Central University of Tamil Nadu, Thiruvarur

Department of Physics

School of Basic and Applied Sciences

Syllabus

Integrated M.Sc. Physics Programme

2020-21

1.Preamble

1. Started in : 2010

2. Programmes offered : Integrated M.Sc. Physics, and Ph.D

3. Vision and Thrust areas of the Department in brief:
   The department of Physics of CUTN envisages itself to be a centre of excellence in basic and applied aspects of Physics, both in teaching and research, in 20 years

4. Unique feature of the department,
   The department @ CUTN is established with well-equipped teaching and research laboratories, on par with international standards. All the classrooms are equipped with audio visual aids and a few with smart class rooms with interactive/communicative teaching aids for effective teaching and learning. In order to kindle students' creative learning, E-magazine, prevega (outreach program) Spark and other extra-curricular/co- curricular activities are inculcated through our perturbations club. The performance of all the students is being monitored constantly through Gurukula mentoring and a group of students are assigned to each faculty member for getting guidance for their academic/career development

2. Eligibility

A Pass in the Plus two examination or equivalent of any recognized board in India with 60% marks (Physics, Mathematics & Chemistry) for General Category, 55% marks for OBC (Non-creamy layer) and 50% marks for SC/ST/PWD candidates.

3. Vision of the Department

The Department of Physics of CUTN envisages itself to be a center of excellence in basic and applied aspects of Physics, both in teaching and research, in next 20 years

4. Mission statements

M1	To establish a world class Department of Physics while being sensitive to the location of the University and the demographics of the student input.
M2	To establish a world class research laboratory with cutting edge technology in multi and trans disciplinary areas of Physics and to train students to develop the high level of global competence in core/ Applied areas of Physics.
M3	To collaborate with Institutes of eminence and Industries for enhanced learning experience through ICT integrated teaching-learning process.

5. Program Educational Objectives (PEO) Integrated Masters Program in Physics

On the successful completion of the program, the student will be able to

PEO1	Apply the knowledge gained in fundamental and applied Physics in solving scientific problems at varied complexity, analyze the same to formulate/ develop substantiated solutions.
PEO2	Apply the research-based knowledge and advanced method to design new experiments, analyze resulting data and interpret the same to provide valid conclusions.

PEO3	Gain broad understanding of ethical and professional skill in scientific applications in the context of local, global, economic, environmental and societal realities and to develop sustainable practical solution for academic and research problems within professional and ethical boundaries.
PEO4	Educate scientifically the new development in Science and Technology and make them critical thinker and innovator.
PEO5	Engage in independent and lifelong learning in the broadest context of technological change and pursue his/her carrier either in higher studies or job in various sectors.

6. Program Outcomes (PO)

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the glo0be and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

7. Graduate Attributes

1. Disciplinary/ interdisciplinary knowledge;
2. Computational and ICT skills/ digital literacy.
3. Communication skills.
4. Ethics/ moral awareness.
5. Problems solving/ Analytical/ reflective thinking.
6. Critical thinking
7. Cooperation/ team work.
8. Self-directed learning.
9. Research related skills.

8. PEO to Mission Statement Mapping

	PEO1	**PEO2**	**PEO3**	**PEO4**	**PEO5**
M1	3	2	2	3	3
M2	2	3	3	3	2
M3	1	3	2	3	1

9. PO to PEO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
PEO1	3	2	3	3	1
PEO2	3	3	3	3	1
PEO3	2	1	3	2	3

PEO4	3	3	3	3	1
PEO5	2	2	3	1	3

10. Programme structure

Course Code	Course Title	Type (Core / DSE/SEC/AECC/AU	Theory /Practical/Lab	L:T:P	Total Credits
SEMESTER - I					
PHY111	Mechanics	Core	Theory		3
PHY112	Physics Laboratory- 1	Core	Practical		2
SEMESTER - II					
PHY121	Waves, Oscillations, Sound and Optics	Core	Theory		3
PHY122	Physics Laboratory – II Wave, Oscillations, Sound, and Optics	Core	Practical		2
SEMESTER - III					
PHY211	Heat and Thermodynamics	Core	Theory		3
PHY212	Physics Laboratory- III	Core	Practical		2
SEMESTER - IV					
PHY221	Electricity and Magnetism	Core	Theory		3
PHY222	Physics Laboratory - IV Electricity and Magnetism	Core	Practical		2
SEMESTER - V					
PHY311	Mathematical Physics I	Core	Theory		4
PHY312	Classical Mechanics	Core	Theory		4
PHY313	Morden Physics & Relativity	Core	Theory		4
PHY314	Physics Laboratory-V Morden Physics	Core	Practical		2
PHY351	Numerical Methods and Computer programming	DSE	Theory		4
PHY352	Computational Laboratory- I	DSE	Practical		2
PHY371	Machine shop	SEC	Theory		
SEMESTER - VI					
PHY321	Mathematical Physics II	Core	Theory		4
PHY322	Quantum Mechanics I	Core	Theory		4
PHY323	Electro Magnetic Theory	Core	Theory		4
PHY324	Condensed Matter Physics – I	Core	Theory		4
PHY325	Condensed Matter Physics – Lab	Core	Practical		2
PHY326	Minor Project	Core	Project		6
PHY0E15	Introduction to Nonlinear Dynamics	Elective	Theory		4

PHY0E32	Astrophysics	Elective	Theory		4
PHY0E02	Semiconductor Physics	Elective	Theory		4
SEMESTER - VII					
PHY411	Quantum Mechanics II	Core	Theory		4
PHY412	Atomic and Molecular Physics	Core	Theory		4
PHY413	Statistical Mechanics	Core	Theory		4
PHY414	Atomic physics and optics lab	Core	Practical		2
PHY451	Electronics	DSE	Theory		4
PHY452	Electronics Lab	DSE	Practical		2
SEMESTER - VIII					
PHY421	Modern Optics	Core	Theory		4
PHY422	Nuclear and Particle Physics	Core	Theory		4
PHY461	Laser Physics	DSE	Theory		4
PHY462	Laser Physics Laboratory	DSE	Practical		2
PHY463	Experimental Methods and Design	DSE	Theory		4
PHY464	Experimental Techniques Lab	DSE	Practical		2
SEMESTER - IX					
PHY511	Condensed Matter Physics-II	Core	Theory		4
PHY551	Computational Physics	DSE	Theory		4
PHY552	Computational Laboratory- II	DSE	Practical		2
PHY571	Advanced Physics Laboratory	SEC	Practical		2
PHYS01	Physics of art	General Elective	Theory		2
SEMESTER - X					
PHY521	Project and Thesis	Project	Project		12

Elective

Course Code	Course Title	Type (Core / DSE/SEC/AECC/AU	Theory /Practical/Lab	L:T:P	Total Credits
PHY0E01	Solar Energy and its application	Elective	Theory		4
PHY0E02	Semiconductor Physics	Elective	Theory		4
PHY0E03	Properties of Material	Elective	Theory		4
PHY0E04	Physics of material and synthesis	Elective	Theory		4
PHY0E15	Introduction of Nonlinear	Elective	Theory		4
PHY0E23	Advanced Electro -magnetic theory	Elective	Theory		4

PHY0E29	Nano material and Nano technology	Elective	Theory		4
PHY0E30	Physics of magnetism and spintronics	Elective	Theory		4
PHY0E32	Astrophysics	Elective	Theory		4
PHY0E33	Plasma Physics	Elective	Theory		4
PHY0E34	Classical Filed theory	Elective	Theory		4

11. Evaluation Scheme

Components	**Weightage (%)**
(Internals I & II	40
End Semester Exams	60

12. Syllabus

- **Course Content**

SEMESTER - I

Course Code,Course Title MECHANICS PHY111	**Theory/~~Practical~~**	**Credits 4**
Unit -1	Frames of reference, Inertial and noninertial frames, Galilean transformation, Newton's laws of motion, Integration of Newton's law with various kinds of forces, Motion in uniform field, Components of velocity and acceleration in Cartesian, polar and cylindrical coordinate systems, system of particles, Centre of mass and its equation of motion, Conservation of energy and linear momentum, Impulse and Linear momentum, Elastic and inelastic collision, direct and oblique collision of two smooth surfaces, Work, power and energy; conservation of mechanical energy	Hours* 12
Unit -2	Angular velocity and angular momentum, conservation of angular momentum, Centripetal acceleration due to rotation, banking of curves, Rotational motion, Rolling, Moment of inertia,Calculation of moment inertia of systems of different geometrical shapes, parallel and perpendicular axis theorems, Radius of gyration, Pendulums, Gravitation and. Gravitational potential due to spherical shell and sphere.	12
Unit -3	Motion in a general central force field and the special case of inverse square force field, Central force problem: Kepler problem, inverse square law force, geosynchronous orbits, weightlessness, global positioning system (GPS), scattering in central force field, Rutherford formula, Virial theorem.	12
Unit -4	Elasticity, strain and stress, Young's modulus, Hook's law, Bulk modulus. Inter relations of elastic constants for an isotropic solid; torsional rigidity; bending moments and shearing forces; cantilever; Elasticity Energy in a strained body, Torsion of a rod, Torsional oscillation, Word done in	12

	stretching and twisting a wire, Searles method – determination of rigidity modulus and moment of intertia, Bending of beam, Beam of I section, Cantilever and depression of a cantilever.	
Unit -5	Fluid statics, Pressure and density, Buoyancy, Archimede's principle, Introduction to surface tension, Derivation and applications of Hydrostatic equation Free surface energy, excess pressure – application to spherical, cylindrical drops and bubbles, variation of surface tensiton with temperature – Jaegar's method, Fluid flow, stream lines and tubes of flow, Equation of continuity; Euler's equation for liquid flow, Bernoulli s theorem applications, Fluid friction and coefficient of viscosity. Poiseuilles equation for incompressible fluids; Stokes law; terminal velocity,effect of temperature on viscosity; Reynolds number.	12
	Tasks and Assignments: **References:** 1. An Introduction to Mechanics (2/e), Daniel Kleppner& Robert Kolenkow. 2. Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., (McGraw Hill). 3. Theoretical Mechanics M.R. Spiegel, (Schaum's Outline Series) (McGrawHill). 4. Mechanics K.R. Symon (AddisonWesley). 5. Introduction to Classical Mechanics R.G. Takwale and P. S. Puranik (Tata McGrawHill). 6. R. P. Feynman, Lectures on Physics (vol1),Narosa Publishing, 2008.	

- **Course Outcomes**
  On the successful completion of the course, the student will be able to
  (Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	Course Outcome	Level
CO 1	Define terms in Mechanics such as force, potential energy, work done and write the Newton laws of motion for various forces.	Remember
CO 2	The concept of elastic & inelastic collisions, motion under a central force, idea of simple harmonic motions, and relativistic mechanics.	Understand
CO 3	Apply the Kepler's laws to planetary motions and ideas of Coriolis force and solve problems related to it.	Apply
CO4	Analyze the bending, shear and torsional deformations of materials under various types of loads.	Analyze
CO5	Solve problems related to fluid flow, Archimede's principle, surface tension, Bernoulli s theorem and its applications.	Skill

(Number of CO's are not fixed)

a1. Tabular Column for action verbs

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	3
CO2	3	3	2	3	3
CO3	3	3	2	3	3
CO4	3	3	2	3	3
CO5	3	3	2	3	3

(If the correlation between mission statement and program specific outcome is high 3 is assigned, for moderate 2, for low 1, and for 0 are assigned)

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	2	2	2
Seminar	-	-	-	-	-
Test (Internal 1 & Internal II)	6	6	6	6	6
Attendance	-	-	-	-	-
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

<u>End Semester Exam- Model Question Paper</u>

Total Marks: 60 *Duration: 3hrs*
Sub Code:PHY111 *Sub Title: Mechanics*

I. Answer in detail (Answer either A* OR *B of Q.Nos 1 to 5. Each Question carries Twelve marks)

1.

A A particle of mass "m" is travelling along the x-axis such that at time t=0, it is located at $x = x_0$ and has speed V_0. The particle is acted upon by a frictional force which opposes the motion and has magnitude proportional to the instantaneous speed. Find the speed and position of the particle at time $t > 0$.

(**OR)**

B A projectile is launched with initial speed V_0 at an angle α with the horizontal. Find the position vector at any time t of the projectile and the time taken by it to reach the highest point.

2.

A Derive an expression for time period of oscillations in a compound pendulum.

(**OR)**

B. Find the moment of inertia of a solid sphere of radius "R" and mass "M" about a diameter.

3.

A A particle of mass "m" is bound by a linear potential V(r) = k r. For what energy and angular momentum will the orbit be a circle of radius "a" about the origin. What is the period of this circular motion?

(OR)

B Find the law of central force when the orbit of a particle moving under the force is described by a cardioid, r = a (1 - Cos(θ)).

4.

A Define neutral surface in a bent beam of uniform cross section. Derive an expression for bending moment in the beam.

(OR)

B Derive an expression for twisting couple per unit twist for a cylinder of length "l" and radius "r".

5.

A Define surface tension. Derive an expression for excess pressure inside soap bubble of radius "r".

(OR)

B Derive Poiseuille's formula for the volume of a liquid flowing per second through a pipe under streamlined flow.

- **Course Content**

Course Code: PHY112 **Course Title: Physics Laboratory-I (Mechanics)**	**Practical**	**Credits: 2**
	List of Experiments Preliminary experiments (a) Vernier calipers (b) Screw gauge (c) Physical Balance. (d) Travelling Microscope Core experiments 1. Young's modulus – cantilever bending 2. Young's modulus –Koenig's Method 3. Torsional Pendulum 4. Verification of Hooke's law 5. Projectile motion 6. Conservation of momentum 7. Conservation of energy 8. Archimedes principle 9. Centripetal force 10. Measurement of surface tension using capillary rise method.	HOURS 3 3 3 3 3 3 3 3 3 3 3 3
	Tasks and Assignments: 1. Virtually executing the experiments 2. Observation submission 3. Viva-Voce 4. Practical Examination **References:** 1. Virtual labs, https://www.vlab.co.in/ **2.** An Introduction to Mechanics – D. Kleppner and R.J. Kolenkow (Tata McGraw-Hill) **3.** Mechanics - K. R. Symon (Addison-Wesley). **4.** Mechanics and General Properties of Matter – D. P. Roychaudhuri and S. N. Maiti(Book Syndicate).	

- **Course Outcomes**

	Course Outcome	**Level**
CO 1	Students can understand the basics of mechanics and its working principles	Understand
CO 2	Students can execute those experiments virtually	Virtual
CO 3	Students can utilize the technology to do the experiments	utilizing
CO4	Students can do this practical experiments with various options which is not available do physically	experimental
CO5	Students can develop their self-knowledge to think for the innovative ideas for the virtual experiments	Research

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	1	2	1	1	1
CO2	1	1	3	1	1
CO3	3	3	2	3	1
CO4	3	2	3	3	1
CO5	2	2	2	2	1

SEMESTER -II

- **Course Content**

Course code: PHY121 **Course Title: Waves, Oscillations, Sound and Optics**		**Theory**	**Credits 3**
Unit -1	**Vibrations:** Simple harmonic motion, Angular simple harmonic oscillator, damped harmonic oscillator, relaxation time, forced oscillations and Resonance; Condition for resonance- sharpness of resonance - coupled harmonic oscillators.		**12 Hrs.**
Unit -2	**Waves:** Transverse vibrations in stretched strings, Wave equation in the linear approximation - Speed, Energy of transverse vibrations, Linear equation of plane progressive wave motion in one dimension; wave propagation - group velocity and phase velocity; Traveling waves, Superposition principle, Wave speed, Power and intensity in wave motion, Interference of sound waves, Stationary waves.		**12 Hrs.**
Unit -3	**Sound**: Waves on strings and surfaces, Propagation and speed of longitudinal waves, Vibrating systems and sources of sound - musical sound and noise, characteristics of musical sound: Loudness, noise, quality and intensity. Beats. The Doppler effect - derivation of expression for Doppler shift in frequency - Shock waves, Velocity of sound and its measurement, Factors affecting the speed of sound. Audible, ultrasonic and infrasonic waves. Ultrasonic-Introduction, production, Applications.		**12 Hrs.**
Unit -4	**Geometrical Optics:** Nature and propagation of light, Reflection, Refraction, Fermat's principle, Images, Plane mirrors, Spherical mirrors, Spherical refracting surfaces, Lenses, Defects of images, Spherical and Chromatic aberrations, Achromatism of two thin lenses separated by a distance. Dispersion produced by a thin prism - Dispersive power - Cauchy's formula.		**12 Hrs.**
Unit -5	**Wave Optics:** Spectrometer - measuring refractive index - Optical instruments (Microscopes and Telescopes), Velocity of light and its measurement. Simple account of Wave theory, Newton's ring, Air Wedge, Color on thin films.		**12 Hrs.**
	References: 1.David Halliday, Robert Resnick and Jearl Walker (2004) Fundamentals of Physics. 7th edition. John Wiley & Sons. 8th Ed. (2008). 2. Vibrations and waves, A.P. French, Second Edition (1971), Norton & Company, Network		

	3. Berkeley Physics Course - Vol. 3: Waves and Oscillations (Crawford) 4. Optics, AjoyGhatak, Fourth Edition (2009), Tata McGraw Hill 5. Fundamentals of Optics: K. G. Mazumdar	

- **Course outcome (CO)**

	Course Outcome	Level
CO1	Recollect essential concepts of oscillations	Remember
CO2	Describe basic concepts of various waves	Understand
CO3	Interpret sound waves	Apply
CO4	Apply geometrical optics to build optical instruments	Skill
CO5	Examine wave properties of light	Analyze

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	1	1	1	1	1
CO3	3	1	2	3	1
CO4	3	2	2	3	1
CO5	2	1	2	2	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	-	-	-	-	-
Test	6	6	6	6	6
Attendance	1	1	1	1	1
Total	**8**	**8**	**8**	**8**	**8**

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO4
Part A **(Subjective either-or type questions)** **$12 \times 5 = 60$ marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Model question paper**

1. Attempt any five questions.

(a) A particle moves on the x-axis following the equation $x = A + B\sin\omega t$. Show that it executes simple harmonic motion.

(b) The amplitude of a damped oscillator becomes half in one minute. The amplitude after 3 minutes will be $1/x$ times the original value. Determine the value of x.

(c) In the case of forced simple harmonic vibrations, what is the frequency at which the body generally vibrates?

(d) Is it true that light always travel in a straight line?

(e) Imagine that you are submerged in a lake, will you be able to see the beach without bringing your head outside of water?

(f) What should be the shape of the surface of a focusing mirror?

$(1 \times 5 = 5$ marks)

2. Answer any seven questions.

(a) The volume of an auditorium is 12000 m3. Its reverberation time is 1.5 seconds. If the average absorption coefficient of interior surfaces is 0:4 Sabin/m^2. Find the area of interior surfaces.

(b) As an ambulance travels east down a highway at a speed of 33.5 m/s (75 mi/h), its siren emits sound at a frequency of 400 Hz. What change in frequency is heard by a person in a car traveling west at 24.6 m/s (55 mi/h) in the following cases?
(i) As the car approaches the ambulance and (ii) As the car moves away from the ambulance.

(c) What is the distance travelled by sound in air when tuning fork of frequency 256 Hz completes 25 vibrations? (The speed of sound in air is 343 m/s.)

(d) A hall has a volume of 1200 m3. Its total absorption is equivalent to 480 m2 of open window. What will be the effect of reverberation time if audience fills the hall and thereby increases the absorption by another 480 m^2 of open window.

(e) A quartz crystal of length 1 mm is vibrating at resonance. Calculate the fundamental frequency. (Assume $Y = 7.9 \times 10^{10}$ Nm^2 and $\rho = 2650$ kg-m^3 for quartz.)

(f) A taut string for which $\mu = 5 \times 10^{-2}$ kg/m is under a tension of 80 N. How much power must be supplied to the string to generate sinusoidal waves at a frequency of 60 Hz and amplitude of 6 cm?

(g) An ambulance with a siren emitting a sound of frequency 1600 Hz overtakes and passes a cyclist pedaling a bike at 2.44 m/s. After being passed, the cyclist hears a frequency of 1590 Hz. How fast is the ambulance moving, if the speed of sound in air is 343 m/s?
(h) A string is 35 cm long and has a mass per unit length of 5.51×10^{-4}kg/m. What tension must be applied to the string so that it vibrates at the fundamental frequency of 660 Hz?

(i) A string with a linear mass density of 0.1 kg/m is under a tension of 100 N. How much power must be supplied to the string to generate a sinusoidal wave of amplitude 2 cm and frequency 120 Hz?

($1 \times 7 = 7$ marks)

3. Attempt any five questions.

(a) A damped harmonic oscillator consists of a block (m = 4 kg), a spring (k = 16 N/m), and a damping force ($F = -b\dot{x}$). Initially, it oscillates with an amplitude of 37 mm; because of the damping, the amplitude falls to three-fifths of this initial value at the completion of the fifth oscillations. What is the value of b?

(b) Derive the equation of motion of a 1 g mass, which is suspended under gravity using a massless string. When the oscillation amplitude θ is small (≤ 0.1 rad), it is observed to execute simple harmonic motion with a period of 0.1 sec. Calculate the length of the string.

(c) The electron in a hydrogen atom is bound to the proton by the Coulomb force. When the proton moves a small distance x from its equilibrium position, the force constant is given by

$$k = \frac{e^2}{4\pi\varepsilon_0 x^3}$$

where, $x = 0.05$ nm may be taken as the radius of the atom. Show that the electron can oscillate with a simple harmonic motion with an angular frequency $\omega_0 \approx 4.5 \times 10^{16}$ rad/s.
$e = 1.6 \times 10^{-19}$C is the charge of an electron, $\varepsilon_0 = 8.85 \times 10^{-12}$ $N^{-1}m^{-2}C^2$ is the free space permittivity and $m_e = 9.1 \times 10^{31}$ kg is the mass of an electron.

(d) Discuss about astigmatism in brief.

(e) A thin plano-convex lens of refractive index 1.5 has a radius of curvature of the curved surface of 10 cm. What is the amount of longitudinal spherical aberration for ray's incident at a height of 1 cm, when the plane side face the incident light?

(f) Consider a lens which has a radius of curvature of 5 cm at the surface where parallel rays are incident. What should be the radius of curvature of the other surface in order achieve a coma free image?

($2 \times 5 = 10$ marks)

4. Answer any two questions.

(a) Explain in detail on superposition and interference waves with conditions of $\phi = 0$, $\phi = \pi$ and $\phi =$ other than 0 and integer multiple of π.

(b) Explain about inverse piezo-electric effect to produce ultrasonic waves. Mention few advantages, disadvantages and applications.

(c) Describe the rate of energy transfer by sinusoidal wave on strings.

