiley Student Ed., 2009.
- Introduction to Electrodynamics by David J. Griffiths, 4th Ed., PHI, 2017.
- Electromagnetics by B. B. Laud, 2nd Ed., New Age International Publication, 2006.
- Electrodynamics by Gupta, Kumar and Singh, Pragati Prakashan, 14th Ed., 2019.
- Classical Electrodynamics by Griener, 1st Ed., Springer Verlag, New York, 1998.

Note: Each unit carries equal weightage of total marks of the course.

Question Paper Template

Unit	Remembering/ Knowledge (1)	Understanding (2)	Applying (3)	Analysing (4)	Evaluating (5)	Creating (6)	Total marks
I	40%	40%	10%	10%	-	-	100 %
II	40%	40%	10%	10%	-	-	100 %
III	40%	40%	10%	10%	-	-	100 %
IV	40%	40%	10%	10%	-	-	100 %

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes					
	1	2	3	4	5	6
• perform multipole expansion of potential due to localized charge distributions	√	√		√		
• solve the problems of scalar and vector potential under different gauges	√	√		√		
• analyse the behaviour of electromagnetic wave to different waveguides	√					
• apply the concepts of electromagnetic waves to real life problems	√	√		√		
• explain power radiated by a point charge, electric dipole radiation, magnetic dipole radiation	√					
• design different antenna using the theory of radiations	√	√		√	√	



M. Sc. (Physics) SEMESTER II

COURSE TITLE: Quantum Mechanics-I

COURSE CODE: PHYMSC-S2P5-4CR24 [CREDITS - 04]

CC V	Course Code: PHYMSC-S2P5-4CR24	
Course Learning Outcomes		
<p>At the end of this course, learners will be able to</p> <ul style="list-style-type: none"> • implement basics postulates of quantum mechanics to quantum systems • estimate the expectation value of physical observables • connect the quantum mechanics to classical mechanics • solve one dimensional problems in quantum mechanics • solve three dimensional problems in quantum mechanics • represent the orbital angular momentum operator in matrix form • determine the eigen values and eigen functions of L_z and L^2. 		
Unit I	Postulates of Quantum Mechanics	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce basic postulates of quantum mechanics to students • make students familiarize the terms used in quantum mechanics such as probability density, superposition principle, observables, expectation value, stationary states etc. • build bridge between quantum mechanics and classical mechanics. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • apply basics postulates of quantum mechanics to quantum systems • determine the eigen value and eigen function of an observable and estimate its expectation value • relate the quantum mechanical solution to classical solution of a physical system. 		
1.1	<p>Basic postulates of quantum mechanics, the state of a system: probability density, the superposition principle, observables and operators, measurement in quantum mechanics: how measurements disturb systems, expectation values, Complete Sets of Commuting Operators (CSCO), measurement and the uncertainty relations, time evolution of the system's state: time evolution operator, stationary states: time-independent potentials, Schrodinger equation and wave packets, the conservation of probability, time evolution of expectation values, symmetries and conservation laws: infinitesimal unitary transformations, finite unitary transformations, symmetries and conservation laws,</p>	[11L]



1.2	Connecting Quantum to Classical Mechanics: Poisson brackets and commutators, Ehrenfest theorem, Quantum Mechanics and Classical Mechanics.	[4L]
Unit II	One-dimensional Problems	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • illustrate methods to solve one dimensional problems using Schrodinger equation. • familiarize students with the concepts of quantization of energy. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • solve one dimensional problems using Schrodinger equation. • analyse the quantum solution and compare the solution to classical solution. 		
2.1	Properties of one-dimensional motion: discrete spectrum, continuous spectrum (unbound states), mixed spectrum, symmetric potentials and parity, the free particle: continuous states, the potential step, the potential barrier and well: the case $E > V_0$, the case $E < V_0$, the tunnelling effect.	[9L]
2.2	The harmonic oscillator: energy eigen values, energy eigen states, energy eigen states in position space, the matrix representation of various operators, expectation values of various operators.	[6L]
Unit III	Three Dimensional Problems	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • illustrate methods to solve three dimensional problems using Schrodinger equation. • familiarize students the concepts of quantization of energy in 3-D problems. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • solve three dimensional problems using Schrodinger equation. • analyse quantum solution and compare the solution to classical solution for 3-D problems. 		
3.1	3-D problems in cartesian coordinates: general treatment; separation of variables, the free particle, the box potential, harmonic oscillators.	[7L]
3.2	3-D problems in spherical coordinates: central potential: general treatment, the free particle in spherical coordinates, the hydrogen atom.	[8L]
Unit IV	Angular Momentum	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce the concepts of angular momentum to students. 		