(d) Write short notes about the
i. characteristics of musical sound,
ii. relation between loudness and intensity of sound
iii. how can we control reverberation time in a hall. **($4 \times 2 = 8$ marks)**

- **Course Content**

Course Code: PHY122 **CourseTitle:** Physics Laboratory-II (Waves, Oscillations, Sound, and Optics)		**Practical**	**Credits: 2**
Experiment	**Title**		**Hrs.**
I	Simple pendulum		6
II	Compound pendulum		6
III	Resonance air column		6
IV	Sonometer		6
V	‘f’ of lenses		3
VI	Focal length of solid and liquid prism		3
VII	Diffraction using grating		6
VIII	Air wedge		3
IX	Small angle prism		3
X	Newton’s rings		6

- **Course outcome (CO)**

	Course Outcome	**Level**
CO1	Recollect the idea of simple and compound pendulum	Remember
CO2	Getting idea of random errors	Analyze
CO3	Familiarizing with standing waves	Skill
CO4	Familiarizing with interference and diffraction	Skill
CO5	Using netwon’s ring method to find the curvature of the plano-convex lens	Analyze, skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	1	1	3	3	1
CO3	3	2	3	3	1
CO4	1	1	3	3	1
CO5	1	1	3	3	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	20	20	20	20	20	100
External	0	0	0	0	0	0
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Experiment/Observation/Performance	10	10	10	10	10
Calculations & Graph	4	4	4	4	4
Viva-Voce	3	3	3	3	3
Record	2	2	2	2	2
Attendance	1	1	1	1	1
Total	20	20	20	20	20

SEMESTER -III

- **Course Content**

Course code: PHY211 Course Title: Heat and Thermodynamics	Theory	Credits 3
Unit -1	**Thermometry:** Thermal equilibrium and notion of temperature; Zeroth law of thermodynamics; Thermometers and temperature scales: Celsius and Fahrenheit scales; Linear, surface and volume expansions; Absorption of heat by solids and liquids; specific heat; Molar specific heat of solids; Constant volume gas thermometer; Platinum resistance thermometer; Callender& Griffith's bridge – Thermistor; Ideal gas temperature scale.	**12**
Unit -2	**Law of Heat and work**: Equivalence of heat and work; Internal energy function; First law of thermodynamics; Second law of thermodynamics: Kelvin-Planck and Claussius statements; Reversible and irreversible transformations. Entropic formulation of second law: reversibility, irreversibility and the principle of the increase of entropy. Carnot engine and refrigerator: Carnot cycle, efficiency, Coefficient of performance, Carnot cycle in P-V and T- S planes; Thermodynamic temperature scale; Different heat engine cycles: Internal combustion engine, Diesel engine and steam engine. Third law of thermodynamics	**12**

Unit -3	**Transfer of heat:** Conduction, convection and radiation; Definition of thermal conductivity, thermal conductivity of bad conductor -Lee's disc method; Black body radiation; Wien's law, Rayleigh-Jean's law and Planck's law; Stefen's law; Specific heat capacity of solids - Dulong &Petit's law; Specific heat capacity of liquid; method of mixtures; Cooling correction - Specific heat of capacity of gases - C_p and C_v by Regnault's and Callender and Barne's methods	**12**
Unit -4	**Phase transition:**Exact and inexact differentials; Relations among partial derivatives of entropy and of Internal energy: Maxwell's relations; Legendre transformation; Helmholtz free energy, enthalpy and Gibbs free energy; Kinetic theory of gases; Meyer's relation; Change of phase, Latent heat, discontinuous and continuous phase transition, regelation, triple point; Examples of phasetransitions. Real gases: Liquefaction of gases; critical point, thermodynamic surfaces, Clausius Clapreyon heat equation; Van der Waals gas: equation of state, critical temperature, critical pressure and critical volume; The Virial Expansion.	**12**
Unit -5	**Statistical Physics**: Macroscopic and microscopic variables; Configuration space, Concept of Phase space; Maximum entropy principle; Statistics of particles - Maxwell-Boltzmann, Bose-Einstein and Fermi Dirac Statistics (qualitative).	**12**
	References: 1. Heat and thermodynamics - Zemansky and Ditman (Mc Graw Hill). 2. F. W. Sears, and G. L. Salinger, Thermodynamics, Kinetic theory, and Statistical Thermodynamics, (Narosa , 1986) 3. An introduction to Thermal Physics, D.V. Schroeder, (Pearson)	

- **Course outcome (CO)**

	Course Outcome	Level
CO1	Recollect knowledge about thermometry	Remember
CO2	Familiarize with the connection of heat and work	Understand
CO3	Describe heat transfer process	Remember
CO4	Interpret phase transitions	Apply
CO5	Apply statistics into heat transfer	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	1	1	1	1	1
CO3	1	1	1	1	1
CO4	2	1	2	3	1
CO5	3	1	2	2	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	-	-	-	-	-
Test	6	6	6	6	6
Attendance	1	1	1	1	1
Total	**8**	**8**	**8**	**8**	**8**

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO4
Part A **(Subjective either-or type questions)** $\mathbf{12 \times 5 = 60}$ **marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Model question paper**

PART A: Answer all the questions. (5 marks)

1. If system A and B with temperature T_1 and T_2respectively, are in thermal equilibrium. Another system C having temperature T_3 brought in contact with system B to thermal equilibrium. Then which of the following statement(s) is (are) correct?and why?
   (a) $T_1 = T_2$ and $T_2 = T_3$
   (b) $T_1 = T_2$,$T_2 > T_3$
   (c) $T_1 = T_3$
   (d) $T_1 \leq T_2$but $T_2 = T_3$

(1.5 marks)

2. Which of the following statements is/are not correct?
   (a) Internal energy is a state function.
   (b) $C_p - C_V = nRT$
   (c) Adiabatic expansion causes cooling.
   (d) If η_I is the efficiency of an irreversible heat engine, and η_R is the efficiency of a reversible heat engine, then $\eta_I \leq \eta_R$.

(1.5 marks)

3. Which of the following relation(s) is/are not correct?
   (a) Enthalpy $H = Vdp + TdS$
   (b) Helmholtz function $A = U + TS$
   (c) For reversible isothermal and isochoric process, Helmholtz free energy remains constant.
   (d) Gibbs free energy does not change in a reversible and isochoric process.

(1.5 marks)

4. Which is not an extensive property of a thermodynamic system.
   (a) Mass
   (b) Volume
   (c) Density
   (d) Entropy

(0.5 marks)

PART B: Answer *any two* from the following questions. (10 marks)

5. The surface of the sun consists mostly of hydrogen atoms and is at a temperature of 6000 K.
   (a) Find the rms speed of a hydrogen atom on the surface of the sun if the mass of a single hydrogen atom is 1.67×10^{-27} kg.
   (b) The sun has a mass of $M \approx 2 \times 10^{30}$ kg and a radius of $r \approx 7 \times 10^{8}$ m. How many hydrogen atoms per mole will be able to escape the gravitational field of the sun if the speed of the hydrogen atoms obey the Maxwell-Boltzmann distribution? The escape speed is given by $v_{\text{esc}} = (2GM/r)^{1/2}$; where $G = 6.673 \times 10^{-11} \text{N} \cdot \text{m}^2/\text{kg}^2$ is the gravitational constant.
   You may use the fact that $\int_{v/v_{rms}=10}^{\infty} f(v)dv \approx 0$.

(2+3=5 marks)

6. A 1000 W ac is used to decrease the temperature of a Physics seminar room from 32℃ to 22℃. If the room has a floor area of 60 m^2 and a height of 3 m, how long will it take? Assume that the air is composed mostly of diatomic molecules of molar mass 29 g/mol and has an average density of 1.16 kg/m^3 in that temperature range.

(5 marks)

7. The van der Waals constants for carbon di oxide gas is $a = 0.364 \text{J} \cdot \text{m}^3/\text{mol}^2$ and $b = 4.27 \times 10^{-5} \text{m}^3/\text{mol}$.
   (a) If 1 mol of carbon di oxide gas at 350K is confined to a volume of 400cm^3, find the pressure of the gas using the ideal gas equation and van der Waals equation.
   (b) Which equation gives the lower pressure and why?

(4+1=5 marks)

PART C: Answer *any three* from the following questions. (15 marks)

8.

(a) Write down any two basic differences among micro-canonical, canonical and grand canonical ensembles.

(b) Write down two basic postulates of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.

(c) Let say there are 5 distinguishable particles namely π, K, p, n and e. Find out the total number of macrostate and microstate if they are arranged in two different boxes by drawing the arrangements.

(1+1+3=5 marks)

9. For ideal gas, write down the first law of thermodynamics in terms of entropy and heat capacities ($C_p$and C_V). Then show that for isobaric process the change in entropy,$\Delta S_p = C_p \ln(V_2/V_1)$.

(5 marks)

10. 10 gmof ice is fully converted into steam at normal atmospheric pressure. Estimate the change in entropy in this process. Given latent heat of ice is $80\ \text{cal/gm}$ and $540\ \text{cal/gm}$ for steam, specific heat capacity of water is$1\ \text{cal} \cdot \text{gm}^{-1} \cdot \text{K}^{-1}$.

(5 marks)

11.

(a) Draw the$T$-V diagram of the Carnot cycle process.

(b) Find out the work done by an ideal gas in adiabatic expansion process if

(i) The initial volume is increased by 1.5 times,

(ii) The temperature is changed by a factor of 2.

Take $K = 1$and $\gamma = 1.67$.

(1+4= 5 marks)

- **Course Content**

Course Code, Course Title PHY212, Physics Laboratory- III (Heat and Thermodynamics lab)	**~~Theory/~~Practical**	**Credits 2**
1	***Preliminary experiments***: An introduction to the subject Temperature of mixing - mix hot and cold water - note their initial and final temperature - try and predict the final temperature 1. Galton's board 2. Thermometry - Measuring temperature using different thermometers such as (a) alcohol (b) mercury (c) IR (contact less) (d) digital (e) min-max (f) dry-wet (for humidity) 3. Place a cube of ice on three different black colored boards - one made of metal, one of wood and one of plastic - qualitative concepts of specific heats and thermal conductivity	Hours* **6**

2	Core Experiments 1. Newton's law of cooling 2. Pressure coefficient of air - Joly's bulb 3. Thermal conductivity of a good conductor - Searle's method 4. Thermal conductivity of a bad conductor - Lee's method 5. Specific heat by method of mixtures 6. Verification of Stefan-Boltzmann law 7. Latent heat of steam/ice 8. Verification of Boyle's law 9. Seeback effect and thermocouple 10. Mechanical equivalent of heat	**30**
	Tasks and Assignments: • Student should summarize the course content at the end and also the beginning of the practical class. • Student should discuss the given experiment within the batch and explain the how they performs the experiment to other batches in the class • Apart from regular lab experiments, students should do experiments on its own in Lab and explain the results. **References:** 1A Manual on Experiments in Physics, R Srinivasan, K R Priolkar and T G Ramesh, e-Booksof the Indian Academy of Sciences**,** India. **2** Laboratory Manual of Experimental Physics ,Arey Albert Llewellyn, Forgotten book publisher, ISBN: 9781334256486, 9781334256486.	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Understand notion of heat, randomness and temperature using different systems	Understand
CO 2	Illustrate different thermodynamics concepts by employing various experiments.	Apply
CO 3	Compare and examine the experimental result with theoretical predictions.	Analyze
CO4	Arrange for the experiment, Demonstrate and Verify the Hypothesis.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	3	3
CO2	3	3	1	3	3
CO3	3	3	3	3	3
CO4	3	3	1	3	3

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	Total
Internal	25	25	25	25	100
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (100 Marks)**

	CO1	CO2	CO3	CO4
Assignments/Observation	8	8	8	8
Seminar/Viva	8	8	8	8
Test/Experiment	8	8	8	8
Attendance	1	1	1	1
Total	25	25	25	25

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Short Answer	-	-	-	-	-
Derivation	-	-	-	-	-
Problem solving	-	-	-	-	-
Total	-	-	-	-	-

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Originality	Ideas are detailed, developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported.	Content is not sound	Copied from other students (or) Not submitted	CO1, CO2, CO3, CO4, CO5
2	**Organiza -tion** **50%**	Originality	Includes title, introduction, statement of main idea and Conclusion.	Organizational tools are weak or missing	No organization	Copied from other students (or) Not submitted	CO1, CO2, CO3, CO4, CO5

- **Rubric for Seminar/Viva**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3, CO4, CO5

2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO1, CO2, CO3, CO4, CO5

- **Question Paper pattern: Internal Assessment**

Sl. No.	Model Questions	Specification	Level
1	Verify Boyles and Charles law in experiments?	Recognize, Recall, Identify	Apply, Analyse, Skill
2	Experiment to find out the Specific heat capacity of Potatoes?	Recognize, Recall,	Apply, Analyse

SEMESTER -IV

- **Course Content**

Course Code, Course Title PHY221, Electricity and Magnetism	**Theory**	**Credits3**
Unit -1	Introductory vector analysis: div, grad, curl; Stokes' and Green's theorems. Electrostatics: Inverse square law, Problems related to coulombs lawCavendish proof, Electric field and intensity, Electric field of a point charge, multiple point charges, dipole, line of charge; Electric field of rings, discs, planes and spheres Electrostatic potential relation between electric field and potential, potential due to a point charge, infinitely charged long wire, uniformly charged disc equipotential surfaces, electric multipoles potential and field due to a point dipole.	8 Hours
Unit -2	Electrostatic energy of charge configurations, energy of a charged sphere. Conductors in an electrostatic field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallelplate capacitor, capacitors and their types, capacitors in series and parralel combinations, capacitance of an isolated conductor. Method of Images and its application to plane infinite sheet of charge and charged sphere.	8 Hours
Unit -3	Magnetism: Magnetic field, magnetic shell, magnetized sphere, forces and couples between magnets, B&H lines of force of a bar magnet, Terrestrial dip circle, magnetic condition of the earth, BiotSavarats law, magnetic field due to a straight, circular conductor and solenoid, Self and mutual indication, calculation of inductance, measurement of L & M. measurement of permeability and susceptibility, basic ideas of para, ferro and diamagnetism cycle of magnetization, hysteresis, energy loss due to hysteresis,	9 Hours

Unit -4	Current Electricity: Steady current, standard cells, secondary cells, Helmholtz Gibb's equation; Force between currents, Ampere's theorem and of its applications; Resistors and Ohm's law, Kirchoff' laws, conservation theorems and their applications; electrical measuring instruments: Wheatstone bridge, Anderson's Bridge, moving coil galvanometers, ballistic galvanometer, Ammeters and Voltmeters, Wattmeter.	8 Hours
Unit -5	Alternating currents: A.C. generators polyphase circuits with star and delta connections, rotating magneitc field and induction motor, principle of working and uses of transformers. Chokes, resonance and resonant circuits, power in A.C. circuits. Resonance circuits – RC, LC and RLC circuits. Phasor representation and Q factor. Impedance of series and parallel resonant circuits. Maxwells's equations in vacuum and media, derivation of wave equation and its plana wave solutions. Basic ideas of reflectance, absorbance, transmittance, and polarization of electromagnetic waves.	9 Hours
	Tasks and Assignments: **References:** 1) Introduction to Electrodynamics, D J Griffiths. 2) Brijlal and Subramaniam, "Electricity and Magnetism", 3) Electronic principles, A.Malivino D. Bates 4) Electricity and Magnetism, Satya Prakash	

- **Course Outcomes**

	Course Outcome	**Level**
CO 1	Coulomb's law, Gauss law, Stoke's theorem, Earnshaw's theorem, Ampere's law, , Faraday's law, Lentz's law, Lorentz' law, Biot-Savart Law, Ohm's law, Kirchoff's law, Norton and Thevenin theorem	Remember
CO 2	Vector analysis, electric field and potential, magnetic field and potential, dielectric medium, capacitance, magnetism, self and mutual inductance, circuit analysis, alternating current circuits, Maxwell's equation.	Understand
CO 3	To find out the electric field and potential for different charge configurations, method image to find electric field and potentials, Use Biot-Savart Law to find magnetic field for different configurations of current carrying conductor, solving different circuit problems using circuit theorem, solving series and parallel a.c circuit having resistance, inductance and conductance.	Apply
CO4	Applying vector analysis to solve problems of electricity and magnetism, using different laws and theorems of electrostatisc and magnetostatics to solve electricity and magnetism problems, to use this to basic knowledge for studying Electrodynamics.	Skill

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	3	3	**1**
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	1

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**Total**
Internal	10	10	10	10	40
External	15	15	15	15	60
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**
Assignments	2.5	2.5	2.5	2.5
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	7.5	7.5	7.5	7.5
Attendance	-	-	-	-
Total	10	10	10	10

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	**CO1**	**CO2**	**CO3**	**CO4**
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	15	15	15	15
Total	**15**	**15**	**15**	**15**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- ***<u>End Semester Exam- Model Question Paper</u>***

Total Marks: 60
Duration: 30 hrs

1. (a) Prove that $\nabla \cdot (\varphi A) = \varphi(\nabla \cdot A) + A \cdot (\nabla\varphi)$, where φ is a scalar function and A is an arbitrary vector. **[12 Marks]**

OR

(b) Show that $\nabla \cdot (\nabla \times A) = 0$, i.e. div curl $A = 0$. Here A is an arbitrary vector. **[12 Marks]**

2. (a) Find out the capacitance of the following capacitors filled with a medium of dielectric constant K as shown in Figure (i) and (ii). The area of each of the capacitors is **A**.

OR

(b) (i) Find the electric potential at the surface of a uniformly charged hollow conducting sphere of radius R having charge Q.

(ii) Find out the electric field strength at a point (3, 4, 5) for a given potential function $\varphi = 4x^2 + 3y^3 - 9z^2$.**[6 + 6 = 12 Marks]**

3. (a) (i) A magnetic needle free to rotate in a vertical plane parallel to the magnetic medium has its North tip down at 600 with the horizontal component of the earth's magnetic field at the place is known to be 0.4 G. Determine the magnitude of the earth's magnetic field at the place.

(ii) How much current must flow in an infinitely long straight conductor to give a flux density of 6x10-5 T at 3 cm from the conductor? **[6 + 6 = 12 Marks]**

(b) A flux of 0.5 mWb is produced by a coil of 900 turns wound on a ring with a

current of 3 A in it. Calculate:

(i) The inductance of the coil

(ii) The e.m.f. induced in the coil when a current of 5 A is switched off, assuming the current fall to zero in 1 milli second and

(iii)The mutual inductance between the coils, if a second coil of 600 turns is uniformly wound over the first coil. **[4 + 4 + 4 = 12 Marks]**

4. (a) Find the load current of the following circuit using Norton's theorem. [12 Marks]

OR

(b) (i) Derive the expression of damping correction for moving coil Galvanometer.

(ii) A copper wire of diameter 0.5mm and length 20m is connected across a battery of emf 1.5 V and internal resistance 1.25 Ohm. If the resistance of the wire is 1.732 Ohm and the electron number density is 8.43 × 1028 per *m*3, calculate the current density and drift velocity. **[6+6 = 12 Marks]**

5. (a) (i) Draw the phasor diagram where the alternating voltage is applied to a circuit containing resistance R and capacitance C in series.

(ii) An a.c. voltage of 110V, 50 Hz is applied to a circuit which contains an inductance of 0.02 H and resistance of 10 Ohm in series. Calculate the current and its phase lag. [6+6=12 Marks]

OR

(b) For a monochromatic plane wave in vacuum, the electric field is given as $E(r, t) = E e^{i(k.r - \omega t)}$ and the magnetic field is given as $B(r, t) = B e^{i(k.r - \omega t)}$. From Maxwell's equation show that (i) $\nabla . B = ik . B$, (ii) $k \times E = \mu_0 \omega H$.

[6 + 6 = 12 Marks]

- **Course Content**

Course Code: PHY222, **Course Title:** Electricity and Magnetism lab		**Practical**	**Credits:** 2
Unit -1	Kirchhoff's Voltage and Current Law		4
Unit -2	Magnetic field along the axis of a circular coil carrying current		4
Unit -3	Anderson's Bridge		4
Unit -4	Deflection Magnetometer		4
Unit -5	Tangent Galvanometer		4
Unit -6	Temperature Coefficient of Resistance		4
	Tasks and Assignments: 1. Virtually executing the experiments 2. Observation submission 3. Viva-Voce 4. Practical Examination **References:** 1. Virtual labs, https://www.vlab.co.in/ 2. Brijlal and Subramaniam, "Electricity and Magnetism", Ratan PrahasanMardisEducational and University Publishers, Delhi, 1990 3. Jacob Millman and Christos C Halkias, "Electronic Devices and Circuits", Tata McGraw Hill Edition, 1991.		

- **Course Outcomes**

	Course Outcome	**Level**
CO 1	Students can understand the fundamentals of electricity and magnetism	Fundamental
CO 2	Students can easily understand those experiments	Understanding
CO 3	Students can utilize the instrumental facility to do the experiments	Utilizing
CO4	Students can do this practical experiments with various options to get new ideas for self-developments	Developements
CO5	Students can develop their self-knowledge to think for the innovative ideas	Higher study

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.

PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	3	1
CO2	2	3	3	3	1
CO3	3	3	3	3	1
CO4	2	3	3	3	**2**

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**Total**
Internal	25	25	25	25	100
External	0	0	0	0	0
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**
Assignments	-	-	-	-
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	25	25	25	25
Attendance	-	-	-	-
Total	25	25	25	25

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	**CO1**	**CO2**	**CO3**	**CO4**
Part – A **Essay Type (Either/OR-type Question)** **25 x 4 = 100 Marks**	25	25	25	25
Total	**25**	**25**	**25**	**25**

SEMESTER – V

- **Course Content**

Course Code,Course Title PHY311, Mathematical Physics I	**Theory**	**Credits 4**
Unit -1	**Ordinary and partial Differential Equations:** Linear ordinary differential equations – Elementary methods – Linear second order differential equations with variable coefficients – Frobenius method-wronskian-physical example. Method of forming partial differential equations – Solution by direct integration – Method of separation of variables – Partial differential equations in physics problems – Wave	Hours* 12

	equation – Equation of vibrating string – One dimensional heat flow – Two dimensional heat flow – Laplace equation	
Unit -2	**Vector Analysis:** Gradient, Divergence, Curl and ∇^2 operators in curvilinear coordinates. Divergence theorem, Stokes theorem. Green's theorem. Linear Vector Spaces : Definition vector space, Subspace, basis, Linear dependence, Inner product Space, complete set, Hilbert space, Schwarz inequality, Gram Schmidt orthogonalization process.	**12**
Unit -3	**Operators**: Linear and nonlinear Operators, Eigen values: degenerate and non degenerate, Eigen functions: adjoint, Hermitian and unitary operators, similarity transformation, differential, integal and matrix representation of operators and its applications.	**12**
Unit -4	**Tensors:** Contravariant and Covariant tensors – Addition – Subtraction – Outer and inner products – Contraction – Metric tensor – matrix representation of tensors- Hooke's law stress— strain Piezoelectricity and dielectric susceptibility – Moment of inertia tensor. Tensor applications in mechanics	**12**
Unit -5	**Complex Analysis:** Functions of complex variable, derivative and Cauchy-Riemann differential equations, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, Cauchy's residue theorem, singular points of an analytic function, evaluation of residues, evaluation of definite integrals.	**12**
	Tasks and Assignments: **References:** 7. ButkovE, Mathematical Physics, (Addison Wesley, New York, 1973). 8. Arfken G and Weber H J, "Mathematical Methods for Physicists", (Academic Press, SanDiego, 2001). 9. Kreyszig E, "Advanced Engineering Mathematics", 8th Edition. (Wiley, New York, 1999).	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Learn to translate physical situation into mathematical equations,findoutsolutions ofthe mathematicalequations,analyzeandinterpretthesolutions.	Understand, Analyze, Skill
CO 2	Tolearntheabstractwayofdefiningquantitieslikespace,dimensionality ofspacesetcwhichcanbeappliedinvariousbranchesof physics	Apply
CO 3	Learnthetensor notation. Applicationoftensornotationinanalysingvariousphysicalsystems	Understand, Analyze
CO4	Togetanideaofcomplex variablesanditsusesinphysicalproblems	Understand, Skill, Apply

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	1
CO2	3	2	2	3	1
CO3	3	1	2	3	1
CO4	3	2	3	3	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	Total
Internal	10	10	10	10	40
External	15	15	15	15	60
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4
Assignments	2	2	2	2
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	8	8	8	8
Attendance	-	-	-	-
Total	10	10	10	10

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	15	15	15	15
Total	**15**	**15**	**15**	**15**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

<u>End Semester Exam- Model Question Paper</u>

Total Marks: 60 | *Duration: 3hrs*
Sub Code:PHY311 | *Sub Title: Mathematical Physics-I*

Instructions

- There are three sections in this question paper.
- **From each section, attempt any three questions.**

Section A

1. Determine whether or not vector $|u\rangle$ and $|v\rangle$ are linearly independent

   (a) $|u\rangle = 2\,t^2 + 4\,t - 3$ and $|v\rangle = 4\,t^2 + 8\,t - 6$

   (b) $|u\rangle = \begin{pmatrix} 1 & 1 & 1 \\ 2 & 2 & 2 \end{pmatrix}$ and $|v\rangle = \begin{pmatrix} 2 & 2 & 2 \\ 3 & 3 & 3 \end{pmatrix}$

2. Find constant a, b and c so that vector $\vec{V} = (-4\,x - 3\,y + a\,z)\,\hat{i} + (b\,x + 3\,y + 5\,z)\,\hat{j} + (4\,x + c\,y + 3\,z)\,\hat{k}$ is irrotational.

3. If A and B are two linear operators then show that $(AB)^{\dagger} = B^{\dagger}\,A^{\dagger}$

4. If $A_{\alpha\beta}$ is an antisymmetric tensor of rank 2 and $\alpha, \beta = 1, 2, ..., n$ then find out the number of independent components it will have.

Section B

5. Expand $f(z) = \frac{1}{z^2\,(1-z)}$ in a Laurent series valid for (a) $0 < |z| < 1$ and (b) $1 < |z| < \infty$.

6. Velocity of a two-dimensional fluid is given by

$$\vec{V} = \hat{x}\;u(x, y) - \hat{y}\;v(x, y)\ .$$

   If the fluid is incompressible (or solenoidal) and the flow is irrotational then show that

$$\frac{\partial u(x,y)}{\partial x} = \frac{\partial v(x,y)}{\partial y} \quad \text{and} \quad \frac{\partial u(x,y)}{\partial y} = -\frac{\partial v(x,y)}{\partial x}.$$

   (Note that, these are Cauchy-Riemann conditions.)

7. The equation of motion of a particle P of mass m is given by

$$m\frac{d^2\vec{r}}{dt^2} = f(r)\ \hat{r}$$

where $\vec{r}$ is the position vector of the particle measured from the origin, $\hat{r}$ is the unit vector in the direction of $\vec{r}$ and $f(r)$ is a function of distance of P from the origin.

(a) Show that $\vec{r} \times \frac{d\vec{r}}{dt} = \vec{c}$ where $\vec{c}$ is a constant vector.

(b) Interpret physically the two cases when $f(r) > 0$ and $f(r) < 0$.

Section C

8. Evaluate the following integral

$$I = \int_{-\infty}^{\infty} \frac{x\ \sin(\pi x)}{x^2 + 2x + 5}\ dx$$

9. Laplace equation in spherical polar coordinate is given as

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial u(r,\theta,\phi)}{\partial r}\right) \ + \ \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial u(r,\theta,\phi)}{\partial \theta}\right) \ + \ \frac{1}{r^2\sin^2\theta}\frac{\partial^2 u(r,\theta,\phi)}{\partial \phi^2} = 0$$

10 x 3 =30

Using separation of variables R, Θ and Φ for radial distance, polar angle and azimuthal , obtain the differential equation for R , Θ and Φ. Finally, solve the differential equation for Φ in terms of unknown coefficients.

10. Consider two vectors:

$$|u\rangle = \begin{pmatrix} 1 \\ 1 \end{pmatrix} \qquad \text{and} \qquad |v\rangle = \begin{pmatrix} 1 \\ -2 \end{pmatrix}$$

Show that they are neither orthogonal nor normalized. Use Gram-Schmidt procedure to form orthonormal set of vectors, a basis of two-dimensional Euclidean space.

11. Find the eigenvalues and eigenvectors of the following matrix:

$$M = \begin{pmatrix} 2 & 0 & -2 \\ -2i & i & 2i \\ 1 & 0 & -1 \end{pmatrix}$$

- **Course Content**

Course Code: PHY 312 **Course Title: CLASSICAL MECHANICS**	**Theory**	**Credits 4**
Unit -1	Langrangian Formulation System of particles, Newtonian mechanics, Non-inertial frame, constraints and degrees of freedom – generalized coordinates-conservation of linear and angular momenta- D'Alemberts principle of virtual work- Lagrange's equation of motion – applications of Lagrange's equation of motion –applications of Lagrange equations of motion; single particle in space-Atwood's machine-bead sliding in rotating wire, generalized momenta, Routh's procedure, symmetry properties and conservations theorems.	Hours* 12

Unit -2	Hamilton Principle Calculus of variation – Liouville theorem-Hamilton’s principle – derivation of Lagrange’s equation from Hamilton’s principle – Hamilton’s principle for nonholonomic system-variational principle – Legendre transformation and Hamilton’s equations of motion –cyclic coordinates and conservation theorem – Hamilton’s equations from variational principle –principle of least action – Solving the Harmonic Oscillator problem using canonical transforms- Canonical transformations- angular momentum using Poisson brackets-Generating functions –Examples – Poisson brackets and its properties	**12**
Unit -3	Small Oscillations Small oscillations of dynamical systems, equilibria and derivations, frequencies of free vibrations and normal coordinates and normal modes; motion of masses connected by springs – vibrations of linear triatomic molecule.	**12**
Unit -4	Kinematics of Rigid Body Independent coordinates of rigid body – orthogonal transformation – properties of transformation matrix – Euler angle and Euler’s theorem – infinitesimal rotation –rate of change of vector – Coriolis force – angular momentum and kinetic energy of motion about a point – moment of inertia tensor – Euler’s equations of motion – torque free motion of a rigid body –heavy symmetrical top.	**12**
Unit -5	Hamilton –Jacobi Theory Hamilton–Jacobi equation for Hamilton’s Principle function-Example; Harmonic oscillator problem- Hamilton’s characteristic function – Action – angle variable in systems of degree of freedom- application of angle of action to Kepler problem and simple harmonic oscillator.	**12**
	Tasks and Assignments: **References:**	

- **Course Outcome (CO)**

	Course Outcome	Level
CO 1	To gain deeper understanding of the basic classical mechanics principles such as constraints, generalised coordinates, D’Alemberts principle, Lagrangian and Hamiltonian formulations.	Remember
CO 2	To be able to formulate and solve the problems on canonical transformations, Poisson brackets and Harmonic oscillators.	Understand
CO 3	To understand the theory of small oscillations which is important in several areas of physics e.g., motion of masses connected by springs –vibrations of linear triatomic molecule and coupled mechanical oscillators.	Apply

CO 4	To understand the motion of rigid body and essential features of a problem (like motion under central force, rigid body dynamics, periodic motions), use them to set up and solve the appropriate mathematical equations.	Analyze
CO 5	To solve Hamilton Jacobi equation and action angle variables in systems of degree of freedom and its application to Kepler problem and harmonic oscillator.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	0	3	3
CO2	3	1	3	3	3
CO3	3	3	3	3	2
CO4	2	1	3	2	3
CO5	0	3	3	3	2

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	2	2	2	2	2
Seminar	-	-	-	-	-
Test	6	6	6	6	6
Attendance	-	-	-	-	-
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**

1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

Model Question Paper

End Semester Exam – Model Question Paper

Course: Classical Mechanics **Code: PHY 053**

Max. Time: 3 Hrs **Max. Marks: 60**

PART-A

Answer any FOUR questions: **4x6=24**

1. Write short notes on constraints and illustrate with examples.
2. Derive Lagrangian equation of motion from the Hamilton's principle.
3. (a) What are action-angle variables?
   (b) Prove
   $$(i)[J_x, J_y] = J_z; (ii)[J_z, P_y] = -P_x$$
4. Distinguish between stable and unstable equilibrium.
5. Using the time-dependent perturbation theory, deduce the period of the plane pendulum with finite amplitude at the first order.

PART-B

Answer any THREE questions: **3x12=36**

6. Two masses 2**m** and m are suspended from a fixed frame by elastic spring of spring constant **k**, obtain Lagrangian and equation of motion assuming only vertical motion.
7. State and Prove Liouville's theorem.
8. Solve the simple harmonic oscillator using Hamilton-Jacobi method.
9. (a) Discuss the theory of small oscillations.
   (b) Let two masses $\mathbf{m_1}$ and $\mathbf{m_2}$ are joined by a spring of force constant **k**. deduce the expression for the normal frequencies of vibration when
   $(i) m_1 >> m_2$
   $(ii) m_1 << m_2$
   $(iii) m_1 = m_2, l_1 = l_2 = l$

- **Course Content**

Course Code: PHY313 **Course Title:** Modern Physics and Relativity		**Credits: 4**	**Theory**	**Hours**
Unit -1	Pre Relativity/Quantum Physics – Brief history of Physics up to 1800 – special mention of scientific ideas from India wave and corpuscular theories of light – Young's Double slit experiment – unification of ideas of electricity and magnetism – Maxwell's equations – Aether hypothesis and MichelsonMorley Experiment.			10
Unit -2	Special theory of Relativity: Einstein's Principles and postulates of relativity and concept of spacetime, length contraction, time dilation and Doppler effect, velocity addition formula, four vector notation, relativistic dynamics variation of mass with velocity. Energy momentum and mass energy relations. energy–momentum fourvector for a particle, relativistic invariance of physical laws Twin paradox, relativity of mass, Einstein's massenergy equivalence, mass less particles.			14
Unit -3	Reference system, Inertial and Noninertial frames, Galilean invariance and conservation laws Newtonian Relativity Principle, Velocity of light, Michelson-Morley experiment–Search for ether–Lorentz transformations Introduction Newton's law of Gravitation and its limitations Gravitational mass and inertial mass Principle of Equivalence. Applications of Relativity: Relativistic Effects and Paradoxes Minkowski Diagrams; Relativistic Momentum, Energy, and Mass Relativistic Particle Collisions; Relativity and Electricity: Coulomb's Law, Magnetic Fields			12
Unit -4	Failure of Classical Physics – Photoelectric effect, Positive rays and their analysis. Cathode rays, e/m Thompsons method, Rutherford's experiment and model of atom and its limitations. Millikan's method, Mass of the electron, Atomic structure, Bohr's theory and evidences in favour of and against the theory, Stark effect, Normal Zeeman effect, SternGerlach experiment, Concept of spin, Pauli's exclusion principle, Franck–Hertz experiment, Fine structure of spectral lines, D lines of sodium .Xrays, Properties, Braggs law, Compton's effect			14

Unit -5	Elementary properties of nucleus, Nuclear structure–binding energy–radioactivity–nuclear fission and fusion–four fundamental forces in nature–basic ideas of elementary particles–particles and antiparticles idea of standard model–discovery of Higgs boson and gravity waves.	10
	Tasks and Assignments: **References:** 1. BeiserA. : Perspectives of Modern Physics 2. Mani H.S. and Mehta G.K.: Introduction to Modern Physics 3. 1000 Solved Problems in Modern Physics, Ahmad.A.Kamal, Springer. **Suggested Reading:** 1. Feynmann R.P. Et al: The Feymann Lectures in Physics, B.I. Publication 2. Khandelwal D.P. : Optics and Atomic Physics, Himalaya Publishing 3. Hertzberg G. : Atomic Spectra and Atomic Structure 4. Hertzberg G. : Molecular spectra and Molecular Structure 5. Introduction to Atomic Spectra : H. E. White (McGraw Hill). 6. Atomic and Molecular Spectroscopy: Dunford. 7. R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, India Pvt. Ltd., 2006. 8. Atoms and molecules by M. Weissbluth 9. Atomic Physics by J. B. Rajam 10. Christopher J. Foot – Atomic Physics, Oxford Master series, 2005 11. G.K.Woodgate, Elementray Atomic Structure, Second Edition Clarendon Press, Oxford. 12. T.A. Littlefield Atomic and Molecular Physics. 13. P. Atkins, J. D. Paula, Atkins' Physical Chemistry, Oxford University Press, (Indian Edition), 8th Edition, 2008. 14. Quantum theory of Atomic Structure Vol I by Slater 15. Quantum theory of molecules and Solids by Slater	

- **Course Outcomes**

	Course Outcome	**Level**
CO 1	Define the major 20th century developments in Physics. Compare and contrast Modern Physics with Classical Physics. Define and explain various areas of cutting edge 21st century Physics and its relation to Modern Physics theories developed in the 20th century.	Remember
CO 2	Understand and describe the basic concepts of the theory of relativity. Differentiate facts from wrong general public ideas about the theory of relativity. Understand the fundamental forces in nature.	Understand
CO 3	Apply quantum mechanical principles/methods to scientific and technical applications,in explaining blackbody radiation, atomic spectra, photoelectric effect, X-ray emission, the structure of the atom, and one dimensional potentials. Demonstrate knowledge of the fundamentals of important physics theories.	Apply
CO4	Discuss the nature of light and the electromagnetic spectrum and outline practical applications. Discuss postulates of the special theory of relativity and their consequences.	Analyse

CO5	Build on a critical thinking, analytical reasoning, and problem solving skills. Perform relativistic calculations for simple cases and solve numerical problems using quantum mechanical calculations on simple systems.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	1	**1**	2
CO2	**3**	**3**	2	**2**	1
CO3	**3**	**3**	**3**	**3**	1
CO4	**3**	**3**	**2**	**2**	1
CO5	**3**	**3**	**3**	**3**	2

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	2	2	2
Seminar	-	-	-	-	-
Test	6	6	6	6	6
Attendance	-	-	-	-	-
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- **Course Content**

Course Code.: PHY314 **Course Title: Physics Laboratory –V (Modern Physics)**		**Practical**	**Credits 2**
1	Millikan's Oil Drop Method		Hours 3
2	Rydberg Constant		**3**
3	Balmer –Emission Spectra		**3**
4	Frank –Hertz Experiment		**3**
5	Zeeman Effect		**3**
6	e/m by Thomson method		**3**
7	Electron Spin Resonance		**3**
8	Compton Effect		**3**
9	Black body radiation		**3**
10	Photoelectric effect		**3**

- **Course Outcomes**

	Course Outcome	Level
CO 1	Study the properties of electrons, photons, and electron-photon interactions	Remember
CO2	Experimental basis of the Quantum Theory of Matter	Understand
CO3	Verification of properties of electrons like charge, e/m ratio, existence of spin	Apply
CO4	Distinguish between theoretical predications & experiment measurements	Analyse
CO5	Hands-on experience with experiments in modern physics and collection of data	Apply

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	1	1
CO2	3	3	3	3	1
CO3	3	3	3	3	3
CO4	3	3	3	3	2
CO5	3	3	3	3	1

- **Course Content**

Course Code,Course Title PHY351, Numerical Methods and Computer programming		**Theory**	**Credits 4**
Unit -1	Approximations and round off errors: Significant digits, true/absolute and truncation errors, Taylor Series – Taylor polynomial error formula. Determination of roots of polynomials and transcendental equations: Bisection methods, Newton-Raphson method, Secant method and Bairstow's method. Solutions of linear simultaneous linear algebraic equations by Gauss Elimination and Gauss- Siedel iteration methods.		12 Hours
Unit -2	Curve fitting- linear and nonlinear regression analysis. Backward, Forward and Central difference relations and their uses in Numerical differentiation and integration, Application of difference relations in the solution of partial differential equations. Numerical solution of ordinary differential equations by Euler, Modified Euler, Runge-Kutta and Predictor-Corrector method.		12 Hours
Unit -3	Numerical integration: midpoint rule, trapezeoidal method, Simpson’s method, Newton-Cotes method, Gaussian rules. Least squares approximation, fitting data to a straight line, fitting data to linear combinations of functions.		12 Hours

Unit -4	Arithmetic expressions, Concepts of variables, expressions and statements, program statements and function calls from the library (printf for example) data types - int, char, float etc. expressions, arithmetic operations, relational and logic operations. Assignment statements, extension of assignment to the operations. Statements, conditional execution using if, else. Optionally switch and break statements may be mentioned.	12 Hours
Unit -5	Branching of a program – branch, loop, conditional loops. Concepts of loops, example of loops in C using for, while and do-while, continue. One dimensional arrays and example of iterative programs using arrays, 2-d arrays. Use in matrix computations. Concept of Sub-programming, functions. Example of functions. Argument passing mainly for the simple variables. Pointers, relationship between arrays and pointers. Argument passing using pointers. Array of pointers, Passing arrays as arguments.	12 Hours
	Tasks and Assignments: **References:** 1. Venkatraman, M. K., "Numerical Methods in Science and Engineering", National Publishing Company, Madras, 1996. 2. Schaum's Outline of Programming with C++, McGraw-Hill; 2nd Edition 3. Numerical Recipes in C++: The Art of Scientific Computing , Cambridge University Press; 2nd 4. Numerical methods by Balaguruswami - TMH.	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Number system, Unix commands, program syntax and numerical techniques.	Remember
CO 2	Taylor series expansion, Root finding methods, numerical methods to solve linear and differential equation, curve fitting and plotting	Understand
CO 3	The theoretical procedure of various root finding methods and finding solutions for linear differential equations in computer programs and solve numerical problems. GNU plot for data visualization.	Apply
CO 4	Skill to solve numerical problems using computer programs and use of different programming techniques for efficient programs.	Skill

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	3	1
CO2	2	3	3	3	1
CO3	3	3	3	3	1
CO4	2	3	3	3	**2**

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**Total**
Internal	10	10	10	10	40
External	15	15	15	15	60
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**
Assignments	2.5	2.5	2.5	2.5
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	7.5	7.5	7.5	7.5
Attendance	-	-	-	-
Total	10	10	10	10

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	**CO1**	**CO2**	**CO3**	**CO4**
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	15	15	15	15
Total	**15**	**15**	**15**	**15**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- ***<u>End Semester Exam- Model Question Paper</u>***

Total Mark:60
Time: 3 hrs

Section - A: Short type questions

1. Answer any FIVE. [4×5 = 20 Marks]

(i) Why double precision floating point format has more number of significant digits than the single precision floating point format. Write down your answer in two lines.

(ii) If you round off 0.1548892 up to 5 digits, find out the round off error you will commit.

(iii) If $f(x)$ is a linear function, which of the numerical integration method you will prefer to find out the area under the curve. Justify your answer in short.

(iv) If there are 6 data points, which are fitted with a second order polynomial having $\chi 2$ = 5.4. What will be the $\chi 2/ndf$value?

(v) Using Lagrange interpolation method, write down the general form of the polynomial for the data table given below in the mixed form of numerics and characters.

(vi) Can you find out the root of the function $f(x) = 1/x^2$ using Bisection method?Justify your answer in short.

(vii) Among forward, backward and central difference method, which one is a

better method for finding out the 1st derivative of a smooth continuous function and why? Answer in short.

x	b	20	0	c1	c2
f(x)	p	0.3	y1	z	10

Section - B: Long type questions

2. Find out the Maclaurin series of the function $f(x) = e^{-x^\wedge 2}$ up to 4th order. Then

calculate the approximation error at x = 1 for this series. **[8+4 = 12 Marks] OR**

Find out the 4th order Taylor polynomial centred at $x = \pi/2$ for the function

$f(x) = sin(x)$. If you use this approximated polynomial to find out the value of $sin(1)$, what will be the approximation error? **[8+4 = 12 Marks]**

3. Estimate the approximated value of $\sqrt{3}$ using Newton-Raphson method. Also find out the relative error if $\sqrt{3}$ = 1.73205. Use 4 iterations and take initial guess 0.5. **[12 Marks]**

OR

Solve the equation $x2 = cos(x)$ using Newton-Raphson method taking 1 as initial guess and use 3 iterations. **[12 Marks]**

4. Solve the following simultaneous linear equation (SLE) using either Gauss Elimination method or Gauss Seidel Iteration method justifying your choice.

$x_1 - x_2 + 3x_3 = 2$

$3x_1 - 3x_2 + x_3 = -1$

$x_1 + x_2 = 3$

OR

Evaluate $\int_0^1 \quad e^{-x^2} dx$using (i) 4-point Gauss-Quadrature method by using c_i and x_i value given in the table below. (ii) Simpson's 1/3rd rule having 6 steps.

[8+8 = 16 Marks]

i=	1	2	3	4
Weight Factor (c_i)	0.347854845	0.652145155	0.652145155	0.347854845
Function Arguments (x_i)	-0.861136312	-0.339981044	0.339981044	0.861136312

- **Course Content**

Course Code, Course Title PHY352, Computational Laboratory- I		**Practical**	**Credits 2**
Part-1	Environment walkthrough		6 Hours
Part-2	Primitive types, assignment, arithmetic expressions, simple I/O		6 Hours
part-3	Control structures I		6 Hours
Part-4	Control structures II		6 Hours
Part-5	Methods I		6 Hours
Part-6	Methods II/Arrays of reference objects, Standard I/O		6 Hours
	Tasks and Assignments: **References:** 1. Schaum's Outline of Programming with C++, McGraw-Hill; 2nd Edition 2. Numerical Recipes in C++: The Art of Scientific Computing , Cambridge University Press; 2nd Edition		

- **Course Outcomes**

	Course Outcome	Level
CO 1	Unix commands, program syntax	Remember
CO 2	Passing of arguments, arithmetic operations, use of inbuilt and user-defined functions, program control	Understand
CO 3	To solve numerical problems using function methods, array, pointer and plotting	Apply
CO4	Skill to solve numerical problems using computer programs and use of different programming techniques for efficient programs.	Skill

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	3	1
CO2	2	3	3	3	1
CO3	3	3	3	3	1
CO4	2	3	3	3	**2**

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**Total**
Internal	25	25	25	25	100
External	0	0	0	0	0
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**
Assignments	-	-	-	-
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	25	25	25	25
Attendance	-	-	-	-
Total	25	25	25	25

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4
Part – A **Essay Type (Either/OR-type Question)** **25 x 4 = 100 Marks**	25	25	25	25
Total	**25**	**25**	**25**	**25**

- **Course Content**

Course Code: PHY371 **Course Title: Machine shop**		**Practical**	**Credits: 2**
Part A:	1. Lines and Lettering 2. Scales and paper sizes 3. Title blocks 4. Basic instruments used a) T-square b) Set-square c) Parallel rules d) Drafting Machine 5. Axonometric projections a) Dimetric projection b) Isometric projection 6. Orthographic projection a) First angle projection b) Third angle projection 7. Introduction to CAD		
Part B:	1. Introduction to machine tools 2. Safety aspects in machine shop 3. Milling 4. Turning 5. Shaping 6. Filing 7. Keyway/slot/groove making 8. Surface/slot milling		
References: 1. R.K. Dhawan, “A text book of Engineering Drawing”, S. Chand Publishers, Delhi,2010. 2.G.S. Phull and H.S.Sandhu, “Engineering Graphics”, Wiley Publications, 2014. 3. K.Venugopal and V.Prabhu Raja, “Engineering Graphics”, New Age International Private Limited, 2008. 4. P.J.Shah, A Text Book of Engineering Graphics, S.Chand& Company Ltd.			