Learning Outcomes:

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

- represent the orbital angular momentum operator in matrix form
- evaluate the eigen values of L_z and L^2 and determine their eigen functions.

4.1	Orbital angular momentum, general formalism of angular momentum, matrix representation of angular momentum, geometrical representation of angular momentum, spin angular momentum: experimental evidence of the spin, general theory of spin, spin 1/2 and the Pauli matrices, eigen functions of orbital angular momentum: eigen functions and eigen values of L_z , eigen functions of L^2 .	[15L]
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Reference Books:

- Quantum Mechanics: Concepts and Applications: Nouredine Zettili, 2nd Ed., John Wiley and Sons Ltd., 2004.
- A text book of Quantum Mechanics: P. M. Mathews and K. Venkatesan, 2nd Ed., Tata McGraw Hill Education Private Limited, 2011
- Introduction to Quantum Mechanics: David Griffiths, 2nd Ed., Pearson Education; 2015.
- Quantum Mechanics: Claude Cohen-Tannoudji, Bernard Diu, Franck Laloe Vol. I & II, 2nd Ed., Wiley-CH, 2019.



Question Paper Template

Unit	Remembering/ Knowledge (1)	Understanding (2)	Applying (3)	Analysing (4)	Evaluating (5)	Creating (6)	Total marks
I	30%	30%	15%	15%	5%	5%	100 %
II	30%	30%	15%	15%	5%	5%	100 %
III	30%	30%	15%	15%	5%	5%	100 %
IV	30%	30%	15%	15%	5%	5%	100 %

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes					
	1	2	3	4	5	6
• implement basics postulates of quantum mechanics to quantum systems	√					
• estimate the expectation value of physical observables	√	√				√
• connect the quantum mechanics to classical mechanics	√					
• solve one dimensional problems in quantum mechanics	√	√				√
• solve three dimensional problems in quantum mechanics	√	√				√
• represent the orbital angular momentum operator in matrix form	√	√				
• determine the eigen values and eigen functions of L_z and L^2	√	√				√



M. Sc. (Physics) SEMESTER II

COURSE TITLE: Statistical Physics

COURSE CODE: PHYMSC-S2P6-4CR24 [CREDITS - 04]

CC VI	Course Code: PHYMSC-S2P6-4CR24
Course Learning Outcomes	
<p>At the end of this course, learners will be able to</p> <ul style="list-style-type: none"> • implement fundamental principles and concepts of statistical mechanics to Fermi-Dirac and Bose-Einstein systems. • gain practical skills in solving problems related to statistical physics using mathematical and computational methods. • analyze and interpret the behaviour of complex systems using statistical mechanics principles. • apply statistical physics in various fields such as condensed matter physics, astrophysics, biophysics, and materials science. • explain phase transitions and critical phenomena using statistical mechanics. 	
Unit I	Formulation of Quantum Statistics [15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • learn the quantum-mechanical ensemble theory and their application to statistical systems • explore the fundamental concepts of indistinguishability and symmetry of quantum particles • familiarize density matrix and partition function of a system of free particles. 	
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • grasp the principles of quantum mechanics and their relevance to statistical systems • apply statistical methods to quantum systems to understand the statistical behavior of particles • distinguish between bosons and fermions and their statistics • analyze experimental data and interpret results using the concepts and methods of quantum statistics • solve theoretical and practical problems using quantum statistical methods. 	
1.1	<p>Quantum-mechanical ensemble theory: the density matrix, statistics of the various ensembles, examples, systems composed of indistinguishable particles, the density matrix and the partition function of a system of free particles. [15L]</p>
Unit II	Ideal Bose Systems [15L]
<p>Learning Objective:</p>	



This unit is intended to

- learn the fundamental principles of Bose-Einstein statistics
- familiarize oneself with the concept of Bose-Einstein condensation and its significance in the context of quantum gases
- explore the thermodynamic properties of ideal Bose systems, including the calculation of partition functions, energy, entropy, and specific heat
- develop the ability to analyze and interpret experimental data related to ideal Bose systems.

Learning Outcomes:

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

- apply the fundamental principles of Bose-Einstein statistics to ideal Bose gases.
- analyze the behaviour of ideal Bose gases at different temperature regimes
- explain the thermodynamic properties of ideal Bose systems, such as energy, entropy, and specific heat, using statistical mechanics principles.
- recognize the experimental techniques used to study Bose-Einstein condensation and interpret experimental data related to ideal Bose systems.
- apply mathematical formalisms, including partition functions and Bose-Einstein distribution functions, to describe ideal Bose systems.