- **Course Outcomes**

	Course Outcome	Level
CO 1	Technical understanding and broaden perspective of the engineering drawing and manufacturing/ machining techniques. Safety practices when working with hand tools and operating machine tools.	Remember

CO 2	Understand the concepts of Engineering Drawing & Standard Practice to be adopted in Engineering Drawing and use of various machining tools. Understand integral parts of lathe, shaping and milling machines and various accessories and attachments used.	Understand
CO 3	Hands on experience and skills for various cutting, turning operations, milling operations, forging and welding.	Apply
CO4	Analyze, identify/control appropriate process parameters and possible defects of manufacturing processes so as to reduce/ remove them.	Analyse
CO5	Enhancing the skills in machining operations like cutting, filing, turning, milling and welding. Skills in Reading and Interpretation of Engineering Drawings	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**1**	**3**	1
CO2	**3**	**1**	**3**	**2**	2
CO3	**3**	**3**	**3**	**3**	2
CO4	**3**	**3**	**3**	**3**	1
CO5	**3**	**3**	**3**	**3**	1

SEMESTER - VI

- **Course Content**

Course Code,Course Title PHY321, Mathematical Physics II		**Theory**	**Credits 4**
Unit -1	**Fourier series:** Fourier series, Fourier integral theorem, Fourier transform, Parseval's identity – related problems, convolution theorem, transform of derivates, Complex form of Fourier series, Fourier transforms of simple function occurring in physical applications - Dirac delta function- properties.	Hours* 12	
Unit -2	**Laplace Transforms:** Laplace transform of elementary functions – Inverse Laplace transforms – Methods of finding Inverse Laplace transforms – Heaviside expansion formula – Solutions of simple differential equations.	**12**	
Unit -3	**Special Functions:** Gamma function with real argument: Definition and properties. Evaluation of gamma function with half-integral arguments. Beta function. Relation between –error function - Legendre Hermite, Laguerre function – Generating function, Recurrence relations and their differential equations - Orthogonality of eigenfunctions - Bessels's function of first kind , Spherical Bessel function, Associated Legendre function, Spherical harmonics.	**12**	

Unit -4	**Group Theory:** Definition of group - symmetry elements - homomorphisms ;isomorphism;Subgroups and cyclic groups; Cosets; Abelian groups; Cayley's theorem ; Reducible and irreducible representation – Character table; Orthogonality theorem.	**12**
Unit -5	**Probability:** Elementary probability theory, random variables, binomial, Poisson and normal distributions, Variance, standard deviation, statistical error. Conditional probability: Bayes theorem and its application.	**12**
	Tasks and Assignments: **References:** 10. A Papoulis and S U Pillai, Probability, Random Variables and Stochastic Processes, McGraw Hills (2002) 11. Butkov E. Mathematical Physics, (Addison Wesley, New York, 1973). 12. Arfken G and Weber H J, "Mathematical Methods for Physicists", (Academic Press, SanDiego, 2001).	

- **Course Outcomes**

	Course Outcome	Level
CO 1	LearnthetechniquesofFourierSeriesandFouriertransform. Application in various branches of physics, chemistry and finance.	Understand, Apply, Skill
CO 2	LearnLaplacetransformationtechniqueanditsapplication	Understand, Apply, Skill
CO 3	Learn and apply special function to signal processing	Analyze, Skill
CO4	Learnstatisticalmethods andtechniques	Skill

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	1
CO2	3	2	2	3	1
CO3	3	2	3	3	1
CO4	3	3	3	3	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	Total
Internal	10	10	10	10	40
External	15	15	15	15	60
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4
Assignments	2	2	2	2
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	8	8	8	8
Attendance	-	-	-	-
Total	10	10	10	10

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	15	15	15	15
Total	**15**	**15**	**15**	**15**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- ***<u>End Semester Exam- Model Question Paper</u>***

Total Marks: *Duration: 3hrs*
Sub Code:PHY 321 *Sub Title: Mathematical Physics II*

QUESTION NUMBER ONE IS COMPULSORY. ANSWER ANY FOUR PARTS.

1. (a) Identify the singular point(s) and the type of singularity of the following differential equation

$$(1-x^2)\frac{d^2y(x)}{dx^2} - 2x\frac{dy(x)}{dx} + l(l+1)y(x) = 0$$

(b) Find the inverse Laplace transform of the following function

$$\tilde{f}(s) = \frac{a^2}{s(s^2+a^2)}$$

(c) Consider the set of four numbers $G = \{i, -1, -i, 1\}$. Show that they form a group under ordinary multiplication. What is the order of the group. Is the group Abelian?

(d) Find the Fourier transform of the exponentially decaying function,

$$f(t) = \begin{cases} Ae^{-\lambda t} & t \geq 0, \lambda > 0 \\ 0, & t < 0 \end{cases}$$

(e) The moment generating function for the Gaussian distribution function is:

$$M_X(h) = \exp\left(\mu h + \frac{1}{2}\sigma^2 h^2\right)$$

find the expectation and variance f this distribution

(f) Show that $\delta(ax) = \frac{1}{|a|}\delta(x)$, where δ is Dirac -delta function.

(g) A bag contains seven red balls and three white balls. Three balls are drawn at random and not replaced. Find the probability function for the number of red balls drawn.

(h) Show that $\Gamma(p+1) = p\Gamma(p)$ where $\Gamma(p) = \int_0^\infty x^{p-1}e^{-x}dx \quad, p > 0$. Find the value of $\Gamma(3/2)$.

[5 × 4 = 20]

ANSWER ANY FOUR OF THE FOLLOWING QUESTIONS

2. (a) Input to an electrical circuit that switches between a high and a low state with time period T can be represented a function

$$f(t) = \begin{cases} -1 & -T/2 \leq t < 0 \\ +1 & 0 \leq t < T/2 \end{cases}$$

Obtain Fourier series representation of $f(t)$. Explain the asymptotic behavior of the Fourier coefficient? [5]

(b) Let $\theta(x)$ is the unit step function, defined as

$$\theta(x) = \begin{cases} 1 & \text{for } x > 0 \\ 0 & \text{for } x < 0 \end{cases}$$

Show that

$$\frac{d\theta(x)}{dx} = \delta(x).$$

[5]

3. (a) Let $f(t)$ is a periodic function having period T such that $f(t+T) = f(t)$. Show that the Laplace transform of $f(t)$ is given as

$$\mathcal{L}[f(t)] = \frac{\int_0^T e^{-st}f(t)dt}{1 - e^{-sT}}$$

[5]

(b) Sketch the function $f(t)$, given as

$$f(t) = \begin{cases} \sin t & 0 < t < \pi \\ 0 & \pi < t < 2\pi \end{cases}$$

extended periodically with period 2π. Find the Laplace transform $\mathcal{L}[f(t)]$. [5]

4. (a) Consider the following four functions

$$f_1(x) = x, \quad f_2(x) = -x, \quad f_3(x) = \frac{1}{x}, \quad f_4(x) = -\frac{1}{x}$$

Show that the set $G = \{f_1, f_2, f_3, f_4\}$ forms a group with the law of combination given as $f_i(x)f_j(x) = f_i(f_j(x))$. Write the multiplication table. [5]

5. Hermite polynomials $H_n(x)$ are the solutions of Hermite equation,

$$\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + 2\nu y = 0.$$

(a) Show that the Hermite polynomial can be given as $H_n(x) = (-1)^n e^{x^2} \frac{d^n}{dx^n}(e^{-x^2})$. [5]

(b) Using the generating function for Hermite polynomial,given as

$$G(x,h) = e^{2xh-h^2} = \sum_n \frac{H_n(x)}{n!}h^n$$

show that

(i) $H_{n+1}(x) = 2xH_n(x) - 2nH_{n-1}(x)$

(ii) $H_n'(x) = 2nH_{n-1}(x)$, where prime indicates the derivative with respect to x.

[5]

6. A random variable X follows Binomial distribution given as $f_X(n,p) = \binom{n}{x} p^x(1-p)^{n-x}$, where p is probability of success of an event, and n is the number of trials.

(a) Obtain an express for the moment generating function for the Binomial distribution. [5]

(b) Show that the relative fluctuation is proportional to $1/\sqrt{n}$. [5]

7. (a) Find the Laplace transform of nth derivative of a function $f^{(n)}(t)$. [5]

(b) For an impulsive force acting on a particle of mass m, the equation of motion is given as

$$m\frac{d^2x}{dt^2} = p\delta(t)$$

where p is a constant. Find the position x at any time t if at $t = 0$, particle is at rest and lies the origin of the coordinate . [5]

- **Course Content**

Course Code, Course Title PHY322, Quantum Mechanics I	**Theory/~~Practical~~**	**Credits 4**
Unit -1	Introduction: The Classical Framework - A quick review of the central notions of the Classical Framework of Physics. Historical perspective and origin of quantum theory: Blackbody radiation, Specific heat of solids, photoelectric effect. Uuncertainty principle, Fourier Transforms, Dirac-delta function, Principle of Complementary and Correspondence principle.	Hours* **12**
Unit -2	Wave mechanics: Wave Particle duality, Debroglie hypothesis of matter waves – Experiments of Davisson and Germar and of G.P.Thomson – Wave packets - Phase velocity, Group velocity, motion and spread of wave packets. Postulates of Quantum Mechanics - Wave function and its statistical interpretation - Normalization - Operators, eigen values and vectors - Orthogonality of Eigen function, Hilbertzspace, Completeness condition, Dirac notation, Expectation value- observables and their averages, Formulation of time dependent and independent Schrodinger wave equation, Wave function collapse, Philosophy of Measurements.	**14**

Unit -3	Time development of Wave functions: Stationary states, Ehrenfest theorem, Constants of motion, probability current and conservation of probability. Uncertainty relation and its derivation, commutators and simultaneous measurements of canonically conjugate observable, minimum uncertainty product, Momentum eigen function. The angular momentum commutators and their significance.	**12**
Unit -4	Application of Schroedinger wave equation: Particle in a box - for particles in a one dimensional potential well – Box normalization - Penetration of rectangular potential barrier in one dimension: derivation of reflection and transmission coefficients. Linear Harmonic Oscillator (LHO) - Solution of the equation of LHO: Hermite differential equation approach and number operator approach, zero point energy, Parity of wave function. Quantum mechanical theory of hydrogen atom.	**14**
Unit -5	Quantum Mechanics pictures: Three pictures of Quantum mechanics: Schrödinger picture, Interaction picture and Heisenberg picture.	**8**
	Tasks and Assignments: • Student should summarize the course content at the end and also the beginning of the next class. • Student should discuss the given problem within the group and explain the solution of the problems to other groups in the class. Students should randomly sit in the class and discuss with each and every students in the class during class seminars and problem solving sessions. **References:** 13. Mathews P M and Venkatesan K, "A Text book of Quantum Mechanics", Tata Mc Graw- Hill, New Delhi. 1976. 14. D. J. Griffith, Introduction to Quantum Mechanics, Pearson Education, 2007. 15. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2005. 16. Liboff, IntrodunctoryQuntum Mechanics, Narosa Publishing House. 17. Quantum Mechanics – Zettli	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Understand Quantum mechanics concepts	Understand
CO 2	Applying the Quantum mechanics concepts to solve one, two and three dimensional problems.	Apply
CO 3	Analyze concept of zero point energy and Quantum tunnelling.	Analyze
CO4	Solve one, two and three dimensional problems in different framework.	Skill
CO5	Remember different Quantum pictures	Remember

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	3	3
CO2	3	1	1	3	3
CO3	3	3	1	3	3

CO4	3	1	1	3	3
CO5	3	3	1	1	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	2	2	2
Seminar	2	2	2	2	2
Test	3	3	3	3	3
Attendance	1	1	1	1	1
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Short Answer	2	2	-	4	2
Derivation	5	5	5	-	5
Problem solving	5	5	7	8	5
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Copied from other students (or) Not submitted	CO1, CO2, CO3, CO4, CO5
2	**Organiz ation** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Copied from other students (or) Not submitted	CO1, CO2, CO3, CO4, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3, CO4, CO5
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO1, CO2, CO3, CO4, CO5

- **Question Paper pattern: Either or type**

Sl. No.	Model Questions	Specification	Level
1	**A** a) A particle in the infinite square well has the initial wave function (8) $$\psi(x,0) = \begin{cases} Ax & 0 \le x \le a/2 \\ A(a-x) & a/2 \le x \le a \end{cases}$$ a)Sketch $\psi(x,0)$ and determine the constant A. b) Find $\psi(x,t)$. c) What is the probability that a measurement of the energy would yield the value E_1? d) Find the expectation value of energy? b)Consider butadiene H_2C=CH-CH-CH_2 which has four π electron. Assume that π electron in butadiene moves along a straight line whose length can be estimated as equal to 5.78 Å. Calculate the energy to make a transit from the n=2 state to the n=3 state. (4) (OR)	Recognize, Recall, Identify	Apply, Analyse, Skill
2	**B** a) Explain complementary principle. (3) b) Why should be the operator in Quantum mechanics is linear (3) c) Why should be the operator in Quantum mechanics is linear. (3) d)Find out the operator (d/dx) is Hermitian or not. If it is not Hermitian how to make it Hermitian. (3)	Explain, Differentiate Define Describe, Discuss	Understand Remember, Apply

- **Course Content**

Course Code: PHY323 **Course Title: ELECTROMAGNETIC THEORY**		**Theory**	**Credits 4**
Unit -1	Special techniques for solving electrostatics problems – Recap of Coulomb's law, Gauss law, method of images, Laplace and Poisson equation, uniqueness theorem. Maxwell's equations in vacuum and media, (differential and integral forms), wave equation, Equation of continuity of current, Displacement current, Poynting vector, energy density in electromagnetic field	Hours* 12	
Unit -2	Vector and Scalar Potentials, multipole expansion (also as special technique for electrostatics). Gauge Transformations: Lorentz and Coulomb Gauge. Poynting's Theorem and Poynting's Vector. EM Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. Review of Special Theory of Relativity and application of EMT, four vectors, transformation properties of E and B fields	**12**	
Unit -3	Wave equation – Electromagnetic waves in vacuum and matter, monochromatic plane waves, plane waves and their propagation – reflection and transmission and Snell's law, Fresnel's equations, , total internal reflection , waves in conductors – skin depth, reflection at a conducting surface, absorption and dispersion, frequency dependence of permittivity, Cauchy's formula,.	**12**	
Unit -4	Waveguides, resonant cavities and optical fibers, cylindrical cavities and waveguides, TE, TM and TEM modes, cut-off wavelength in a rectangular waveguide; Q factor of a cylindrical resonant cavity; Introduction to optical fibers – single mode and multimode; numerical aperture and angle of acceptance. Step index and graded index fibers, attenuation in fibers, couplers and connectors, fiber optic communications.	**12**	
Unit -5	Relativistic charged particle dynamics in EM fields, motion of charged particle in uniform static electric field, uniform static magnetic field and crossed E and B fields. Lenard – Weichart potential, radiation from localized oscillating charge, multipole expansion, dipole radiation	**12**	

- **Course Outcomes**

	Course Outcome	**Level**
CO 1	Define terms in Electrostatics, Magnetostatics and Electromagnetism. Recall Maxwell's equations.	Remember
CO 2	The concept of Electromagnetic fields, forces and potentials. Interpret the various boundary conditions.	Understand
CO 3	Apply the concepts of electromagnetism to guided waves and fiber optics.	Apply
CO4	Analyze the motion of a charged particle under relativistic conditions and the radiation thus produced.	Analyze
CO5	Solve numerical problems related to electromagnetism, plot the field diagrams in free space and in guided waves.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	1
CO2	3	3	3	3	2
CO3	3	3	3	3	1
CO4	3	3	2	3	2
CO5	3	3	3	3	2

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

CENTRAL UNIVERSITY OF TAMIL NADU
Integrated M.Sc Programme - Physics

Sub Code:PHY323 *Total Marks: 60*
Sub Title: *Electromagnetic Theory* *Duration: 3hrs*

I. Answer in detail (Answer either A* OR *B of Q.Nos 1 to 5. Each Question carries Twelve Marks)

1.
A) i) Find the electric field a distance z above the midpoint of a straight line segment of length 2L which carries a uniform line charge λ.
ii) A hollow spherical shell carries charge density $\rho = k/r^2$ in the region a < r < b. Find the electric field in three regions (i) r< a, (ii) a < r < b, and (iii) r > b. Use Gauss law for the calculation..

OR

B) Derive an expression for potential energy and electric field of point dipole.

2.
A i) Derive an expression for the divergence and curl of magnetic field $\vec{B}$. (8 Marks)
ii) State Ampere's law of magnetostatics. Express the Ampere's law in both differential and integral forms. (4 Marks)

OR

B i) Find the magnetic vector potential of a finite segment of straight wire carrying a current I. (8 Marks)
ii) Show that the vector potential $\vec{A} = (\vec{B} \times \vec{r})/2$ satisfies the necessary conditions to represent uniform magnetic field $\vec{B}$. (4 Marks)

3. **A) i)** Derive Faraday's law in differential and integral form.(4 M)
ii) An infinitely long straight wire carries a slowly varying current I(t). Determine the induced electric field, as a function of the distance "s" from the wire. (8 Marks)

OR

B) i) A uniform magnetic field $\vec{B}(t)$ is acting perpendicular to a circular region. What is the induced electric field? (4Marks)
ii) A square loop of wire, with sides of length "a", lies in the first quadrant of the x-y plane, with one corner at the origin. In this region, there is a non-uniform time dependent magnetic field $\vec{B}(y,t) = ky^3t^2\hat{z}$. Find the emf induced in the loop (4Marks)
iii) Discuss how a capacitor conducts alternating current using the concept of displacement current density. (4 M)

4. A) Discuss the reflection and transmission of monochromatic light at normal incidence on the boundary between two dielectric media. Derive a for reflection and transmission coefficients.

OR

B) Discuss how electro-magnetic waves propagate inside a conductor. Derive an expression for attenuation coefficient for damping of wave propagation inside a conductor.

5. A) Discuss how electromagnetic waves propagate inside a hollow wave guide. Derive the propagation equations for electromagnetic fields in the wave guide and hence show that TEM waves can not exist inside a hollow wave guide.

OR

B) Discuss the propagation of TE waves in a rectangular waveguide and derive an expression for cut-off frequency.

- **Course Content**

Course Code: PHY324 **Course Title:** Condensed Matter Physics - I		**Theory**	**Credits 4**
Units	**Content**		**Hrs.**
I	**Chemical Bonding & Crystal Physics** Different types of bonding ionic, covalent, metallic, van der Wall's. and hydrogen bonding, Lattice energy - Madelung constants – Born Haber cycle – cohesive energy. Crystalline and amorphous solids, primitive and unit cells, Bravais lattices, crystal structure, lattice and basis. packing factors – cubic, hexagonal, diamond structures Lattice translation operation. Elementary idea of point symmetry operations (inversion centre, rotation and reflection symmetry). lattice planes – Miller indices for directions and planes. Reciprocal lattice. Geometrical interpretation of the Bragg equation in the reciprocal space. Bragg's law and Bragg's law, Ewald's construction, Debye Scherer method, Structural characterization using XRD.		12
II	**Lattice Dynamics and Phonons** Lattice Vibrations: Vibration modes of continuous medium; concept of Phonons; Phonon dispersion relation – Localised modes, Lattice specific heat; Mono atomic and diatomic lattices – harmonic approximation - phonon frequencies and density of states Classical theory, Einstein's theory and Debye's theory of specific heat. – anharmonic effects - thermal expansion - thermal conductivity - normal and Umklapp processes - scattering experiments.		12
III	**The Free Electron Theory** Thermionic emission, work function, electrical conductivity of the free electron gas: Classical free electron theory (Drude model) and its draw back; Drude Lorentz Model, Sommerfield's quantum theory. the heat-capacity of the conduction electrons (Electron Specific heat).: Schrodinger's wave equations and its applications in particle in box; Physical significance of wave function; Thermal conductivity in metals - Boltzmann transport theory - Widemann-Franz law and its validity. Failure of the free electron model.		12
IV	**Energy Bands in Solids** Electrons in periodic potential, Origin of energy bands in solids, classification of solids as metals, insulators and semiconductors on the basis of the band picture, Origin of the energy gap, Bloch's theorem in one dimension, nearly free electron approximation - formation of energy bands and gaps - Brillouin zones and boundaries - the Kronig-Penney model. E-K diagram, Reduced zone representation, Brillouinzone, concept of effective mass and holes, Fermi- Dirac distribution function, Density of states for electrons in band. temperature dependence of Fermi energy, Concept of holes and effective mass; Hall Effect, Fermi surface -Cyclotron resonance. Types of semiconductors: intrinsic and extrinsic semiconductors.		12

V	**Magnetism, Dielectrics & Superconductivity** Electron spin and magnetic moment; Origin of magnetism; Types of Magnetism: Dia, para, ferro, ferri, and antiferromagnetism; Langevin theory of Dia and paramagnetism, Curie's law; Magnetic domains & hysteresis, Magnetic materials, Magnetic storage devices, Memory materials. Concepts of dielectrics, Dipole moment; Basic concepts and types of polarization, A.C. effects, Ferroelectricity, Piezo electricity, Ferro and piezo electric materials. Superconductors' critical parameters – anomalous characteristics persistent current, Meissner effect, Type-I & II super- conductors, BCS pairing mechanism Josephson effect, electronic specific heat in superconducting state - Energy gap and Isotope effect -London equation – Coherence length – Single particle tunneling - SQUID - High temperature superconductors - applications.	12
	Tasks and Assignments: **References:** **Books recommended:** 1. Elementary solid state physics, M.Ali Omar – Pearson Education (2002) 2. Charles Kittel., "Introduction to Solid State Physics", John Wiley, (2019) 3. Neil W.Ashcroft and N. David Mermin, Solid State Physics, India edition IE, Thomsom books, Reprint, 2007 4. S. O. Pillai, "Solid state physics", New age International Pvt Ltd, 6th edition, 2005 5. Wahab, M. A., "Solid State Physics", Narosa Publishing, 2nd Edition, 2005 6. Solid State Physics - D. L. Bhattacharyya (Calcutta Book House) (1990) **Supplementary Reading:** 1. Harald Ibach and Hans Lueth, Solid State Physics, 2nd edition Springer (1996) 2. H.P.Myers, Introductory Solid State Physics, 2nd edition, Viva Books Pvt. Ltd (1998) 3. M.Ali Omar, Elementary Solid State Physics, revised printing Pearson Education (2000) 4. M.S. Rogalski and S.B. Palmer, Solid Statae Physics, Gordon Breach Science Publishers (2000) 5. Y.K. Lim, Problems and solutions on Solid State Physics, World Scientific (2003) 6. A.J.Dekkar, Electrical Engineering Materials, Pearson Ed.1, 2015 7. Ibach, Harald, Lüth, Hans,Solid State Physics:An Introduction to principles of Materials Science", Springer,4 Ed (2009). 8. James D. Patterson, Bernard C. Bailey, Solid State Physics: Introduction to the theory", Springer-Verlag, edition 3, 2019 9. A.R.Verma and O.N.Srivastava: Crystallography Applied to Solid State Physics (1991)	

- **Course Outcome (CO)**

	Course Outcome	Level
CO 1	To get knowledge about various aspects of chemical bonding and understand the formation of solids with various crystal structures and symmetries. Apply the knowledge to resolve the crystal structure of solids through XRD and structural characterization tools.	Acquire, Understand, Apply, Skill
CO 2	Understand the concept of phonons and their role on specific heat of solids. Apply the knowledge to analyze the phonon dispersion relation for simple solids. Gain insight into the origin of thermal conductivity, thermal expansion though phonon scattering processes.	Remember, Evaluate, analyze, Skill
CO 3	Understand the electron dynamics in metals through simple concepts and apply it to understand electronic and thermal conductivity in solids. Gain knowledge about wave functions and apply the electronic heat capacity, Hall effect etc.	Remember, Understand, analyze, Apply
CO 4	Analyze the electron dispersion relation in periodic potential and understand the origin of electronic bands. Distinguish insulators, semiconductors, and metals through their band structure and density of states. Explain Hall effect, effective mass, electronic specific heat etc. through band picture.	Acquire, Understand, Apply, Skill
CO 5	Gain knowledge about the origin of magnetism, ordering of magnetism, and various theory involved in understanding magnetism in solids. Understand the concept of electronic polarization and its role on piezoelectricity and ferroelectricity. Analyse the role of electron phonon coupling on superconductivity and understand various aspects of superconductivity including high Tc superconductors.	Understand,analyze Apply, Skill

- **Mapping of ProgramOutcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	3
CO2	3	2	2	1	3
CO3	3	2	3	3	3
CO4	3	3	2	1	3
CO5	3	3	3	2	3

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	3	3	3	3	-
Seminar	-	-	-	-	3
Test	5	5	5	5	5
Attendance	-	-	-	-	-
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Part –A **(Either/or-type Question-5 x 12 = 60marks)**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- **Model Question Paper**

Sl. No.	Model Questions	Specification	Level
	PART –A Essay Answer **The answer should not exceed 400 words Marks: 5 x 12 = 60**		
1	**A)** **i.** The lattice constant for aluminum is 4.041 angstroms. What is d220? **(2)** **ii.** Define Anisotropy with example. **(2)** **iii.** Define Miller Indices and write the procedure to find the Miller indices. **(4)** **iv.** Draw the XRD pattern for Single crystal, Poly-crystal, Gas and Liquid. **(4)** (Or) **B)** **i.** Define packing fraction. Calculate the packing fraction for simple cubic, body centered cubic and face centered cubic crystals.**(5)** **ii.** Write a short note on electron and neutron diffraction methods and how these methods different from X-ray diffraction method. **(5)** **iii.** Na^+ has a radius of 98pm and Cl^- has a radius of 181pm in FCC NaCl. Find into which interstitial hole the cation will go.**(2)**		
2	**A)** **i.** Explain VSEPR theory with examples for sp, sp2, sp3, sp3d and sp3d2 hybridization. **(5)** **ii.** What is Born-Haber cycle. Write the to find lattice energy of CaO using Born-Haber cycle.**(5)** **iii.** Draw the potential energy diagram for molecules and define each region. **(2)** (OR) **B)** **i.** Discuss Einstein model for heat capacity with its achievements and limitations.**(5)** **ii.** Define (i) ionization energy, (ii) electron affinity, (iii) cohesive energy, (iv) Dissociation energy, (v) Define electronegativity in term of two of the above terms.**(5)** **iii.** Differentiate polar and non-polar covalent bond with examples. **(2)**		
3	**A)** **i.** Explain Hall effect. How it varies for a p-type and an n-type semiconductors? **(5)** **ii.** Discuss Schrödinger Wave Equation.**(5)** **iii.** Define Wiedemann-Franz law.**(2)**		

	(OR) **B)** **i.** Derive the equation for Hall coefficient and Hall voltage.**(5)** **ii.** How one can obtain carrier concentration and carrier mobility in Hall measurements.**(4)** **iii.** In an LED, the energy released when an electron and hole recombine is2.8x10-19 J. Calculate the wavelength of the light released and identify it. **(3)**		
4	**A)** **i.** Distinguish between n-type and p-type semiconductors.**(5)** **ii.** What is the difference between metal, semiconductor and insulator? Explain with band diagram and give examples for each.**(5)** **iii.** Why metals are malleable and ductile.**(2)** (OR) **B)** **i.** Elaborate major polarization mechanism. **(5)** **ii.** Explain Clausius-Mossotti Equation. **(2)** **iii.** Explain polar and non-polar dielectrics.**(3)** **iv.** Define Avalanche Breakdown.**(2)**		
5	**A)** **i.** Derive the magnetic susceptibility of paramagnetic substance using classical Langevin'sthorem.(5) **ii.** Discuss about magnetic storage devices.(5) **iii.** Differentiate between Neel point and Curie Point **(2)** (OR) B) **i.** Explain Meissner effect. How it varies for Type – I and Type – II superconductors.**(5)** **ii.** What is Cooper pair? **(2)** **iii.** What are the applications of superconductors? **(3)** **iv.** Define London Equations.**(2)**		

- **Course Content**

Course Code, Course Title **PHY325&Condensed Matter Physics Laboratory**		**Practical**	**Credits 2**	**Hours**
1	Calculation of Unit cell parameters using X-ray diffraction method			3
2	Guoy's Balance experiment for the determination of susceptibility of solids			3
3	Determination of dielectric permittivity of solids			3
4	Hall effect			3
5	Measurement of thermal diffusivity			3
6	Measurement of DC/AC conductivity of solid samples			3
7	Determination of band gap of a solid/semiconductor			3
8	Study of solar cell characteristics			3
9	Thermal and Electrical conductivity of metals			3
10	Experimental analysis of flat plate collector of solar water heater			3

- **Course Outcomes**

	Course Outcome	Level
CO 1	Identification of crystal structure of solids	Remember
CO2	Prediction of the thermal and electrical properties of solids and explanation of their origin	Understand
CO3	Estimation of band gap, charge carriers type and carrier concentration in solids	Apply
CO4	Demonstration of Dielectric and DC/AC conductivities of insulators	Analyse
CO5	Able to convert solar energy into electrical and thermal energy	Apply

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	2	2
CO2	3	3	1	3	3
CO3	3	3	3	3	2
CO4	3	3	3	2	2
CO5	3	2	3	3	3
CO5	3	1	2	3	1

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	20	20	20	20	20	100
External	0	0	0	0	0	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (100 Marks)**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Experiment/Observation/Performance	10	10	10	10	10

Calculations & Graph	4	4	4	4	4
Viva-Voce	3	3	3	3	3
Record	2	2	2	2	2
Attendance	1	1	1	1	1
Total	20	20	20	20	20

SEMESTER – VII

- **Course Content**

Course Code, Course Title PHY411, Quantum Mechanics II		**Theory/~~Practical~~**	**Credits 4**
Unit -1	**Approximation methods for stationary systems** : Time – independent perturbation theory : (a) Non–degenerate and (b) Degenerate perturbation theory, application to Zeeman effect, fine structure, helium atom and anharmonic oscillator, Isotopic shift and Stark effect, WKB approximation, Variational method and their applications.		Hours* 12
Unit -2	**Time-dependent perturbation theory:**, Time-dependent perturbation theory, Transition to a continuum of final states – Fermi's Golden rule. First order correction – Semiclassical radiation theory, interaction between electromagnetic wave and atoms – transition probabilities - radiation field quantization, polarizability of a system, Photo-electric effect, Einstein's coefficients – selection rules for harmonic oscillator and hydrogen atom., Adiabatic and sudden approximations, Spontaneous emission, absorption, induced emission, dipole transitions, selection rules.		12
Unit -3	**Symmetries:**Construction of wave functions for a system of identical particles.Bosons and Fermions; symmetric and anti-symmetric wave functions; Pauli principle.Symmetry- Galilean invariance; Translation and Rotation operation; Parity and time reversal; Wave function for time, space translation and rotation; Eigen value and Eigen function of angular momentum		12
Unit -4	**Scattering:** Non-relativistic scattering, solution of scattering problem by the method of partial wave analysis, optical theorem, Scattering Amplitude - Expression in terms of Green's Function - Born approximation and its validity for scattering problems, Interaction with classical radiation fields; Rayleigh scattering - Scattering theory- Scattaring cross section, Phase Shifts - Scattering by coulomb and Yukawa Potential.		12
Unit -5	**Relativistic Quantum Mechanics:**Dirac equation: Motivation for Dirac equation, Properties of Dirac matrices, positive and negative energy states, Plane wave solution of Dirac equation. Spin of Dirac particle- Spin wave function of Dirac particle and Magnetic moment.Introduction to Quantum Field Theory, Second Quantization of Schrodinger Equation.		12
	Tasks and Assignments: **References:** 1. Mathews P M and Venkatesan K, "A Text book of Quantum Mechanics", Tata Mc Graw- Hill, New Delhi. 1976. 2. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2005.		

	3. Liboff, IntroduntoryQuntum Mechanics, Narosa Publishing House. 4. Quantum Mechanics – Zettli

- **Course Outcomes**

	Course Outcome	Level
CO 1	Finding the energy levels of quantum systems subject to time independent perturbations.	Understand
CO 2	Applying the concept of time dependent perturbation theory to study atom-light interactions.	Apply
CO 3	Analyze the quantum scattering of identical particles and find the cross section for scattering.	Analyze
CO4	Solve problems related to perturbation theory, identical particles, and scattering theory in quantum mechanics.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	3	3
CO2	3	2	2	3	3
CO3	3	1	2	3	3
CO4	3	2	2	3	3

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	Total
Internal	10	10	10	10	40
External	15	15	15	15	60
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4
Assignments	2.5	2.5	2.5	2.5
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	7.5	7.5	7.5	7.5
Attendance	-	-	-	-
Total	10	10	10	10

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	15	15	15	15
Total	**15**	**15**	**15**	**15**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- ***<u>End Semester Exam- Model Question Paper</u>***

Total Marks: 60 *Duration: 3hrs*
Sub Code: PHY411 *Sub Title: Quantum Mechanics II*

I. Answer in detail (Answer either A* OR *B of Q. Nos 1 to 5. Each Question carries Twelve marks)

1.
A) Consider a particle in an infinitely deep potential well inside a cube of dimension L. Consider a perturbation $H' = k\,x$ to the system. Apply first-order perturbation theory to the first excited state and calculate the first order corrections to the energy.

(OR)

B) Using the Variation method, derive an estimate for the ground state energy of a particle moving under the potential $V(x) = \begin{cases} kx, & x \geq 0, \\ \infty, & x < 0. \end{cases}$ Choose x exp(-βx) as the trail wave function.

2.

A) Develop time dependent perturbation theory upto first order in the perturbation and derive the Fermi-Golden rule.

(OR)

B) A simple harmonic oscillator (one dimension) was subjected to an electric field suddenly at time $t = 0$. Assuming that the oscillator was in ground state at time $t < 0$, determine the probability of finding the system in the new ground state after time $t > 0$.

3.

A) Derive the unitary transformation induced by space translation of a quantum system. Also, carry out the operation, $e^{-i\, P_x a/\hbar}\Psi_0$,where Ψ_0 represents the ground-state wave function of a one-dimensional harmonic oscillator.

(OR)

B) Discuss time reversal symmetry operations on a quantum system. Show that the time reversal operator is an anti-unitary operator. Derive the commutation relations between time reversal operator and position and momentum operators.

4.

A) Discuss the quantum theory of scattering and derive an expression for scattering amplitude in the first Born approximation.

(OR)

B) Calculate the differential scattering cross-section for the potential$V(r) = -V_0\, Exp\left[\frac{-r^2}{2a^2}\right]$using the Born approximation. You may use the following integral

$$\int_0^\infty e^{-\alpha t^2} Cos(2\beta t)\, dt = \frac{1}{2}\sqrt{\frac{\pi}{\alpha}}\, e^{\frac{-\beta^2}{\alpha}}.$$

5.

A) Discuss the Dirac's formulation of relativistic quantum theory and derive the Dirac equation from first principles. Also, obtain the relativistic energies of a free particle.

(OR)

B) Discuss Dirac's interpretation of negative energy states for a free particle and its observable consequences.

- **Course Content**

Course Code, Course Title PHY412, Atomic and Molecular Physics		**Theory/~~Practical~~**	**Credits 4**
Unit -1	Molecular Binding: Vander Waals, ionic bonding and valence bond, Review of group theory for spectroscopy: symmetry elements and operations, matrix representations, introduction to spectroscopic term symbols; classification of molecules, introduction to character table of point group, reducible and irreducible representation for C2v and C3v. Fourier transforms in spectroscopy- need for FT, basic ideas, basic instrumentation.		**Hours** **12**

Unit -2	Pure rotational energy levels and spectra (Rigid and non-rigid), Isotopic effect. Symmetric top, asymmetric top and spherical molecules- energy levels Rotational spectra and its selection rules. Idea of symmetry elements and point groups for simple molecules, such as H2O, NH3 etc.. Selection rules.	**12**
Unit -3	Angular momenta and magnetic moment in atoms and their interactions, Spin-orbit interaction in one valence electron. Fine structure of spectral line: Fine structure of hydrogen lines and its corrections; Fine structure of structure of single and many electron atoms using LS and j-j coupling. Intensities of fine structure lines. Alkali-type spectra and quantum defect, hyperfine structure. Width of a spectral line: Natural width, Doppler width and collision induced width. Selection rules.	**12**
Unit -4	Vibrational states and spectra of diatomic molecule-harmonic and anharmonic approximation, Morse P.E. Curve, Rotation-vibration energy levels and spectrum, progression and sequence, Raman spectroscopy. Selection rules.	**12**
Unit -5	Electronic ground states of homonuclear diatomic molecule. Electronic spectra of diatomic molecule-P, Q, R branches determination of band origin. Band intensities and Franck-Condon Principle, Hund coupling cases. Selection rules. Photoelectron spectroscopy – XPS and UPS.	**12**
	References: 1. J M Hollas, Modern spectroscopy Wiley. 2. Bransden and Joachain, Physics of Atoms and Molecules 2 ed. Addison Wesley 3. B S Tsukerblat, Group Theory in Chemistry and Spectroscopy: A Simple Guide to Advanced Usage Dover Books. 4. S Svanberg, Atomic and Molecular Spectroscopy: Basic aspects and Practical applications Springer 5. Willard Dean, Merritt and Settle, Instrumental methods of analysis CBS publishers.	

- **Course outcome (CO)**

	Course Outcome	Level
CO1	Acquire knowledge about various molecular bonds and their group representations	Remember
CO2	Familiarize with the rotational motion of molecules	Understand
CO3	Examine different coupling schemes of the bound electron in an atom	Analyze
CO4	Examine different ro-vibronic levels in molecules	Apply
CO5	Sketch photoelectron energy levels	Create

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	2	1	2	1	1
CO3	2	1	2	2	1

CO4	3	1	2	3	1
CO5	3	3	3	3	1

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	1	1	1	1	1
Seminar	-	-	-	-	-
Test	6	6	6	6	6
Attendance	1	1	1	1	1
Total	**8**	**8**	**8**	**8**	**8**

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO4**
Part A **(Subjective either-or type questions)** $\mathbf{12 \times 5 = 60}$ **marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Model questions**

1. (a) A doubly ionized Lithium atom is hydrogen like with atomic number Z = 3. If the ionization potential of the hydrogen atom is 13.6 eV, what is the wavelength of the radiation which can excite the electron in Li^{2+} from the second to the third Bohr orbit?

(b) What is the probability of finding the 1s electron in a hydrogen atom in the first Bohr orbit?
(c) How much energy is required to remove an electron from the He atom?

4+4+2=10 marks

2. (a) A μ^- meson can be captured by a proton to form a hydrogen-like muonic atom. The muon is 207 times heavier and have equal charge to that of an electron. Calculate the radius of the first Bohr orbit and the binding energy of this muonic atom.
(b) Find the wavelength of the first line in the Lyman series of such an atom.

6+4=10 marks

3. (a) An atom in a state with l = 1 emits a photon with wavelength 532 nm as it decays to a state with $l = 0$. If the atom is placed in a magnetic field with magnitude B0 = 2 T, what are the shifts in the energy levels and in the wavelengths of the emitted photon?
(b) In a Stern-Gerlach experiment, a beam of silver atoms enters into a region of inhomogeneous magnetic field with a speed of 525 m/s. Note that the magnetic dipole moment of silver is the same as that for hydrogen, since 1 its valence electron is in an $l = 0$ state. If the atomic mass of silver is 0.1079 kg/mol and the magnetic field region is 50 cm long, what value of the magnetic field gradient is required to give a separation of 1 mm between the two spin components at the exit the field region?

4+6=10 marks

4. (a) What is Pauli's antisymmetric principle?
(b) Construct the ground state wavefunction of He atom that obeys the above principle.
(c) Briefly explain the central field approximation method.

2+4+4=10 marks

5. (a) What is Born-Oppenheimer approximation?
(b) Give an order of magnitude estimate of the energy scales for the electronic, vibrational and rotational motion in a molecule.
(c) The H2 molecule has a reduced mass M = 0:5 M_H and the equilibrium distance $R_e = 0.7 \times 10^{-10}$m. What is the spacing between the rotational energy levels of J = 2 and J = 1 in eV?

2+4+4=10 marks

6. (a) The Lenard-Jones potential energy curve is given by

$$E_{el}^{LJ}(R) = \frac{a}{R^{12}} - \frac{b}{R^6}$$

Draw the attractive and the repulsive contribution to the potential separately and explain the physical reasons of their origin.
(b) Describe the Morse potential with a diagram and outline the advantages of using it.

(2+4) +4=10 marks

7. (a) Mention the range of wavelength in which pure rotational spectra of rigid N_2 molecules can be found.
(b) The first few energy levels of CO2 molecule are uniformly separated by approximately 2.5 meV. At a temperature of 250 K, what is the ratio of number of molecules in the third excited state to the second excited state?
(c) State and explain the Franck-Condon principle.

2+4+4=10 marks

- **Course Content**

Course Code, Course Title PHY413, Statistical Mechanics	**Theory/~~Practical~~**	**Credits 4**
Unit -1	Introduction: Microstates and macrostates- phase space and volume in phase space, density distribution in Phase space, Phase space evolution. Conditions for equilibrium. Different thermodynamic systems and concepts of ensemble. Time average and ensemble average; Ergodic theory. Microcanonical ensemble : Hypothesis of equal a priori probability, Boltzmann entropy; Statistical definition of temperature, pressure, and chemical potential. partition functions and properties, calculation of thermodynamic quantities, perfect gas in micro canonical ensemble; Gibbs Paradox; Sackur-Tetrode equation; correct enumeration of microstates. practical implication of microcanonical ensemble. Derivation of ideal and slightly non ideal gas equation.	Hours* 16
Unit -2	Canonical ensemble: Equilibrium between a system and a heat reservoir; Gibb's canonical entropy, energy fluctuations in the canonical ensemble; derivation of equipartition theorem, ideal and slightly non ideal gas equation; application: a system of Harmonics oscillator; statistics of paramagnetism.	12
Unit -3	Grand canonical ensemble: Partition functions and properties, calculation of thermodynamic quantities, density and energy fluctuations. Various thermodynamic potentials and their connection with partition functions. Maxwell-Boltzmann (MB) distribution law: Derivation. Calculation of thermodynamic quantities for ideal monatomic gases. Equivalence of ensemble.	12
Unit -4	Quantum Statistics: Bose-Einstein (BE) Statistics, Fermi-Dirac (FD) Statistics, examples illustrating counting procedures for MB, BE and FD statistics and derivation; Entropy maximization; Thermodynamics interpretation of Lagrange's undetermined multiplier; Comparison between the three statistics.Conditions under which the quantum mechanical distribution functions reduce to the classical MB distribution. Thermodynamic behaviour of Bosons and Fermions; Black body radiation and Planck's radiation; Bose- Einstein condensation (qualitative discussion); Fermi distribution at zero and nonzero temperatures.	12
Unit -5	Brownian Motion: Fluctuation, Einstein theory of Brownian motion, diffusion coefficient; Langevin theory (qualitative discussion); Fluctuation-dissipation theorem; random walks and self avoiding walks.	8
	Tasks and Assignments: • Student should summarize the course content at the end and also the beginning of the next class. • Student should discuss the given problem within the group and explain the solution of the problems to other groups in the class. • Students should randomly sit in the class and discuss with each and every students in the class during class seminars and problem solving sessions. **References:** 1. Statistical Mechanics: K. Huang (John Wiley and Sons). 2. Fundamentals of Statistical and Thermal Physics, F. Reif, (Mc Graw Hill) 3. Statistical Mechanics by Pathria – Elsevier.	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Understand concept of ensemble	Understand
CO 2	Applying the ensemble concepts to open, closed thermodynamics system.	Apply
CO 3	Examine the concept of equivalence of ensemble.	Analyze
CO4	Solve different thermodynamics systems by using classical and quantum statistics	Skill
CO5	Find out the application of ensemble concept in diffusive systems.	Evaluate

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	3	3
CO2	3	1	1	3	3
CO3	3	1	1	3	3
CO4	3	3	1	3	3
CO5	3	3	1	1	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	2	2	2
Seminar	2	2	2	-	-
Test	3	3	3	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Short Answer	2	2	-	4	4
Derivation	5	5	5	-	-
Problem solving	5	5	7	8	8
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Originality	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Copied from other students (or) Not submitted	CO1, CO2, CO3, CO4, CO5
2	**Organization** **50%**	Originality	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Copied from other students (or) Not submitted	CO1, CO2, CO3, CO4, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3, CO4, CO5
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO1, CO2, CO3, CO4, CO5

- **Question Paper pattern: Either or type**

Sl. No.	Model Questions	Specification	Level
1	**A** The quantum state available to a given physical system are (i) a group of g_1 equally likely states with a common energy value ε_1 and (ii) a group of g_2 equally likely states, with a common energy value ε_2. (a) Show that the entropy is given by $S = -k\{P_1 \ln(P_1/g_1) + P_2 \ln(P_2/g_2)\}$, where P_1 and P_2 are respectively the probability of the system being in a state	Recognize, Recall, Identify	Apply, Analyse, Skill

	belonging to group 1 or group 2 : $P_1+P_2=1$. (5) (b) Assume that the P's are given by a canonical distribution, show that $S = k\{\ln g_1 + \ln(1+[g_2/g_1]e^{-x}) + x/(1+[g_1/g_2]e^{x})\}$, where $x=(\varepsilon_2 - \varepsilon_1)/(kT)$, assumed positive. (7) (OR)		
2	**B** a)Show that the phase space density is conserved. (3) b) Explain clearly under what condition the Liouville theorem can be applicable for the equilibrium thermodynamic system.(2) c) Write down the fundamental postulates of Statistical Mechanics. (2) d) Explain briefly the microstates and macrostats with a specific examples. (2) e) Explain the importance of equivalence of ensembles. (3)	Explain, Differentiate Define Describe, Discuss	Understand Remember

- **Course Content**

Course Code: PHY414 Course Title: Physics Laboratory VII (Atomic and Optics)		Practical	Credits: 2
Experiment	**Title**		**Hrs.**
I	Abbes Refractometer- To Study the variation of RI with temperature of different liquid		6
II	Half shade Polari meter- Determination the specific Rotation of given solution.		6
III	GM counting system		6
IV	Diffraction due to Helical Structure		6
V	Optical Characterization of given Solid/Thin film Liquid by UV		6
VI	Fourier Transform Infrared Spectroscopy		6
VII	Raman Spectroscopy		6
VIII	X-ray photoelectron spectroscopy		6