2.1	Thermodynamic behaviour of an ideal Bose gas, Bose–Einstein condensation in ultracold atomic gases, thermodynamics of the blackbody radiation, the field of sound waves, elementary excitations in liquid helium II.	[15L]
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Unit III	Ideal Fermi Systems	[15L]
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Learning Objective:

This unit is intended to

- understand the principles of quantum mechanics and statistical mechanics relevant to fermionic particles
- learn about the behaviour of fermionic particles at low temperatures, including the Pauli exclusion principle and Fermi energy
- investigate the properties of Fermi gases, such as degeneracy pressure and heat capacity.

Learning Outcomes:

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

- interpret the distinct behaviour of fermions governed by the Pauli exclusion principle and Fermi-Dirac statistics.
- apply the Fermi-Dirac Statistics to Fermi systems.
- analyze the properties of Fermi gases, including degeneracy pressure, specific heat, and behaviour at low temperatures.
- solve Fermi system-related problems.



3.1	Thermodynamic behaviour of an ideal Fermi gas, magnetic behaviour of an ideal Fermi gas, the electron gas in metals, ultracold atomic Fermi gases, statistical equilibrium of white dwarf stars, statistical model of the atom	[15L]
Unit IV	Phase Transitions: Criticality, Universality, and Scaling	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • provide a foundation of phase transitions • explore Ising model in zeroth approximation and first approximation. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • apply the theory of phase transition to Ising model • analyse the thermodynamic properties near critical points • solve the research problems related to phase transition in lattice gases and binary alloys. 		
4.1	General remarks on the problem of condensation, condensation of a Van der Waals gas, a dynamical model of phase transitions, the lattice gas and the binary alloy, Ising model in the zeroth approximation, Ising model in the first approximation.	[15L]
<p>Reference Books:</p> <ul style="list-style-type: none"> • Statistical Mechanics by R. K. Pathria and P. D. Beale, 3rd Ed., Elsevier 2011. • Greiner, Neise and Stocker, Thermodynamics and Statistical Mechanics, 2nd Ed., Springer 1997. • Fundamentals of Statistical and Thermal Physics by F. Reif, Waveland Press, Reprint, 2009. • Statistical Physics Vol. 5 by F. Reif, 8th Ed. Reprint, 2017. • Statistical Mechanics by Kerson Huang, 2nd Ed., Wiley 1987. • Statistical Physics Vol. 5 by Landau and Lifshitz, 3rd Ed., Butterworth-Heinemann 1996. 		



Question Paper Template

Unit	Remembering/ Knowledge (1)	Understanding (2)	Applying (3)	Analysing (4)	Evaluating (5)	Creating (6)	Total marks
I	30%	30%	15%	15%	5%	5%	100 %
II	30%	30%	15%	15%	5%	5%	100 %
III	30%	30%	15%	15%	5%	5%	100 %
IV	30%	30%	15%	15%	5%	5%	100 %

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes					
	1	2	3	4	5	6
<ul style="list-style-type: none"> • implement fundamental principles and concepts of statistical mechanics to Fermi-Dirac and Bose-Einstein systems. 	√		√			
<ul style="list-style-type: none"> • gain practical skills in solving problems related to statistical physics using mathematical and computational methods. 	√	√	√			√
<ul style="list-style-type: none"> • analyze and interpret the behaviour of complex systems using statistical mechanics principles. 	√	√	√			√
<ul style="list-style-type: none"> • apply statistical physics in various fields such as condensed matter physics, astrophysics, biophysics, and materials science. 	√	√	√			√
<ul style="list-style-type: none"> • explain phase transitions and critical phenomena using statistical mechanics 	√					



M. Sc. (Physics) SEMESTER II

COURSE TITLE: Electronic Communication

COURSE CODE: PHYMSC-S2E5-4CR24 [CREDITS - 04]

EC V	Course Code: PHYMSC-S2E5-4CR24	
Course Learning Outcomes		
<p>At the end of this course, learners will be able to</p> <ul style="list-style-type: none"> • acquire knowledge of sampling functions, Fourier transform and probability distribution for signal analysis • analyse types of modulation and demodulation methods • interpret and gain knowledge on various angle generation methods • correlate the significance of noise occurrence and removal in transmitted signals • interpret the concepts of digital communication • explain various pulse code modulation methods • differentiate between various digital carrier schemes. 		
Unit I	Fourier Transform and Probability	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce sampling function and its characteristics • make students familiarize with Fourier transforms of different waveforms • make students aware of the concepts of probability distribution function. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • acquire knowledge of sampling functions and Fourier transform of different functions • use Parseval's theorem and apply correlation between waveforms • apply probability distribution for signal analysis. 		
1.1	<p>Sampling function, response of a linear system, normalized power, normalized power in a Fourier expansion, power spectral density, effect of transfer function on power spectral density, Fourier transform, examples of Fourier transform, convolution, Parseval's theorem, correlation between waveforms, autocorrelation, autocorrelation of a periodic waveform, autocorrelation of non-periodic waveform of finite energy, concept of probability, random variables: conditional probabilities, cumulative distribution function, and probability density function.</p>	[15L]
Unit II	Amplitude Modulation	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce students to fundamentals of modulation • make them aware of the different types of modulation 		



<ul style="list-style-type: none"> introduce students to methods of generating modulation and demodulation. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> gain knowledge on types of modulation methods analyse various demodulation methods. 		
2.1	<p>Amplitude Modulation (AM): Conventional amplitude modulation sideband and carrier power, generation of AM signals, Demodulation of AM signals, amplitude modulation: Single Side Band (SSB), time domain representation of SSB signals, generation of SSB signal, demodulation of SSB signals, amplitude modulation: Vestigial Side Band (VSB) modulation, use of VSB in broadcast television, comparison of various amplitude modulation systems.</p>	[9L]
2.2	<p>DSB-SC: Double Side Band (DSB) Suppressed Carrier (SC) AM, modulators: multiplier modulator, non-linear modulator, switching modulator, demodulation of DSB-SC signals.</p>	[6L]
Unit III	Angle Modulation and Noise	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> introduce the students to angle modulation introduce students to the importance of studying noise in signals. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> understand the methods of angle (frequency and phase) modulation interpret and gain knowledge on various angle generation methods correlate the significance of noise occurrence and removal in transmitted signals. 		
3.1	<p>Angle modulation, concept of instantaneous frequency, generalized concept of angle modulation, Wide Band FM (WBFM), generation of FM waves: indirect method of Armstrong FM generation, direct generation: parameter variation method, phase locked loop, analysis of phase locked loop, stereophonic FM broadcasting, comparisons: frequency and phase modulation, frequency and amplitude modulation, external and internal noise, noise calculations, noise figure, noise temperature.</p>	[15L]
Unit IV	Digital Communication	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> introduce students to fundamentals of digital communication make the students aware of various pulse modulation methods 		



<ul style="list-style-type: none"> • make students aware of working of various transmitter and receiver. 		
<p>Learning Outcomes:</p> <p>At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • interpret the concepts of digital communication • use different pulse modulation methods • explain various pulse code modulation methods • differentiate between various digital career schemes. 		
4.1	<p>Introduction:</p> <p>Comparison of analog and digital communication systems, sampling theorem: low pass signals, pulse amplitude modulation, other forms of pulse modulation, time division multiplexing, quantization of signals, quantization error, pulse code modulation, PCM system, non-uniform quantization, compandor, differential PCM: analysis of DPCM, signal to noise ratio improvement, delta modulation, threshold of coding and overloading, adaptive delta modulation and output signal to noise ratio.</p>	[8L]
4.2	<p>Digital carrier schemes:</p> <p>Frequency Shift Keying (FSK): FSK bit rate and baud, FSK transmitter and receiver, bandwidth considerations of FSK, phase shift keying: binary PSK transmitter and receiver, bandwidth considerations of BPSK, M-ary encoding, Differential Phase Shift Keying (DPSK).</p>	[7L]
<p>Reference Books:</p> <ul style="list-style-type: none"> • Principles of communication systems: H. Taub and D. L. Schilling, 3rd Ed., McGraw-Hill. 1986. • Modern Digital and Analog communication systems: B. P. Lathi, 3rd Ed., Oxford University Press, 1998. • Electronic communication systems: G. Kennedy, 3rd Ed., McGraw-Hill, 1998. • Electronic communications: D. Roddy and J. Coolen, 2nd Ed., PHI, 1981. • Electronic Communication (Analog, Digital and Wireless) by Sanjeev Gupta, 3rd Ed., Khanna Publishers. • Advanced Electronic Communications systems: W. Tomasi, 5th Ed., PHI, 2003. • Fundamentals of communication systems: J. G. Proakis and M. Salehi, 2nd Ed., Pearson Education, 2005. • Digital and Analog communication systems: K. Samshanmugum, 1st Ed., John Wiley & Sons, 1979. • Communication Systems: S. Haykin, 4th Ed., John Wiley & Sons, 1979. • Radio Engineering :G. K. Mithal, Applied Electronics Vol. II, 1987. 		