- **Course outcome (CO)**

	Course Outcome	Level
CO1	Recollect laws of optics	Remember
CO2	Verification of Malus's law	Analyze
CO3	Familiarizing with wave phenomena of light	Skill
CO4	Examine Fourier optics	Analyze
CO5	Use spectroscopic techniques to characterize material	Create

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	1	1	3	3	1
CO3	3	2	3	3	1
CO4	1	1	3	3	1
CO5	1	1	3	3	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	20	20	20	20	20	100
External	0	0	0	0	0	0
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (100 Marks)**

	CO1	CO2	CO3	CO4	CO5
Experiment/Observation/Performance	10	10	10	10	10
Calculations & Graph	4	4	4	4	4
Viva-Voce	3	3	3	3	3
Record	2	2	2	2	2
Attendance	1	1	1	1	1
Total	20	20	20	20	20

- **Course Content**

Course Code, Course Title **PHY451 & ELECTRONICS**		**Theory/~~Practical~~**	**Credits 4**
Unit -1	Review of Series and Parallel LCR Circuits, ideal voltage and current sources, Superposition principle, Thevenin's theorem, Norton theorem, Millman theorem, Maximum power transfer theorem. Phasor analysis of circuits. Basis of Semiconductor Physics: Semiconductor diodes: p-n junction diode, I-V characteristics, Schockley model, construction and i-v characteristics of Zener, Avalanche, Schottky-barrier diode, Tunnel diodes, LED and photodiodes.		Hours* 12
Unit -2	Construction, operation and Characteristics of BJT, UJT, FET, MOSFET and CMOS configuration. OPAMP - Basics of differential amplifiers-Characteristics of ideal and practical opamps-Applications; inverting, non-inverting, Summing, difference, integrating, differentiating amplifiers		12
Unit -3	Introduction to elements of Boolean algebra, AND, OR, NOT, NAND, NOR, XOR and XNOR logics. Combinational circuits: Adders, subtractors, multiplexer/demultiplexer, decoder and encoders-Flip Flops; S-R, J-K, counters- synchronous, asynchronous, Modulo-ncounters-shift registers; Serial to parallel and vice-versa, universal shift registers, ring counter.		12
Unit -4	Rectifiers, Oscillators and Amplifiers: Half-wave and Full-wave rectifiers; Oscillators – RC, LC, crystal, negative resistance, Hartley ,Colpitt oscillators – basic construction only. Amplifier – Class A, B, AB and C; voltage, current and power amplifiers.		12
Unit -5	Basics of Filter circuits: Low-pass, High-pass, Band-pass, Band-stop – implementation of the above filters using (a) LCR elements (b) diode/FET elements; Filter Topologies, Basics of electrical connections, Single phase and three phase connections, RMS values, Thyristor, and electronic switches.		12

	References: 1. Integrated Electronics: Analog & Digital Circuit Systems – Jacob Millman &Halkias, TMH. 2. "Hands-On F: A Practical Introduction to Analog and Digital Circuits" by Daniel M. Kaplan and Christopher G. White, Cambridge University Press, 2010. 3. Mehta V K, 'Principles of Electronics", S.Chand and Company Ltd., 2005. 4. Malvino A P and Leach D P, "Digital Principles and Applications", TMH Delhi, 2007. 5. Allen Mottershed, "Electronic Devices and Circuits", Prentice Hall of India Private Ltd., 2002 6. Electronic Fundamentals and Applications – D. Chattopadhyay and P. C. Rakshit 7. Electronics Fundamentals and Applications – J. D. Ryder (PHI Pvt. Ltd). 8. Electronic Device and Circuit Theory – R. Boylestad and L. Nashelsky (Prentice –Hall). 9. Integrated Electronics – J. Millman and C. C. Halkias (Mc Graw Hill). 10. Joseph P J Karr, "Elements of Electronic Instrumentation and Measurement", Prentice Hall, 1996. 11. Transistor Physics and Circuit Design, D.C. Sarkar. 12. Engineering Electronics, Terman. 13. A.P.MALVINO, Principles of Electronics, Tata Mc-Graw Hill 7th Edition. 14. B.L. Theraja, Basic Solid State Electronics, S.Chand Co. Ltd., 1997. 15. V.K.Mehta, Principles of Electronics, S.Chand Co. Ltd. 5th Edition **16.** N NBhargava , D C Kulshreshtha , S C Gupta , Basic Electronics and Linear Circuits, Tata McGraw Hill.

- **Course Outcomes**

	Course Outcome	Level
CO1	Ability to simply the complicated circuits by using network theorems	Remember
CO2	Learning of operational principle, construction and output characteristics of diodes, Transistors and Op-amp.	Understand
CO3	Differentiation of different diodes through their I-V characteristics	Apply
CO4	Designing of half wave and full wave rectifiers with diodes; amplifiers and oscillators with transistors and op-amps, construction of active filters with op-amps	Analyze
CO5	Illustration of logic gates and verification of truth tables	Skill
CO6	Ability to design various filters for electronic device applications	Skill

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.

PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	**2**	**3**	**1**
CO2	**2**	3	**1**	3	**2**
CO3	3	3	3	**1**	**3**
CO4	3	3	**2**	3	**2**
CO5	3	3	3	3	**1**
CO6	3	1	1	3	**3**

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	CO6	Total
Internal	7	7	7	7	6	6	40
External	10	10	10	10	10	10	60
Total	**17**	**17**	**17**	**17**	**16**	**16**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5	CO6
Assignments	1	1	1	1	1	-
Seminar	1	1	1	1	-	1
Test (Internal 1 & Internal II)	5	5	5	5	5	5
Attendance	-	-	-	-	-	-
Total	7	7	7	7	6	6

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5	CO6
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	10	10	10	10	10	10
Total	**10**	**10**	**10**	**10**	**10**	**10**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

End Semester Examination -Model Question Paper

CCENTRAL UNIVERSITY OF TAMIL NADU
(Established by an Act of Parliament, 2009)

नीलक्कुड़ी परिसर/Neelakudi Campus, कंगलान्चेरी/Kangalancherry, तिरुवारूर/Thiruvarur - 610 101

End Semester Examinations- Nov/Dec- 2016

Integrated M.Sc- IV Year- Semester- VII
PHY073- ELECTRONICS

Reg. No:

Total Marks: 60
Duration: 3Hour

ANSWER ALL **5 X 12= 60**

1. A(a) Explain *Maximum Power Transfer* theorem and derive the condition for transfer of maximum power from a source to a load. (6)

(b) Given an *LCR* series circuit, describe the conditions when the circuit impedance is *(i)* Resistive, *(ii)* Inductive and *(iii)* Capacitive.**(3)**

(c) Discuss the condition to obtain *Stiff Current Source* with graphical representation. (3)

(OR)

1. B (a) What is the significance of *Schottky Diode*? Describe the terms **(i)** Charge storage, **(ii)** Reverse current and **(iii)** Reverse recovery time, for a diode. **(7)**

(b) What effect does reverse recovery time has on rectification and, explain, how it could be eliminated by using *Schottky Diode*? **(3)**

(c) Why *Schottky Diode* is also called as hot carrier diode? **(2)**

2. A (a) Explain the term current amplification factor and deduce the relation between β and α for a *Common Emitter* connection. **(4)**

(b) In the given circuit shown in *Figure 1*, what is the voltage between the collector and ground?
If the current gain is 100? **(4)**

(c) Describe the working of a *JFET*. **(4)**

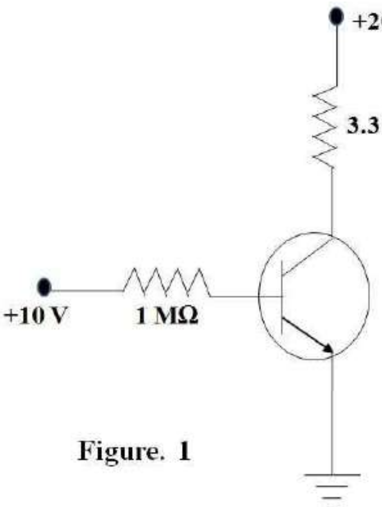


Figure. 1

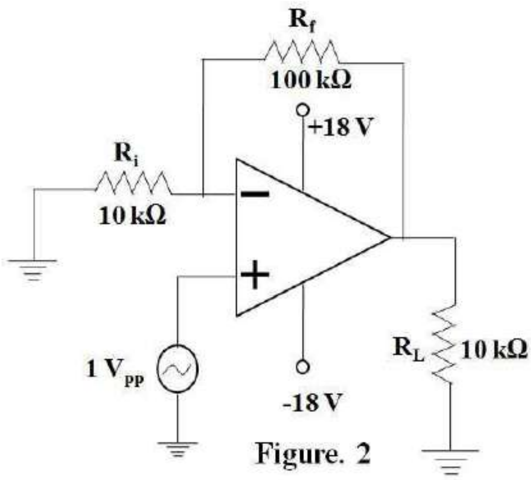


Figure. 2

(OR)

2. B(a) Draw the equivalent circuit of a *UJT* and explain the circuit action in detail. **(6)**

(b) What is known as *Voltage Follower?* Calculate the voltage gain and mention the significance of *Voltage Follower.* **(3)**

(c) For the non-inverting amplifier circuit shown in *Figure 2,* find **(i)** Closed-loop voltage gain, **(ii)** Maximum operating frequency. The slew rate is 0.5 V/μs. **(3)**

3. A (a) Draw an internal circuitry and logic symbol of a falling edge triggered *J-K Flip-Flop* and explain each mode of operation with a truth table and the input - output wave forms. Assume the initial condition of J, K, CLK pulse and Q are in zero state. **(5+4)**

(b) Draw a logic circuit that implements the expression **$X = AC\overline{D} + \overline{A}B\,(CD+BC)$** **(3)**

(OR)

3. B(a) Draw an internal circuitry and logic symbol of a *Full Subtractor* with the truth table and write down the *Boolean Expressions* for DIFFERENCE and BORROW. **(5)**

(b) Explain operation of a *3- bit Synchronous Binary Counter* and sort out the binary state sequence with a timing diagram for eight clock pulse. Assume the initial condition of J and K inputs are in HIGH state and the CLK pulse, Q_0, Q_1, and Q_2 outputs are in LOW state. **(7)**

4. A(a) Explain Full Wave Bridge Rectifier circuit operation and narrate peak inverse voltage with necessary circuit. **(3+2)**

(b) In a *Centre- Tap Full Wave Rectifier* circuit, an a.c. supply of 230 V is applied through a transformer of turn ratio 5:1 and the diodes are assumed to be ideal, i.e., having zero internal resistance. Find: **(i)**d.c. output voltage **(ii)** Peak inverse voltage **(iii)** Rectification efficiency. **(3)**

(c) A 1 mH inductor is available. Choose the capacitor values in a *Colpitts Oscillator* so that f = 1 MHz and m_v = 0.25. **(4)**

(OR)

4. B (a) Describe the circuit operation of a *Hartley Oscillator* and deduce the relation for operating frequency and feedback fraction. **(5)**

(b) Why does *"crossover distortion"* occur in a *Class- B* amplifier? Describe how it can be eliminated by using a *Class- AB* amplifier (with circuits and waveforms). **(7)**

5. A (a) Describe the operation of a *Sallen-Key Low-Pass Filter* circuits.**(4)**

(b) Describe the operation of (i) *R-C* and (ii) *C-L-C* Filter circuits and deduce the expression for ripple factor. **(8)**

(OR)

5. B(a) Draw the V – I characteristics of a *Zener diode* and discuss the behaviour of a *Zener diode* under forward and reverse biasing. **(4)**

(b) As shown in *Figure 3*, a diode is in series with 220 Ω and the voltage across the resistor is 4 V. What is the current through the diode? **(2)**

(c) A *JFET* has the following parameters: I_{DSS} = 32 mA; $V_{GS\,(off)}$ = – 8 V; V_{GS} = – 4.5 V. Find the value of drain current. **(2)**

(d) How operating amplifier can act as an *Integrator*? Explain and deduce the expression for output voltage. **(4)**

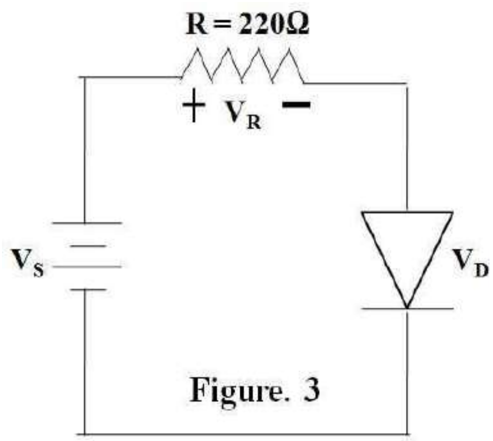


Figure. 3

- **Course Content**

Course Code, Course Title **PHY452 & ELECTRONICS Lab**		**Practical**	**Credits: 2**
1	Verification of Norton's and Thevenin's theorem.		3
2	Construction of ideal power supply using by voltage regulator Ic's(7805/7905).		3
3	Characteristics of BJT/FET.		3
4	Operational amplifier: Summing,Inverting.		3
5	Operational amplifier: Differentiator,Integrator.		3
6	Study of I-V characteristics of PN junction diode and zener diode and voltage regulation by Zener diode		3
6	Clipping and clamping circuits using by junction diode		3
7	Voltage regulator using IC 7805		3
8	Transistor characteristics a) CB, b) CE and c) CC.		3
9	Construction of Logic gates: AND, OR, NOT using by diodes.		3
10	Construction of Logic gates: AND, OR, NOT using by transistor r		3
11	Study of Half Adder and Full Adder.		3
12	To realize basic gates AND, OR, NOT from Universal gates (NAND & NOR)		3
13	Study of DeMorgans Theorem.		3
14	Study of Flip Flops: RS, JK		3
15	Colpitt Oscillator.		3
16	Study of Filters Circuit a) Low Pass b) High Pass c) Band Pass		3

- **Course Outcomes**

	Course Outcome	**Level**
CO 1	Verification of network theorems	Remember
CO 2	Understanding the output characteristics of P-N junction and Zenor diodes	Understand
CO 3	Study of output characteristics of transistors in different configuration & MOSFET	Apply
CO4	Demonstration of voltage regulator using Zenor diodes & IC 7805, Construction of rectifiers, amplifiers and Oscillators	Analyze
CO5	Construction of logic gates; flip-flops	Skill

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	1
CO2	3	3	2	1	2
CO3	2	3	2	2	1
CO4	3	3	1	3	2
CO5	3	3	2	3	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	20	20	20	20	20	100
External	0	0	0	0	0	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (100 Marks)**

	CO1	CO2	CO3	CO4	CO5
Experiment/Observation/Performance	10	10	10	10	10
Calculations & Graph	4	4	4	4	4
Viva-Voce	3	3	3	3	3
Record	2	2	2	2	2
Attendance	1	1	1	1	1
Total	**20**	**20**	**20**	**20**	**20**

SEMESTER - VIII

- **Course Content**

Course Code, Course Title PHY421, Modern Optics		**Theory**	**Credits2**
Unit -1	**Wave Propagation:** One dimensional wave, the differential wave equation, harmonic waves, superposition principle, graphical method for superposition principle, the complex representation, plane waves, three-dimensional wave equation, spherical waves, cylindrical waves, electromagnetic wave, Rayleigh scattering, origin of refractive index, Huygen's principle, Fermat and mirages, Fresnel's equation, total internal reflection		12
Unit -2	**Interference and Diffraction:** Interference of light: single and double slit interference, Michaelson interferometer, Multiple beam-interference, FabryPerot Etalon, Fabry-Perot Interferometer – resolving power, Diffraction - Fraunhoffer diffraction – Single Slit and Double Slit diffraction, Diffraction grating N-Slit diffraction, resolving power of gratings and prisms. Fresnel diffraction – Half period zones, Diffraction by a circular aperture, opaque disc, zone plate.		12

Unit -3	**Polarization:** Polarization of light - polarization by reflection, refraction and scattering - Plane, elliptically and circularly polarized light- Double refraction - Brewster law - Nicol prism - wollaston prism - Rochon prism polarizer and analyzer - Malus's law- wave plate & half wave plate - polaroid- Birefringence, Birefringence crystals, Birefringence polarizer - polarization by scattering - Optical Activity - Fresnel's explanation of rotation - origin of optical rotation in liquid and in crystals - Determination of specific rotatory power using Laurent's half-shade Polarimeter	12
Unit -4	**Fourier Optics:** Fourier series, nonperiodic waves, Fourier integrals, pulses and wave packet, phase and group velocity, Normal and anomalous dispersion, coherence length, Discrete Fourier transform, Coherence Time and Line width via Fourier Analysis, Spatial Coherence and Temporal Coherence – Transform of the Gaussian wave packet - Michelson Stellar Interferometer - Fourier Transform Spectroscopy	12
Unit -5	**Quantum and Non-linear optics:** Quantization of electromagnetic field in a cavity, Fock states of radiation field, quadrature operators, coherent and squeezed states of radiation, photon statistics, mechanical effects of light - laser cooling and trapping of atoms, principle of complimentarity, quantum erasure, Non Linear Processes: Propagation of Electromagnetic Waves in a Nonlinear medium, Parametric Amplification, Singly resonant and doubly resonant parametric oscillator, Second Harmonic generation, Optical Mixing, Self-Focusing, optical bistability – absorptive and dispersive bistability.	12
	References: 1. Optics, AjoyGhatak, Tata McGraw Hill 2. Optics: Principles and Applications, Kailash K. Sharma, 1st Edition (2006), Academic Press. 3. Optics, Hecht and Ganesan, Pearson	

- **Course outcome (CO)**

	Course Outcome	Level
CO1	Recollect knowledge about electromagnetic waves	Remember
CO2	Familiarize with the interference and diffraction phenomena	Understand
CO3	Examine the polarization of light	Analyze
CO4	Apply the Fourier method in Optics	Skill
CO5	Interpret non-linear and quantum phenomena in light propagation	Apply

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	1	1	1	1	1
CO3	1	1	1	1	1
CO4	3	2	2	3	1
CO5	3	1	2	1	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	-	-	-	-	-
Test	6	6	6	6	6
Attendance	1	1	1	1	1
Total	**8**	**8**	**8**	**8**	**8**

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO4
Part A **(Subjective either-or type questions)** $\mathbf{12 \times 5 = 60}$ **marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiz ation** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Model question paper**

Central University of Tamil Nadu
Department of Physics
PHY421 Modern Optics
End Semester Exam

I.M.Sc. Physics VIII Semester Maximum marks: 60

Attempt {either 1 or, 2}; {either 3 or, 4}; {either 5 or, 6}; {either 7 or, 8}; {either 9 or, 10}. Five questions in total.

1. (a) An electromagnetic wave having an amplitude of 1 V/m arrives at an angle of 30 degto the
normal in air on a glass plate of refractive index 1.6. If the wave's electric field is entirely perpendicular to the plane-of-incidence, determine the amplitude of the reflected wave.

(4)

(b) A p-polarized light is incident at an angle of incidence of θiat the interface of two dielectric media of indices $n_i$and $n_t$respectively. Show that the amplitude reflection and transmission co-efficient have the following form

$$r_{\parallel} = \frac{n_t \cos\theta_i - n_i \cos\theta_t}{n_i \cos\theta_t + n_t \cos\theta_i}; r_{\parallel} = \frac{2n_i \cos\theta_i}{n_i \cos\theta_t + n_t \cos\theta_i}$$

(5)

(c) Derive Brewster's law using Fresnel's equations.

(3)

2. (a) The electric field associated with a plane light wave has the form
$\vec{E}$ (z, t) = −7.37ˆx ei(kz−ωt) V/m. Given that ω = 5.62×1015 rad/s and k = 1.70×107 rad/m, find the associated magnetic field and the intensity of the light.

(4)

(b) A s-polarized light is incident at an angle of incidence of θiat the interface of two dielectric
media of indices *ni*and $_{nt}$respectively. Show that the amplitude co-efficients have the following
form

$$r_{\parallel} = \frac{n_t \cos\theta_i - n_i \cos\theta_t}{n_i \cos\theta_t + n_t \cos\theta_i}; r_{\parallel} = \frac{2n_i \cos\theta_i}{n_i \cos\theta_t + n_t \cos\theta_i}$$

(5)

(c) Determine the state of polarization of the light wave whose electric field amplitude is given as
$\vec{E}$ (z, t) = ˆxE0 sin{2π(z/λ − νt)} − ˆyE0 cos{2π(z/λ − νt+ 1/4)}

(3)

3. (a) Two parallel narrow horizontal slits are separated by a distance of 2.6 mm. These are directly illuminated by yellow plane waves. Horizontal fringes are formed on a vertical viewing screen placed 4.5 m from the aperture plane. The centre of the fifth bright band is 5 mm above the centre of the zeroth bright band. Determine the wavelength of the light in air. If the entire space is filled with some transparent liquid of index 1.47, what would be the location of the fifth bright fringe?

(7)

(b) A line source of 600 nm light is 5 mm above and parallel to a Lloyd's mirror. Fringes are observed on a screen 5 m from the source. Locate the first intensity maximum above the mirror's surface.

(5)

4. (a) A thin film of water (n = 1.33) floats on the surface of a liquid of refractive index 1.52. The
arrangement is illuminated perpendicularly by 647 nm light and a large region of the film appears bright red. What is the minimum thickness of the film?

(6)

(b) Suppose a wedge-shaped air film is made between two sheets of glass, with a 100 μm thick
paper used as the spacer at their very ends. If a beam of He-Ne laser comes directly from above, determine the number of bright fringes that will be seen across the wedge.

(6)

5. (a) Imagine 12 narrow, parallel, long slits of width a, each separated from the next slit by a centre-to-centre distance of 5a. The apertures are illuminated normally by plane waves and produce a Fraunhofer diffraction pattern on a distant screen. Determine the relative irradiance of the first order principal maximum compared to the zeroth order principal maximum.

(5)

(b) We wish to resolve two bright yellow sodium lines (589.5923 nm and 588.9953 nm) in the second-order spectrum produced by a transmission grating. How many slits or grooves must the grating possess at minimum?

(2)

(c) A circular hole in an opaque screen has a diameter of 4.98 mm. It is illuminated perpendicularly by light from a He-Ne laser (λ0 = 543 nm) and forms a Fraunhofer diffraction pattern on a distant screen. Determine the angular width of the Airy's disk. How big would it be if the hole was made 10 times smaller?

(5)

6. (a) An opaque screen ΣΣ′ contains a circular aperture 4 mm in diameter. A monochromatic point
source (λ0 = 550 nm) lies on the axis running through the center of the aperture perpendicular to ΣΣ′. The source is at 3 m in front of ΣΣ′, and the observational point P is 3 m beyond it, both on the central axis. Show that the diffraction pattern is of the near-field variety. Calculate the number of Fresnel zones that fill the hole as seen from P.

(6)

(b) We want to make a Fresnel zone plate with a principal focal length of 2 m for a mercury vapour
lamp operating at a wavelength of 578 nm. How big should the central transparent disk be? If it has 30 transparent regions, what is the minimum diameter of the plate?

(6)

7. (a) Determine the intensity pattern of the Young's double slit experiment using Fourier method.

(6)

(b) The waveform of a wave-packet in the position space is given

$$\psi(x, t = 0) = \sqrt{\frac{a}{\pi}}\, e^{-ax^2}$$

If σ_x and σ_k are the ranges over which the wavefunction drops by a factor of $1/e^2$ from its peak in x-space and k-space respectively, then prove that $\sigma_x\sigma_k = 1$.

(6)

8. (a) Why a 4G channel provides faster connectivity compared to a 2G channel?

(2)

(b) A LED radiates in vacuum at a mean wavelength of 607 nm. If the emission has a linewidth
of 18 nm, what is the corresponding temporal width?

(4)

(c) Given that f(x) in the real domain is real, show that $C_{ff}(X)$ is an even function, where,

$$C_{ff}(X) = \int_{-\infty}^{+\infty} dx\, f(x) f^*(x - X)$$

(4)

9. (a) What is nonlinear optical susceptibility? Obtain an expression of it for the second harmonic
generation process.

(9)

(b) If a beam of Nd:YAG laser (λ = 1064 nm) is made to incident on a KDP crystal, What is the
wavelength of the light after is passes through the crystal?

(3)

10. (a) Explain briefly about the coherent build up length for the second harmonic generation process?

(3)

(b) What is an optical parametric amplifier (OPA)? If an OPA is pumped at a wavelength of 800
nm and a seed is sent at a wavelength of 1064 nm, what is the wavelength of the idler?

(4)

(c) What is self-focusing? Find an expression for the non-linear refractive index in terms of the
third order non-linear susceptibility.

(5)

- **Course Content**

Course Code, Course Title PHY422, Nuclear and Particle Physics		**Theory**	**Credits 4**
Unit -1	Properties of Nuclei: Nuclear mass, charge, size, binding energy, spin and magnetic, electric quadrupole moment. Isobar, isotope and isotones. Mass spectrometer (Bainbridge). Binding energy per nucleon versus mass number curve and its characteristics.	12 Hours	
Unit -2	Nuclear structure: Nature of forces between nucleons, nuclear stability, binding energy of the nucleus, qualitative description of the liquid drop model of the nucleus, extreme independent shell model of the nucleus and its predictions for magic numbers and ground state spin parity of the nucleus, Bethe-Weizsacker mass formula (only statement and explanation of the terms in the formula).Parity, Sub-barrier fusion, Symmetries in nuclei, Quantum Mechanical features of nuclear system.	12 Hours	

Unit -3	Radioactivity: alpha, beta and gamma rays, velocity and energy of alpha particles, Geiger- Nuttal law, Beta decay, nature of beta ray spectra, neutrinos and positrons, inverse beta decay, range and strength of weak force, half-life and decay rate of radioactive elements, radioactive series. Description of detectorsand scintillation counters.	12 Hours
Unit -4	Qualitative Approach to Nuclear Reactions: Conservation principles in nuclear reactions, Threshold energy, nuclear reaction cross- sections - Types of fission- distribution of fission products – fissile and fertile materials – neutron emission in fission – spontaneous fission - Explanation of nuclear fission using liquid drop model, fission products and energy release. Spontaneous and induced fission transuranic elements. Chain reaction - fusion- energy released – stellar energy – controlled thermonuclear reaction – plasma confinement. Reactors: Qualitative description of fission reactors, schemes for nuclear fusion, fuels, moderators, and coolants.	12 Hours
Unit -5	Elementary Particles: Four basic interactions in nature and their relative strengths, examples of different types of interactions, Quantum numbers: -mass, charge, spin, isotropic spin, intrinsic parity, hypercharge, Charge conjugation. Conservation of various quantum numbers, Classification of elementary particles, hadrons and leptons, baryons and mesons, elementary idea about quark structure of hadrons, octet and decuplet families. Introduction to Neutrino structure, Solar Neutrinos, Neutrino detection, Solar Processes - R, S process – Astrophysics.	12 Hours
	Tasks and Assignments: **References:** 1. Introductory Nuclear Physics: S. Wong (Prentice Hall of India). 2. Nuclear Physics – Cottingham and Greenwood (Cambridge University Press). 3. Concepts of Nuclear Physcics – R. Cohen (Tata-Mc Graw Hill). 4. Introductory Nuclear Physics, Kenneth S. Krane (John Wiley) 5. Introduction to Elementary Particles, David Griffiths (Wiley, VCH 2nd Edition) 6. An Introductory Course in Modern Particle Physics, Francis Halzen and Alan D. Martin (Wiley, 1984). 7. Radiation Detection and Measurement: G. F. Knoll (John Wiley, 1989).	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Shell model, Quantum mechanical treatment of nucleon system, scattering, Alpha decay, beta decay, interaction of radiation with matter, Gell-Mann’s eight fold way, conservation of different quantum numbers and their relation to symmetry	Understand
CO 2	Shell model to find nuclear spin, magnetic moment and electrical quadrupole moments of various nuclei. Apply quantum mechanics to solve alpha-decay and beta-decay process, also to understand nuclear reactions. Theory of interaction of radiation with matter to understand	Apply

	the working principle of radiation detectors. Conservation of various quantum numbers to understand three fundamental forces.	
CO 3	Discovery of nucleus and Strong force, models of nucleus, Shell model, properties of radiation, various nuclear reactions, four fundamental forces and their properties, classification of elementary particles, symmetry and different quantum numbers.	Analyze
CO 4	Liquid drop models give a very simple idea to model a system and explain its properties. Deuteron problem is helpful to solve quantum mechanical systems, and finding out scattering cross sections, solving kinematic problems related to particle decay using invariant mass methods.	Skill

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	2	3	1
CO2	3	1	3	3	1
CO3	3	2	1	2	1
CO4	3	2	2	3	1

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**Total**
Internal	10	10	10	10	40
External	15	15	15	15	60
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**
Assignments	2.5	2.5	2.5	2.5
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	7.5	7.5	7.5	7.5
Attendance	-	-	-	-
Total	10	10	10	10

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	15	15	15	15
Total	**15**	**15**	**15**	**15**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiz ation** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- ***End Semester Exam- Model Question Paper (Total Mark 60)***

1. (a) (i) Find out the binding energy for $^{65}Cu_{29}$.

(ii) Taking the help of 3-dimensional harmonic oscillator problem, one can show that the magic numbers are 2, 8, 20, 40, 70, 112, 168,..., etc. for N = 0, 1, 2, 3, 4, 5,..., respectively. But for N = 4, why the magic number is 82 instead of 70 for the Nuclear Shell model? [6 + 6 = 12 Marks]

OR

(b) (i) Find out the atomic number, Z for the most stable isobar against the

β-decay if the mass number A = 216.

(ii) Find out the spin and parity for the ground state of following nuclei $^{31}P_{15}$ and $^{141}Pr_{59}$. [4 + 8 = 12 Marks]

2. (a) (i) If sixty hours after a sample of beta emitter $^{24}Na_{11}$ has been prepared, only 6.25% of it remains undecayed, estimate the half-life of this isotope. (ii) Calculate the Q value (in MeV unit) of reaction $^{14}N_7\,(\alpha, p)\,^{17}O_8$. [6 + 6 = 12 Marks]

OR

(b) For an elastic nuclear reaction, $x + X \rightarrow Y + y$, using the Q equation, get

the expression for the kinetic energy of the target nucleon X. [12 Marks]

3. (a) (i) The α-particles emitted in the α-decay of $^{214}Po_{84}$ have an energy of

7.68 MeV. Assuming that α-particles have the same kinetic energy inside the 214*Po* nucleus, determine the number of collisions per second that the α-particles makes with the walls of the the nucleus.

(ii) Briefly describe the working principle of proportional counter.

[6 + 6 = 12 Marks]

OR

(b) (i) Find out the kinetic energy (in MeV unit) of the α-particles emitted in the

following α-decay process $^{226}Ra_{88} \rightarrow {}^{222}Rn_{86} + {}^4He$.

(ii) Briefly describe the working principle of scintillator detector.

[6 + 6 = 12 Marks]

4. (a) For a nucleon-nucleon scattering problem, for ground state.

[6 + 6 + 4 = 16 Marks]

OR

(b)(i) In β-decay process, derive the expression for the number of available final states per unit energy for neutrino.

(ii) Show that spontaneous fission occurs for the nuclei with $Z^2/A \geq 44$.

[8 + 8 = 16 Marks]

5. (a) $K0$ moving with K.E 77 MeV decays to a pi meson and another particle of unknown mass. The pi meson is moving along the direction of the original $K0$ with momentum 381.6 MeV/c. Find the mass of the unknown particle. Given mass of $K0$ = 497.7 MeV/c2 and mass of pion is 139.6 MeV/c2.

[8 Marks]

OR

(b) (i) Complete these two reactions: (p) $K- \rightarrow \mu- + ?$, (q) $\pi- + ? \rightarrow K0 + \Lambda 0$.

(ii) Draw the Feynman diagram of the process: $\Sigma+ \rightarrow \Lambda 0 + e^+ + \nu_e$.

[4 + 4 = 8 Marks]

- **Course Content**

Course Code, Course Title **PHY461, Laser Physics**		**Theory/Practical**	**Credits 4**
Unit -1	Principles of Lasers: Interaction of radiation with matter – Absorption, spontaneous and stimulated emission – Einstein coefficients – relation between spontaneous and stimulated emmision rates, Light amplification – Threshold condition for laser action, Line broadening mechanisms – Natural, Collision and Doppler broadening. Laser operations – Two level system, Population inversion in three level and four level systems- Threshold pump power, relative merits and de-merits of three and four level system.		Hours* 12
Unit -2	Laser Types - Mathematical description of Gaussian beams using Maxwell's equations. Propagation of Gaussian beams through optical elements. ABCD law for Gaussian beams. Hermite-Gaussian beams. Laser Systems - Gas lasers: He-Ne laser, Carbondioxide laser, Nitrogen gas laser, Argon ion gas laser – Solid state lasers: Ruby laser, Nd-YAG laser, Dye lasers - Optically pumped laser systems		12
Unit -3	Laser Operations: Resonant cavities, modes of a rectangular cavity, quality factor of an optical resonator, ultimate laser line width ,		12

	Longitudinal and Transverse mode selection, Pulsed lasers - Q-switching and Mode locking concepts and techniques. - Resonator configurations - Stability of resonators, - Characteristics of Gaussian beam.	
Unit -4	Fiber Lasers: Erbium doped fiber laser – basic equations for amplification and its steady state solutions, derivation for doped fiber length, threshold pump power and laser output power, Erbium doped fiber amplifier, mode locking using non-linear polarization, semiconductor lasers, optical gain in semiconductors, density of states, interaction of semiconductor with light, light amplifcation and gain coefficient in semiconductors, Quasi-Fermi levels, Gain in diode laser, Quantum-Well lasers – derivation for gain coefficient.	12
Unit -5	Laser Applications: Holography , Basic Principle – Holographic interferometry – Speckle Metrology, Material processing- welding, cutting, and drilling. laser tracking, pollution monitoring using lasers, lasers in isotope separation, lasers in precision length measurement, lasers in information storage, bar-code scanner, Biological and Medical applications of lasers.	12
	Tasks and Assignments: References: Lasers Theory and Applications: K. Thyagarajan and A.K. Ghatak (McMillan). C.O. Shea, W.R. Callen and N.T. Rhodes, “An Introduction to Lasers and their Applications”", Addison Wesley, 1969. J. Verdeyen, 'Laser Electronics', Second Edition, Prentice Hall, 1990. Goldman and Rockwell, 'Lasers in Medicine', Gordon and Breach, New York, 1985. B.B. Laud, 'Laser and Non-Linear Optics', Second Edition, New Age International (p) Limited publishers, 1996. Optics and Atomic Physics – B. P. Khandelwal (SiblalAgarwala). Optical Electronic – A. K. Ghatak and K. Tyagrajan. Introduction to Fibre Optics - R. A. Shotwell (EEE, Prentice Hall).	

- **Course Outcomes**

	Course Outcome	**Level**
CO 1	Define basic radiation phenomena in atoms such as spontaneous and stimulated emissions, and absorption of radiation.	Remember
CO 2	The concept of laser operation and derivation of threshold condition for laser oscillation.	Understand
CO 3	Apply the ideas of Q-switching and mode locking concepts for producing laser pulses.	Apply
CO4	Analyze the operation of fiber and semiconductor lasers for light amplification	Analyze
CO5	Get knowledge to focus lasers for optical experiments in laboratory.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	2	2	3	3
CO5	3	3	3	3	3

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	2	2	2
Seminar	-	-	-	-	-
Test (Internal 1 & Internal II)	6	6	6	6	6
Attendance	-	-	-	-	-
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5

2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

<u>End Semester Exam- Model Question Paper</u>

Total Marks: 60
Duration: 3hrs
Sub Code:PHY461 *Sub Title:Laser Physics*

I. Answer in detail (Answer either A* OR *B of Q.Nos 1 to 5. Each Question carries Twelve marks)

1.
A) Derive an expression for absorption/gain coefficient of a lightbeam passing through an atomic
medium. .

(OR)

B) Discuss natural broadening mechanism and derive an expression for normalized line shape function for natural broadening .

2.
A) Derive ABCD Law for focusing of a Gaussian beam by a thin convex lens of focal length f.

(OR)

B) Discuss, with neat diagram, the principle and working of a He-Ne laser.

3.
A) Define quality factor (Q-factor) of a resonator cavity and derive an expression for Q-factor in terms of loss parameters of the cavity.

(OR)

B) Discuss how high energy laser pulses can be produced using the techniques of Q-switching. Derive an expression for peak power of the laser pulse generated by Q-switching.

4.

A) Derive an expression for gain in erbium doped fiberamplifier.Also, derive conditions on pump power for transparency of the signal in the fiber amplifier.

(OR)

B) Derive an expression for joint density of states available for interaction (emission or absorption) of light with frequency ν in a semiconductor.

5 **. A).**Define holography and explain recording and reconstruction of a hologram. Discuss the use of lasers in holography.

(OR)

B) Discuss the techniques of isotope separation using lasers. Explain the process of atomic vapor and molecular laser isotope separation

- **Course Content**

Course Code,Course Title **PHY461, Laser Physics Lab**		**Practical**	**Credits 2**
Experiment	**Title**		**Hrs.**
I	Diffraction due to surface tension waves on water.		6
II	Diffraction due to helical structure.		6
III	Laser beam characteristics a) Beam waist b) Intensity profile		6
IV	a) Determination of laser parameter-divergences and wavelength for a given laser source using grating. (b) Particle size determination.		6
V	Fibre optics characterisation-To find numerical aperture of single mode fibre and losses.		6
VI	Brewster's Angle experiment to find refractive index.		6
VII	Polarization of Laser (Verification of Malus Law).		6
VIII	Interference and Diffraction through slit.		6

- **Course outcome (CO)**

	Course Outcome	**Level**
CO1	Recollect basics laws of optics	Remember
CO2	Verification of Laser parameters	Analyze
CO3	Familiarizing with Optical fibers	Skill
CO4	Examine diffraction effects	Analyze
CO5	Verify wave phenomena of lasers	Analyze

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	1	1	3	3	1
CO3	3	2	3	3	1
CO4	1	1	3	3	1
CO5	1	1	3	3	1

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	20	20	20	20	20	100
External	0	0	0	0	0	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Experiment/Observation/Performance	10	10	10	10	10
Calculations & Graph	4	4	4	4	4
Viva-Voce	3	3	3	3	3
Record	2	2	2	2	2
Attendance	1	1	1	1	1
Total	20	20	20	20	20

- **Course Content**

Code: PHY463 **Course Title: Experimental Methods and Design**		**Credits: 4**	**Theory**	**Hours**
Unit -1	Measurement of fundamental constants: e, h, c – Measurement of high and low resistances, inductance and capacitance – Detection of X-rays, Gamma rays, charged particles, neutrons – Ionization chamber – Proportional counter – GM counter – Scintillation detectors – Solid State detectors.			12
Unit -2	Emission and Absorption Spectroscopy – Measurement of Magnetic field – Hall effect – Magnetoresistance – X-ray and neutron Diffraction.			10
Unit -3	Vacuum Techniques – Basic idea of conductance, pumping speed – Pumps: Mechanical Pump – Diffusion pump – Gauges – Thermocouple gauge – Penning gauge – Pirani gauge – Hot Cathode gauge – Low temperature systems – Cooling a sample over a range up to 4 K – Measurement of low temperatures.			12

Unit -4	Measurement of energy and time using electronic signals from the detectors and associated instrumentation – Signal processing – A/D conversion – multichannel analyzers – Time-of-flight technique – Coincidence Measurements – true to chance ratio – Correlation studies. Error Analysis and Hypothesis testing – Propagation of errors – Plotting of Graph – Distributions – Least squares fitting – Criteria for goodness of fits – Chi square test.	12
Unit -5	Design of experiment – need for experiments (validation of theory/ verification of theory/ addition to database); computer interfacing; Data collection and analysis – errors and accuracy of data collected, types of errors, propagation of errors, reporting data – mean, variance, method of least Bsquares fit, central limit theorem, error bars. Data reproducibility and ethics of data collection.phase sensitive detection; shielding of cables.	14
	Tasks and Assignments: **References:** 1. J.P. Holman, Experimental Methods for Engineers. 7th Edition. McGraw Hill (2000). 2. J. M. Lafferty (Editor) (1998), Foundations of Vacuum Science and Technology, Wiley Interscience. 3. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley(2004). **Suggested Reading:** 4. Anthony Kent, Experimental Low-Temperature Physics ,Macmillan Physical Science (1993). 5. T. G. Beckwith, R. D. Marangoni and J. H. Lienhard ,Mechanical Measurements,6th Edition(2006),Prentice Hall. 6. Ernest O Doebelin, Measurement Systems: Application and Design. 5th edition, Tata McGraw Hill. 7. Albert D Helfrick and William D Cooper (1992), Modern Electronic Instrumentation and Measurement Techniques. Prentice Hall. 8. Hermann K P Neubert, Instrument Transducers: An introduction to their performance and design. Oxford University Press(2003). 9. J. A. Blackburn Modern Instrumentation for Scientists and Engineers, Springer (2001).	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Different experimental techniques, need for vacuum technology, methods used in the design of experiments.	Remember
CO 2	Understand the strength and limitation of each technique and choose the right technique for characterization of properties. Understand the methods used in the design of experiments and how these methods are connected to statistical models.	Understand

CO 3	Approach complex industrial and business research problems and address them through a rigorous, statistically sound experimental strategy. Apply the analytical techniques and graphical analysis to the experimental data.	Apply
CO4	Analyze the pros and cons of applying the experimental methods to correlate with the Physics theory.	Analyse
CO5	Design simple experiments him/her self and have a general insight into how data analysis is done in connection to designed experiments.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	2	2
CO2	3	3	1	2	2
CO3	3	3	3	3	1
CO4	3	3	2	3	1
CO5	3	3	3	3	2

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- **Course Content**

Course Code: PHY464 **Course Title: Physics laboratory-XI (Experimental Techniques)**	**Credits: 2**	**Laboratory/ Practicals**	**Hours**
1. Measurement of resistivity of semiconductors by four probe method.			3
2. Verify the following laws (i) AC Wheatstone bridge (ii) Maxwell's Bridge (iii) De Sauty's bridge			3
3. Determine the optical constants of Thin film deposited on transparent substrate.			3
4. Determine the electric dipole moment of organic molecule (Acetone)			3
5. Determine the dielectric constant of Non polar liquid (Benzene)			3
Repeat/ Revisit experiments			3
6. Experimentally determine the temperature dependence of the capacitance of a ceramic capacitor			3
7. Permittivity of dielectric materials (LCR meter)			3
8. Measurement of High and Low Resistance			3
9. Lock in amplifier.			3
Repeat/ Revisit experiments			3

References:

1. B.L. Worsnop and H. T. Flint , Advanced Practical Physics, Asia Publishing House.
2.Erhan Gülmez: Advanced Physics Experiments (1999)
3. C.L. Arora, Practical physics, S. Chand Publication,
4. Daryl W. Preston and Eric R. Dietz: The Art of Experimental Physics.
5. Class materials and the references within.