Question Paper Template

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

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes					
	1	2	3	4	5	6
• acquire knowledge of sampling functions, Fourier transform and probability distribution for signal analysis	√	√				
• analyse types of modulation and demodulation methods	√	√	√			√
• interpret and gain knowledge on various angle generation methods	√					
• correlate the significance of noise occurrence and removal in transmitted signals	√	√	√			
• interpret the concepts of digital communication	√		√			
• explain various pulse code modulation methods	√	√	√			√
• differentiate between various digital career schemes	√				√	



M. Sc. (Physics) SEMESTER II

COURSE TITLE: Nanotechnology and Its Applications

COURSE CODE: PHYMSC-S2E6-4CR24 [CREDITS - 04]

EC VI	Course Code: PHYMSC-S2E6-4CR24	
Course Learning Outcomes		
<p>At the end of this course, the learner will be able to</p> <ul style="list-style-type: none"> • interpret the fundamentals of nanomaterial and its properties • apply various methods for the synthesis of nanomaterials • classify various tools for characterizing nanomaterials • understand the properties and applications of carbon nanostructures • relate the properties of nanomaterials to the quantum phenomena • classify various applications of nanomaterials. 		
Unit I	Physics of Nanomaterials	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce the Physics of nanomaterials. • make students familiarize with different synthesis methods 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • interpret the fundamentals of nanomaterial and its properties • apply various methods for the synthesis of nanomaterials. 		
1.1	Introduction to properties of individual nanoparticles, metal nanocluster, magic numbers, theoretical modelling of nanoparticles, geometric structure, electronic structure, reactivity, fluctuations, magnetic clusters, bulk to nano-transitions, semiconducting nanoparticles; optical properties, photofragmentation, coulombic explosion.	[10L]
1.2	Method of synthesis – plasma-based methods, chemical methods, thermolysis, pulsed laser methods, mechanical milling.	[5L]
Unit II	Characterization of Nanomaterials	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • infer the characterization tools for studying nanomaterial properties. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • classify various tools for characterizing nanomaterials. 		
2.1	X-ray diffraction, Scanning Electron Microscope (SEM), Atomic Force Microscope (AFM), Scanning Tunneling Microscope (STM), Infrared spectroscopy, Raman spectroscopy, Photo-emission spectroscopy, Magnetic resonance spectroscopy.	[15L]



Unit III		Carbon Nanostructures	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> introduce the basics of carbon nanostructures, its properties and applications. 			
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> understand the properties and applications of carbon nanostructures. 			
3.1	<p>Introductions, carbon molecules; nature of carbon bonds, new carbon structures, carbon clusters, discovery of C₆₀, structure of C₆₀ and its crystal, alkali-doped C₆₀, superconductivity in C₆₀, larger and smaller fullerenes, other Buckyballs, carbon nanotubes; fabrication, structure, electrical properties, vibrational properties and mechanical properties, application of carbon nanotubes; field emission and shielding, computers, fuel cells, chemical sensors, catalysis.</p>		[15L]
Unit IV		Application of Nanomaterials	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> illustrate the concepts of quantum phenomena of nanostructures learn various applications of nanomaterials. 			
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> relate the properties of nanomaterials to the quantum phenomena classify various applications of nanomaterials. 			
4.1	<p>Quantum approach: Preparation of quantum nanostructures, size and dimensionality effects, conduction electrons and dimensionality, partial confinement, properties dependent on density of states, excitons, single-electron tunnelling.</p>		[8L]
4.2	<p>Applications: Infrared detectors, quantum dot, quantum well and quantum wire LASERS, nanomachines and nanodevices - nanoelectromechanical systems, molecular and super-molecular switches.</p>		[7L]
<p>Reference Books:</p> <ul style="list-style-type: none"> Introduction to Nanotechnology by C P Poole, Jr., F J Owens, 1st Ed., Wiley 2003. Nanotechnology: Understanding Small Systems by B Rogers, S Pennathur, 3rd Ed., CRC Press 2014. Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience by E Wolf 2nd Ed., Wiley 2006. Nanotechnology: Basic Science and Emerging Technologies by M Wilson and K Kannagara, G Smith and M Simmons 1st Ed., CRC Press 2002. 			



- Material Characterization, ASME Handbook by T Bruno, R Deacon, J Jansen, N Magdefrau, E Mueller, G Vroot and D Yang 3rd Ed., ASM International 1992.
- Semiconductor Material and Device Characterization by D. K. Schroder, 3rd Ed., Wiley-IEEE Press 2006.

Question Paper Template

Unit	Remembering/ Knowledge (1)	Understanding (2)	Applying (3)	Analysing (4)	Evaluating (5)	Creating (6)	Total marks
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II	40%	40%	10%	10%	-	-	100 %
III	40%	40%	10%	10%	-	-	100 %
IV	30%	30%	20%	20%	-	-	100 %

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes					
	1	2	3	4	5	6
• interpret the fundamentals of nanomaterial and its properties	√					
• apply various methods for the synthesis of nanomaterials	√		√			√
• classify various tools for characterizing nanomaterials	√		√			√
• understand the properties and applications of carbon nanostructures	√					
• relate the properties of nanomaterials to the quantum phenomena	√					
• classify various applications of nanomaterials	√		√			√



M. Sc. (Physics) SEMESTER II

COURSE TITLE: Numerical Techniques and FORTRAN programming

COURSE CODE: PHYMSC-S2E7-4CR24 [CREDITS - 04]

EC VII		Course Code: PHYMSC-S2E7-4CR24	
Course Learning Outcomes			
<p>At the end of this course, learners will be able to</p> <ul style="list-style-type: none"> • apply various least square curve fitting methods for data analysis • apply various methods of numeric differentiation for Physics problems • classify and use different numerical methods for solving integrals • use programming skills to solve various numerical problems. 			
Unit I	Least Square Fit		[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce various least square curve fitting methods to the students. 			
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • apply various least square curve fitting methods for data analysis. 			
1.1	Introduction, least squares curve fitting procedures, fitting a straight line, multiple linear least squares, linearization of nonlinear laws, curve fitting by polynomials, curve fitting by a sum of exponentials, weighted least squares approximation, linear weighted least squares approximation, nonlinear weighted least squares approximation.		[15L]
Unit II	Numerical Differentiation and Integration		[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce students to the fundamentals of numeric differentiation • make them aware of various numerical techniques for integration. 			
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • apply various methods of numeric differentiation for Physics problems • classify and use different numerical methods for solving integrals. 			
2.1	Introduction, numerical differentiation, errors in numerical differentiation, cubic splines method, differentiation formulae with function values, maximum and minimum values of a tabulated function.		[6L]
2.2	Numerical integration, Trapezoidal Rule, Simpson's 1/3-Rule, Simpson's 3/8-Rule, Boole's and Weddle's Rules, use of cubic splines, Romberg		[9L]



	integration, Newton-Cotes integration formulae, Euler-Maclaurin formula, numerical integration with different step sizes, Gaussian integration, generalized quadrature, numerical calculation of Fourier integrals, numerical double integration.	
Unit III	FORTRAN Language	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce the students to numerical constants, variables, conditional statements and loops. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • write the programs for various Physics problems. 		
3.1	Numeric constants and variables, arithmetic expressions, list-directed input statements, list-directed output statements, conditional statements, relational operators, the block IF construct, example programs using IF structures implementing loops in programs, the block DO loop, count controlled DO loop, rules to be followed in writing DO loop, logical expressions and more control statements.	[15L]
Unit IV	FORTRAN Programming	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • make the students aware of the concepts of arrays, processing files and array operations • introduce them to programming practices for various mathematical tools. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • use programming skills to solve various numerical problems. 		
4.1	Functions and subroutines: basics, defining and manipulating arrays, elementary format specifications, procedure with array arguments, processing files in FORTRAN, creating a sequential file, array operation with mask, FOR ALL Statement. least squares curve fitting, integration, roots of equations, matrix diagonalization, solution of differential equations. good programming practices.	[15L]
<p>Reference Books:</p> <ul style="list-style-type: none"> • Computer Programming in Fortran 90 and 95 by V. Rajaraman, 1st Ed., PHI Learning Private Limited, 2013 • Introductory Methods of Numerical Analysis by S. S. Sastry, 5th Ed., PHI Learning Private Limited, 2012. 		



- Computer Oriented Numerical Methods by V. Rajaraman, 4th Ed., PHI Learning Private Limited, 2018.
- Numerical Methods for Scientists and Engineers by K. S. Rao. 3rd Ed., PHI Learning Private Limited, 2006.
- Numerical Methods for Mathematics, Science and Engineering by J. H. Mathews, 2nd Ed., Prentice Hall, 1992.
- Programming and computing with FORTAN 77-90: P.S. Grover, 1st Ed., Allied publishers, 1990.

Question Paper Template

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

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes					
	1	2	3	4	5	6
• apply various least square curve fitting methods for data analysis	√	√			√	
• apply various methods of numeric differentiation for Physics problems	√	√			√	
• classify and use different numerical methods for solving integrals	√	√	√		√	√
• use programming skills to solve various numerical problems	√	√	√		√	√



M. Sc. (Physics) SEMESTER I

COURSE TITLE: Particle Accelerators and Detectors

COURSE CODE: PHYMSC-S2E8-4CR24 [CREDITS - 04]

EC VIII	Course Code: PHYMSC-S2E8-4CR24	
Course Learning Outcomes		
<p>At the end of this course, learners will be able to</p> <ul style="list-style-type: none"> • classify particle accelerators based on their properties • understand construction, working and application of different particle accelerators • explain the interaction between nuclear radiation and matter • infer characteristics required for designing nuclear radiation detectors • understand the construction and working of various types of nuclear radiation detectors and study their applications • explain various stages of electronic circuits required in nuclear radiation detecting instruments. 		
Unit I	Particle Accelerators	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce the students to various particle accelerators and their merits and demerits. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • classify particle accelerators based on their properties • understand construction, working and application of different particle accelerators. 		
1.1	Acceleration of charged particles, Van de Graaff accelerator, Cockroft-Walton voltage multiplier, tandem accelerator, linear accelerator, cyclotron, synchrocyclotron, betatron, applications of particle accelerators.	[15L]
Unit II	General Characteristics of Nuclear Detectors	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce students to the interaction of nuclear radiation with the matter and study the effects thereof. • familiarize with general characteristics of nuclear detectors. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • explain the interaction between nuclear radiation and matter • infer characteristics required for designing nuclear radiation detectors. 		



2.1	Interaction of particles with matter, detector response, sensitivity, energy resolution, timing characteristics, dead time, detection efficiency, modes of detector operation.	[15L]
Unit III	Nuclear Radiation Detectors	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> introduce the students to different types of nuclear radiation detectors. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> understand the construction and working of various types of nuclear radiation detectors and study their applications. 		
3.1	Types and principle of different detectors, G. M. counter, scintillation detectors, semiconductor detectors, Si(Li), Ge(Li) detectors, intrinsic germanium detectors, gamma-ray spectrometer, pulse height selection, analysis of gamma-ray-spectra, alpha and beta spectrometers, solid state nuclear track detectors.	[15L]
Unit IV	Nuclear Electronics	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> introduce the students to various stages of electronic circuits required in nuclear radiation detecting instruments. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> explain various stages of electronic circuits required in nuclear radiation detecting instruments. 		
4.1	Nuclear electronics for pulse signal processing - pre-amplifiers, amplifiers, pulse shaping, discriminators, single channel analyser (SCA), analogue-to-digital converters (ADC) and multi-channel analyser (MCA), time to amplitude converters (TAC).	[15L]
<p>Reference Books:</p> <ul style="list-style-type: none"> Introductory Nuclear Physics by K. Krane, 1st Ed. (1988), Wiley India Pvt. Ltd. Reprint 2016. Nuclear Physics by S. N. Ghoshal, 1st Ed. (1994), S. Chand & Co. Pvt. Ltd., 2015. Introduction to Nuclear and Particle Physics by Mittal, Gupta and Verma, 3rd Ed., PHI Learning Pvt. Ltd. 2017. Nuclear Physics by D. C. Tayal, 5th Ed., Himalaya Publishing House 2017. Radiation Detection and Measurement by G. F. Knoll, 4th Ed., Wiley 2010. 		



- Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy, 1st Ed. (1986), New Age International Publishers Ltd., Reprint 2014.

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	40%	40%	10%	10%	-	-	100 %
III	30%	30%	20%	20%	-	-	100 %
IV	30%	30%	20%	20%	-	-	100 %

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes					
	1	2	3	4	5	6
• classify particle accelerators based on their properties	√	√	√			
• understand construction, working and application of different particle accelerators	√	√				
• explain the interaction between nuclear radiation and matter	√					
• infer characteristics required for designing nuclear radiation detectors	√	√			√	
• understand the construction and working of various types of nuclear radiation detectors and study their applications	√	√			√	
• explain various stages of electronic circuits required in nuclear radiation detecting instruments.	√				√	



M. Sc. (Physics) SEMESTER II

COURSE TITLE: Advanced Arduino and IoT

COURSE CODE: PHYMSC-S2SEC2-2CR24 [CREDITS - 02]

SEC II		Course Code: PHYMSC-S2SEC2-2CR24
Course Learning Outcomes		
<p>At the end of this course, learners will be able to</p> <ul style="list-style-type: none"> • use different sensors, motors and LCD displays • use combination of input and output devices to work in programmed manner • design a product as a project using different devices to solve a real-world problem. 		
Unit I	Embedded Systems and Arduino	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • introduce the students to advanced programming using Arduino UNO board. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • use different sensors, motors and LCD displays • use combination of input and output devices to work in programmed manner. 		
1.1	Using different types of voltage regulator dc-dc modules, identifying modules for step up/step down voltage conversion, interfacing sensors with different voltage requirements, brief overview of using modules for Li-Ion battery interfacing.	[7L]
1.2	Using ADC for sensing analog signals, generating analog voltages using PWM, reading from analog sensors, putting things together for sensing the environmental parameters, use of map() function, actuators, relay switch (ac voltage), motors (dc, servo and stepper).	[8L]
Unit II	Sensor Fundamentals	[15L]
<p>Learning Objective: This unit is intended to</p> <ul style="list-style-type: none"> • familiarize the students with various wireless technologies for data transfer. 		
<p>Learning Outcomes: At the end of this unit, the learner will be able to</p> <ul style="list-style-type: none"> • design a product as a project using different devices to solve a real-world problem. 		
2.1	Brief fundamentals of Bluetooth, GSM, Wi-Fi technologies. Various ESP8266 modules and their uses. Substituting Arduino board with a Nodemcu or ESP32, commenting out code for software problems, identifying and isolating circuit components for hardware related problems.	[15L]



Reference Books:

- Arduino for Dummies, John Nussey, 2nd Ed., John Wiley & Sons,
- Arduino Essentials, Francis Perea, Packt Publishing
- Arduino for Beginners: Essential Skills Every Maker Needs, John Baichtal, Que Publishing
- <https://www.tutorialspoint.com/arduino/index.htm>

Note:

- The subject is to be taught using hands-on methodology. The students will be “learning by doing” and shall be using the computer from day 1 to learn the various topics mentioned above. The extensive use of online resources is recommended and students should be able to search on internet and verify interfacing technique of the device to be connected to Arduino board. There shall be only laboratory work for the subject and students will be examined for the same.
- Students are assumed to be familiar with Arduino boards so interfacing experiments may be speeded up so as to allot more time to project design and assembling.
- The students are to design a project using any embedded system board and interface (at least) two sensors as input and one output device. The components required for the project are to be procured by the students themselves.
- The students are required to make a presentation about their project and submit a written project report.
- The project has to be made / assembled in the institute laboratory under the supervision of guide allotted.
- **Ready-made projects are strictly not to be encouraged.**
- The students will be marked for their performance at the presentation and project work.
- The candidates will have to appear for a viva voce while submitting the project.



Question Paper Template

Evaluation Criterion	Examination	% Marks
Attendance	CIE	10%
Performance during hands on sessions	CIE	20%
Project	SEE	40%
Viva Voce	SEE	30%
	Total	100%

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

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes					
	1	2	3	4	5	6
<ul style="list-style-type: none"> • use different sensors, motors and LCD displays 	√	√			√	
<ul style="list-style-type: none"> • use combination of input and output devices to work in programmed manner 	√	√			√	√
<ul style="list-style-type: none"> • design a product as a project using different devices to solve a real-world problem 	√	√	√	√	√	√



M. Sc. (Physics) SEMESTER II

COURSE TITLE: MSc Sem II Lab Course

COURSE CODE: PHYMSC-S2PR2-6CR24 [CREDITS - 06]

Practical II	Course Code: PHYMSC-S1PR1-6CR24
Course Learning Outcomes	
<p>After the successful completion of the course, learners will be able to</p> <ul style="list-style-type: none"> • demonstrate practical skills • correlate the Physics theory concepts through practical 	
Group-A Practicals	
1	To study Hall effect.
2	To study Electron Spin Resonance (ESR).
3	To determine energy band-gap of different semiconducting materials.
4	To determine charge of electron using Millikan's oil drop method.
5	To determine e/m using Helical method.
6	To determine electrical conductivity of graphite.
7	To study Frank-Hertz experiment.
Group-B Practicals	
1	To determine characteristics of GM tube.
2	To study counting statistics using GM tube.
3	To study Ultrasonic interferometer.
4	To determine magnetic susceptibility of the given material.
5	To study Co-60 spectrum and calculation of resolution of detector in terms of energy.
6	To determine linear and mass absorption coefficients using Scintillation detector.
7	To study energy calibration of gamma ray spectrometer (study of linearity).
Group-C Practicals	
1	Study the hermiticity of given operator/commutator/matrix.
2	Evaluate the given commutators.
3	Solve time independent Schrödinger Equation for a given potential in one dimensional.



4	Find the matrices representing the operators J^2 , J_x , J_y and J_z for a given value of j .	
5	Minor Project	

Reference Books:

- Advanced Practical Physics by B. L. Worsnop and H. T. Flint, 3rd Ed., Asia Publishing House, New Delhi, 2021
- University Practical Physics by D. C. Tayal, Edited by Ila Agarwal, 1st Ed., Himalayan Publishing House, 2000.
- Experimental Physics: Modern Methods by R. A. Dunlap, Oxford University Press, New Delhi 1988.
- Methods of Experimental Physics: Series of Volumes by D. Malacara, Academic Press Inc. 1988.

Note:

- The duration of each experiment is of 4 hours. Three such experiments are to be performed by each student per week.
- In the external exam, a student will have to perform three experiments, one from each group. The experiment will be of 4-hour duration.
- There should be three examiners, one for each group, in the external examination.

Question Paper Template

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

Mapping of CLOs and PSOs

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