- **Course Outcomes**

	Course Outcome	Level
CO 1	Different experimental techniques, methods used in the design of experiments.	Remember
CO 2	How to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions.	Understand
CO 3	Apply the gained knowledge on the operational details of the experiments and interpret the obtained data.	Apply
CO4	Analyze the resulting data of the given experiment(s), and submit lab report at the end of every lab session.	Analyse
CO5	Able to design and carry out an experiment on his/her own, Design simple experiments him/her self and have a general insight into how data analysis is done in connection to designed experiments.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	2
CO2	3	3	3	2	1
CO3	3	1	3	3	1
CO4	3	3	3	3	2
CO5	3	3	3	3	2

SEMESTER - IX

- **Course Content**

Course Code: PHY511 **Course Title: Condensed matter physics II**	**Theory**	**Credits 4**
Unit -1	Inter and intra molecular interactions, self-assembly and self-association, correlations, formation of condensed phases, length, time and energy scales in condensed matter systems Basic phenomenology of soft condensed matter systems: phase behaviour, diffusion and flow, viscoelasticity.	Hours* **12**
Unit -2	Order Parameter, Phases and Phase transitions Mean Field theory and phase diagrams, order parameter, metastable states. Interfaces and wetting, Young’s equation, solid-liquid interaction.	**12**
Unit -3	Introduction to Liquid crystals, Frank free energy, Landau de Gennes model of isotropic-nematic transition, Onsager's mean field theory, nematic-smectic transition.	**12**

Unit -4	Introduction to colloids, Poisson- Boltzmann theory, DLVO theory, sheared colloids, stability of colloidal systems, measurement of interaction.	**12**
Unit -5	Introduction to Polymers & Membranes: Model systems, chain statistics, ideal polymers, role of solvent, Equivalent Kuhn chain, mean square end-to-end- length and radius of gyration, Probability distribution in an ideal polymer, Entropic "Hook's Law", ideas of self-avoidance, rubber elasticity, viscoelasticity and reptation	**12**

- **Course Outcomes**

	Course Outcome	**Level**
CO 1	Understand the origin of condensed phases and the scales involved	Understand
CO 2	Understand phase transitions and wetting	Understand
CO 3	Understand liquid crystals and apply phase transition principles to their meso phases	Understand and Apply
CO4	Analyze colloids with respect to various theories	Analyze
CO5	Analyze polymers with respect to statistical physics models	Analyze

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	1	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

- **Rubric for Assignments**

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- **Course Content**

Course Code: PHY551 **Course Title:** Computational Physics		**Theory**	**Credits 4**
Units	**Content**		**Hrs.**
I	**Introduction and overview** Introduction and Basic concepts, Theoretical Background, Basic equations for interacting electrons and nuclei, Coulomb interaction in condensed matter, independent electron approximations,Exchange and correlation, Periodic solids and electron bands, Structures of crystals: lattice + basis,The reciprocal lattice and Brillouin zone, and the Bloch theorem. Time reversal and inversion symmetries, Integration over the Brillouin zone and special points Density of states - Uniform electron gas and simple metals.		12
II	**Introduction to quantum mechanical modeling: Hartree-Fock and Density function theory** Non-interacting and Hartree-Fock approximation, the correlation hole and energy. Density functional theory: foundations,Thomas-Fermi-Dirac approximations: example of a functional. The Hohenberg-Kohn theorems,Constrained search formulation of density functional theory, Extensions of Hohenberg-Kohn theorems, The Kohn-Sham ansatz. Replacing one problem with another: The Kohn-Sham variational equations Exc, Vxc and the exchange correlation hole - meaning of the eigenvalue. Intricacies of exact Kohn-Sham theory.		12
III	**Exchange Correlation Functionals, Correlation effects. And SCF calculations** Functionals for exchange and correlation - The local spin density approximation (LSDA), Generalized-gradient approximation (GGAs) , LDA and GGA expressions for the potential Vxc(r), Non-collinear spin density, Non-local density formulations: ADA and WDA - Orbital dependent functionals I: SIC and LDA+U. Orbital dependent functional II:		12

	OEP and EXX, Hybrid functionals -Tests of functionals Solving Kohn-Sham equations – Self-consistent coupled Kohn Sham equations - Total energy functionals - Achieving self-consistency – Numerical mixing schemes - Force and stress.	
IV	**Electronic structure from plane wave and localized basis methods** Determination of electronic structure – Atomic sphere approximation in solids,Plane waves and grids: basics - The independent particle Schrodinger equation in a plane wave basis. The Bloch theorem and electron bands - Nearly free-electron-approximation - Form factors and structure factors. Plane-wave method - 'Ab initio' pseudopotential method - Projector augmented waves (PAWs) - Simple crystals: structures, bands, - Supercells: surfaces, interfaces, phonons, defects - Clusters and molecules. Localized orbitals: tight-binding – Tight-binding bands: illustrative examples - square lattice and CuO2 planes - Examples of bands: semiconductors and transition metals - Electronic states of nanotubes. Localized orbitals: full calculations – Solution of Kohn-Sham equations in localized bases. Analytic basis functions: Gassians - Gassian methods: ground state and excitation energies - Numerical orbitals - Localized orbitals: total energy, force, and stress - Applications of	12
V	**Mixed Basis Methods and Their Applications** Augmented plane waves (APW's) and 'muffin-tins' – Solving APW equations: examples Muffin-tin orbitals (MTOs). Linearized augmented plane waves (LAPWs) - Applications of the LAPW method - Linear muffin-tin orbital (LMTO) method - Applications of the LMTO method - Full potential in augmented methods - Molecular dynamics (MD): forces from the electrons - Lattice dynamics from electronic structure theory - Phonons and density response functions - Periodic perturbations and phonon dispersion curves - Dielectric response functions, effective charges - Electron-phonon interactions and superconductivity.	12

Tasks and Assignments:

References:

Books recommended:

1. H.Skriver, The LMTO Methods, Springer (1984).
2. Electronic Structure Basic Theory and Practical Methods Richard M. Martin, Cambridge University Press (2004).
3. Modeling Materials Continuum, Atomistic and Multiscale Techniques ELLAD B. TADMOR, Cambridge University Press (2012).
4. Atomic and Electronic Structure of Solids, Efthimios Kaxiras, Cambridge University Press (2003).
5. Computational Chemistry of Solid-State Materials, Richard Dronskowski, WILEY-VCH (2005).
6. Mizutani U. Introduction to the Electron Theory of Metals (CUP,2001).
7. Roessler U. Solid State Theory. An Introduction (2ed., Springer, 2009)

Supplementary Reading:

1. N.W. Ashcroft and N.D.Mermin, Solid State Physics. Saunders, 2004.
2. G.C.Fletcher. Electron theory of solids. North Holland Pub. Co. 1980.
3. Density Functional Theory – D. S. Sholl and J.A. Steckel, Wiley, 2009.
4. A Primer in Density Functional Theory – C. Fiolhais, F. Nogueira, and M. Marques, Springer, 2016.

- **Course Outcome (CO)**

	Course Outcome	Level
CO 1	Introduce students to modelling of solids and predict as well as interpret their various properties using computational modelling.	Acquire, Understand,
CO 2	Show how these modelling methods can be used to understand fundamental material structure and properties as well as the relationships between material structure and material behavior.	Evaluate, Analyze, Skill
CO 3	Develop an understanding of the assumptions and approximations that are involved in the modelling frameworks at the various time and length scales.	Remember, Understand, Analyze, Apply
CO 4	Students will be introduced to the basis for the simulation techniques, learn how to use computational modelling, and how to present and interpret the results of simulations.	Understand, Apply, Skill
CO 5	The students will learn various computational parameters and practical knowledge involve in modelling functional properties of solids and with that knowledge they can design materials in the computational lab for various applications.	Understand,Analyze, and Apply

- **Mapping of ProgramOutcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	2	3	3
CO2	3	3	3	2	3
CO3	3	2	3	3	3
CO4	3	3	2	1	3
CO5	3	3	3	3	3

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**23**	**17**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	3	3	3	-	3
Seminar	-	-	-	3	-
Test	5	5	5	5	5
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Part – C **(Essay-12 x 5 = 30 marks)**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

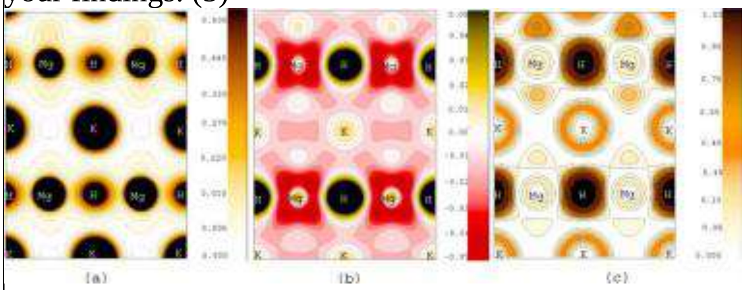
- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3, CO5,
2	**Organiz ation** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO3, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO4

- **Model Question Paper**

Sl. No.	**Model Questions**	**Specification**	**Level**
	PART – C Essay Answer **Answer any 12 from below Marks: 12 x 5 = 60**		
1	a) What is Bloch's theorem? (1) b) Write the Hamiltonian for an interacting many-body system and name each term (2) c) What is Local Density Approximation? and What are the trends and limitations ofLDA? (3)		
2	a) What are Miller indices? (2) b) Describe the procedure for determining the Miller indices of a crystal plane? (3)		
3	a) What is reciprocal lattice? (2) b) What are its characteristics? Sketch the reciprocal lattice for a bcc lattice. (3)		
4	a) What is Fermi Dirac distribution? Draw Fermi Dirac distribution function for asemiconductor at low and high temperature. (5)		
5	The charge density (a), charge transfer (b) and ELF plots of KMgH3 is given below. Comment about the chemical bonding interaction between the constituents. Use all three plots to support your findings. (5) 		
6	a) What are the fixed basis set methods? What is the advantage and disadvantage of using fixed basis set methods? (2) b) What is the partial wave method? List the advantages and disadvantages of using it. (3)		
7	a) Write about the different absorption processes in semiconductors. (4) b) Calculate the energy of a light in eV having wave length 400 nm. (h = 6.6260 × 10−34 J.s, c = 3 x 108 m/s) (1)		
8	a) Draw band structure and density of states for metal, semiconductor and insulator with appropriate example for each (3) b) Explain direct and indirect band gap semiconductors with examples? (2)		
9	a) Describe the primary and secondary effects of spatial overlap and electronegativity difference of elements forming bond on the bandgap of the material. Include		

	appropriate schematics and examples (5)		
10	a) List out the important point for choosing the electronic structure code (3) b) Write a short note on VASP and Gaussian code (2)		
11	a) Define interband transitions and Fermi energy (1) b) Explain n-type and p-type silicon? (2) c) Explain the band structure of zinc blend-type semiconductor (2)		
12	a) Explain the three basic methods used for modern electronic structure calculation? (3) b) Write about the types of Van der Walls forces? (2)		
13	a) Write about steepest descent and conjugate gradient energy minimization methods. What are their advantages and disadvantages? (5)		
14	a) Write the definitions of a). Schottky defect b). Frenkel defect c). edge dislocation d). screw dislocation e). grain boundary (5)		
15	a) Draw the potential energy function graph and label its different regions. (2) b) Explain covalent and metallic bonding. (3)		

- **Course Content**

Course Code, Course Title PHY551, Computational Physics	**Theory/~~Practical~~**	**Credits 4**
Unit -1	**Introduction :** Basic concepts of computation and simulation. Difference between numerical computation and simulation. Computational Languages, Algorithms, Codes, Pseudo Codes, Flow charts. Modelling of Natural phenomena: Interatomic potentials, Equations of motion. Various computation techniques for different physical systems.	Hours* **12**
Unit -2	**Probability distributions:** Probability theory, Probability density or distribution, Discrete and Continuous Distributions. Uniform distribution, Binomial, Poisson's, Gaussian, Lorentz and Exponential distributions. Marginal density and Joint density. Mean, Variance, Covariance and correlation functions.	**12**
Unit -3	**Random Numbers:** Random processes, random variables, random number. True random numbers, Pseudo random numbers. Pseudo random number generators: Linear congruential generator, Lagged Fibbonacci generator, ran3 generator, Mersenne Twister generator. Various test for pseudo random number generators	**12**
Unit -4	**Monte Carlo Methods:** Coin tossing experiments, Die Experiment, Validity of Stirling Approximation, Box-Muller algorithm, Inversion Method, Rejection Method, Averages and Standard deviations, Errors and Numerical convergence. Numerical Verification of Central Limit Theorem	**12**
Unit -5	**Sampling Techniques:** Simple sampling, importance sampling, acceptance ratio, Details balance condition, Metropolis algorithms; Implementation of Monte Carlo algorithms: Random walk, self-avoiding walk, Ising model, nucleation, crystal growth, fractal system etc.	**12**

	Tasks and Assignments: • Student should summarize the course content at the end and also the beginning of the next class. • Student should discuss the given problem within the group and explain the solution of the problems to other groups in the class. • Students should randomly sit in the class and discuss with each and every students in the class during class seminars and problem solving sessions. **References:** 1. H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods. 2. K.P.N. Murthy, Monte Carlo Methods in Statistical Physics, University Press, 2004. 3. D. Frenkel and B. Smith, "Understanding molecular simulation from algorithm to applications", Kluwar Academic Press, 1999.

- **Course Outcomes**

	Course Outcome	Level
CO 1	Understand concept of simulation	Understand
CO 2	Applying the probability concepts to different physical system.	Apply
CO 3	Examine the concept of random numbers.	Analyze
CO4	Solve different systems by using Monte Carlo	Skill
CO5	Find out the application of Monte Carlo in different systems.	Evaluate

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	3
CO2	3	3	1	3	3
CO3	3	3	1	3	3
CO4	3	3	2	3	3
CO5	3	3	1	3	3

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	2	2	2
Seminar	2	2	2	-	-
Test	3	3	3	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Short Answer	2	2	2	-	-
Derivation	5	5	5	4	4
Problem solving	5	5	5	8	8
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Originality	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Copied from other students (or) Not submitted	CO1, CO2, CO3, CO4, CO5.
2	**Organization** **50%**	Originality	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Copied from other students (or) Not submitted	CO1, CO2, CO3, CO4, CO5.

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3, CO4, CO5.
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO1, CO2, CO3, CO4, CO5.

- **Question Paper pattern: Either or type**

Sl. No.	Model Questions	Specification	Level
1	**A** Consider an N particles closed system interacting two at a time, conserving energy. Start with N particles each having the same velocity unity. i.e. $\{v_i = 1 \ \forall i = 1, 2, \cdot\cdot\cdot, N\}$. Pick up two particles at random; let them be i and j, and i not equal to j. Reset their velocities as per the following iteration rule, $v_i(new) = (v_j(old) + v_i(old)) / \sqrt{2}$ $v_j(new) = (v_j(old) - v_i(old))/\sqrt{2}$. Repeat the above several times. After initial warm up time of say 4 N iterations.Prove that the above algorithm leads to independent Gaussian random numbers (12) (OR)	Recognize, Recall, Identify	Apply, Analyse, Skill
2	**B** a) Explain the theory and implementation of Mersenne Twister random number generator. (7) b) Explain Box-Muller algorithm and its implementation using "C" program (5)	Explain, Differentiate Define Describe, Discuss	Understand Remember

- **Course Content**

Course Code: PHY552, Course Title: Physics Laboratory-XII (Computational Physics II)	Practical	Credits: 2

List of Experiments

1. Introduction to Linux environment and TB- LMTO code.
2. Plotting crystal structure using plotting software like VESTA.
3. Band structure plotting and analyzing for Si.
4. Plotting the total and partial density of states (DOS) and analyzing the bonding interaction present in Si
5. Plotting and analyzing the band structure, total DOS and partial density of states of GaAs. Comparing the electronic structure with that of Si.
6. Plotting the charge density for NaCl, Si and GaAs and analyzing bonding interaction.
7. Plotting and analyzing the band structure, total DOS and partial density of states of TiO_2. Explain why it's a transparent conductor.

8. Plotting absorption spectra of Si and GaAs

9. Plotting COHP between C-C in diamond and between Ga-As in GaAs. And explain. Total energy vs Volume curve for Diamond and Lead. And calculate the Bulk modulus.

Tasks and Assignments:

1. Execution of experiments.
2. Observation submission
3. Viva-Voce
4. Practical Examination

References:

1. https://www.vasp.at/wiki/index.php/The_VASP_Manual
2. https://vaspkit.com/tutorials.html
3. Martin, R. (2004). *Electronic Structure: Basic Theory and Practical Methods*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511805769

Parr, R., & Weitao, Y. (1995-01-05). Density-Functional Theory of Atoms and Molecules. : Oxford University Press. Retrieved 17 Sep. 2021, from https://oxford.universitypressscholarship.com/view/10.1093/oso/9780195092769.001.0001/isbn-9780195092769.

- **Course Content**

Course Code: PHY571 **Course Title: Physics Laboratory XIII (Advanced Physics)**		**Credits: 2**	**Laboratory/ Practicals**	**Hours**
	1. Growth of KDP Crystal.			3
	2. Thin film deposition using Physical Vapor Deposition Method.			3
	3. FTIR Study of binary liquids (Ethylene glycol-Ethylene system)..			3
	4. Determine the lattice constants of ceramics.			3
	Repeat/ Revisit experiments			3
	5. Growth of ADP Crystal.			3
	6. DSC – study of phase transitions in liquid crystals			3
	7. Thin film Coating by Spray Pyrolysis techniques (PVA)			3
	8. Preparation of thin film (Solid/soft matter)			3
	Repeat/ Revisit experiments			3

References:

1. B.L. Worsnop and H. T. Flint , Advanced Practical Physics, Asia Publishing House.
2.Erhan Gülmez: Advanced Physics Experiments (1999)
3. 4. Daryl W. Preston and Eric R. Dietz: The Art of Experimental Physics.
5. Class materials and the references within.

- **Course Outcomes**

	Course Outcome	Level
CO 1	Working principles of the various techniques, identify the strength and limitation of each technique.	Remember
CO 2	Understand the intuitive ideas governing the functioning of various techniques, categorize and analyze the resulting data to obtain objective conclusions.	Understand
CO 3	Use the different measuring devices and meters to record data with precision and accuracy. Apply the gained knowledge on the operational details of the experiments for sample preparation.	Apply
CO4	Analyze the resulting data of the given experiment(s), and submit lab report at the end of every lab session.	Analyse
CO5	Plan and conduct experimental while employing proper note-taking methods.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	3	1
CO2	3	3	3	1	2
CO3	3	2	3	3	2
CO4	3	3	3	3	1
CO5	3	3	3	3	1

ELECTIVE COURSES

- **Course Content**

Course Code: PHY0E01 **Course Title:** Solar energy and its application		**Theory**	**Credits: 4**
Units	**Content**		**Hrs.**
I	**Introduction** Energy scenario current, energy future, energy sources - Energy demand and availability; Conventional, Nonconventional, and Renewable energy resources; Environmental impacts of conventional energy usage.		12
II	**Solar Collector, Thermal Technology, and Applications** Solar radiation and electromagnetic spectrum, solar radiation entering the earth system, Solar angle of incidence on tilted surface - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods - evacuated tubular collectors - concentrator collectors – compound parabolic concentrators - parabolic trough concentrators – performance of the collectors.		12
III	**Solar Photovoltaic System and Applications** Basic principle of solar photovoltaic conversion, Solar cell parameters and characteristics. Block diagram of general PV conversion system and their characteristics, – Photovoltaic cell technologies - p-n junction under equilibrium and biasing, open circuit voltage and short circuit current, I-V and P-V curves, calibration and efficiency measurement – PV cell, modules, and array, - Array design, peak power point operation - Load estimation, Selection of inverters, Battery sizing, array sizing. Voltage regulation - maximum tracking - centralized and decentralized PV systems - standalone - hybrid and grid connected system - System installation - operation and maintenances - field experience – Applications - PV market analysis and economics of PV systems.		12
IV	**Solar refrigeration and Air-conditioning** Potential and scope of solar cooling, Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and air-conditioning, solar operation of vapor absorption cycle, temperature concentration diagram, enthalpy concentration diagram, steady flow process with binary mixtures, Energy balance for various components of vapor absorption cycle, Analysis of absorption system using concentration chart. Solar Passive Architecture - passive cooling concepts: evaporative cooling - radiative cooling.		12
V	**Other Applications of Solar Energy Technologies** Solar water heaters – Solar cooker – desalination - Solar Air heaters - Application of solar air heaters. Solar Drying with various driers – Heating and Drying of Agricultural products – moisture content and its measurement – solar ponds – Application of solar ponds – Solar pumping.		12

Tasks and Assignments:

References:

Books recommended:

1. S.P. Sukhatme, Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
2. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition (Tata McGraw Hill, 2008)
3. G.N. Tiwari, Solar Energy: Fundamentals, design, Modeling and Applications: 2002, Narosa Publishing house
4. Fonash Solar Cell Devices: (Academic Press, New York) (1981)
5. Stooker W.F, Jones J.W. Refrigeration and Air Conditioning, Tata McGraw-Hill (2009)
6. Caparra, Refrigeration and Air Conditioning Tata McGraw-Hill (2000)
7. Kreider, J.F. and Frank Kreith, Solar Energy Handbook, McGraw Hill, 1981.
8. Tiwari G.N., Tiwari A.K., Solar Distillation Practice, Anamaya Publishers, New Delhi (2008)
9. VVN Kishore, Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. (TERI Press, 2008).
10. Goswami, D.Y., Kreider, J. F. and & Francis, Principles of Solar Engineering, 2000.
11. G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, 1999.
12. G. D. Rai, Solar Energy Utilization, KhannaPublishers, Delhi. (1996)
13. Volker Quaschning, Understanding Renewable Energy Systems, Vol.1 (2005)
14. Marcelo Godoy Simmoes Renewable Energy Systems CRC Press (2004)
15. John Twidell Renewable Energy Resources Taylor and Francis (2006)
16. Renewable Energy Sources and Their Environmental Impact Abbasi & Abbasi Prentice Hall of India (2004).

Supplementary Reading:

1. Garg H P., Prakash J., Solar Energy: Fundamentals & Applications, Tata McGraw Hill, 2000.
2. Duffie, J. A. and Beckman, W. A., Solar Engineering of Thermal Processes, John Wiley, 1991.
3. Alan L Fahrenbruch and Richard H Bube, Fundamentals of Solar Cells: PV Solar Energy Conversion, Academic Press, 1983.
4. Larry D Partain, Solar Cells and their Applications, John Wiley and Sons, Inc, 1995.
5. Roger Messenger and Jerry Vnetre, Photovoltaic Systems Engineering, CRC Press, 2004.
6. Sodha, M.S, Bansal, N.K., Bansal, P.K., Kumar, A. and Malik, M.A.S. Solar Passive Building, Science and Design, Pergamon Press, 1986.
7. Krieder, J and Rabi, A., Heating and Cooling of Buildings: Design for Efficiency, McGraw-Hill, 1994.
8. MA Green: Solar Cells Operating Principles, Technology, and System

	Applications (Prentice-Hall, 1981) 9. MA Green: High Efficiency Silicon Solar Cells (Trans Tech Publications) (1987) 10. SJ Fonash: Solar Cell Device Physics (Academic Press, 1982) 11. Handbook of photovoltaic science and engineering, ed. Antonio Luque and Steven Hegedus (John Wiley and Sons) (2010) 12. Anna Mani, S Rangarajan: Handbook of Solar Radiation Data for India, 1980 (Allied Publishers) 13. Richard C Neville, RC Neville, Bas Van Der Hoek: Solar Energy Conversion: The Solar Cell (Elsevier Science & Technology) (1995) 14. Peter Würfel : Physics of Solar Cells: From Basic Principles to Advanced Concepts (Wiley-VCH)(2009) 15. JF Kreider and F Kreith: Solar Heating and Cooling: Active and Passive Design (Hemisphere Publishing Corporation, 1982) 16. Low Temperature Engineering Application of Solar Energy, ed. RC Jordan (ASHRAE) (1967) 17. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications (Tata McGraw Hill) (2006) 18. AB Meinel& MP Meinel: Applied Solar Energy: An Introduction (Addison) 19. Climatological and Solar data for India, Seshadri, (Sarita Prakashan), 1969. 20. Energy Technology, S. Rao and B. B. Parulekar, (Khanna Publishers), 1995. 21. Terrestrial Solar Photovoltaics, Tapan Bhattacharya, (Namsa : Publication House, New Delhi), 1998. 22. Renewable Energy Sources and Conversion Technology, N. K. Bansal, M. Kleeman and S. N. Srinivas, (Tata Energy Research Institute, New Delhi), 1996. 23. Fundamentals of Solar Cells, F. A. Faherenbruch and R. H. Bube, (Academic Priess) (1983). 24. Thin Film Solar Cells, K. L. Chopra and S. R. Das, (Plenum Press), 1983. 25. Shan K. Wang, Hand Book of Air Conditioning and Refrigeration (2000) 26. Ahmadul Ameen, Refrigeration and Air Conditioning (2006)	

- **Course Outcome (CO)**

	Course Outcome	**Level**
CO 1	Gain basic understanding about energy use and its environmental impact and various renewable energy technologies adopted to mitigate climate change and sustainable development.	Acquire, Understand, Apply, Skill
CO 2	Acquire knowledge about the various parameters involved in measuring the solar irradiance on earth and its variation and various solar thermal technologies including collectors and concentrators.	Remember, Evaluate, Analyze, Skill

CO 3	Understand the basic aspects of photovoltaic technologies and apply it to various solar cell applications including efficiency improvement, tracking, energy storage, grid balancing etc.	Remember, Understand, Analyze, apply
CO 4	Gain knowledge about solar passive and active cooling/heating and various solar refrigeration technologies, various solar cooling technologies.	Acquire, Understand, Apply, Skill
CO 5	The students will learn various applications of solar energies including solar heaters, cookers, solar ponds, solar collectors, solar desalination, solar driers and their basic working principles.	Understand,Analyse Apply, Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	3	3
CO2	3	3	1	2	3
CO3	3	3	3	3	3
CO4	3	3	2	1	3
CO5	3	3	3	3	3

- **Evaluation Scheme**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	3	3	-	-	3
Seminar	-	-	3	3	-
Test	5	5	5	5	5
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Part – A **Objective Type (20 x 1 = 20 marks)**	4	4	4	4	4
Part –B **(Essay-8 x 5 = 40 marks)**	8	8	8	8	8
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- **Model Question Paper**

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice Marks: 20 x 1 = 20**		
1	The _______________ is placed through the focus so most of the heat will be transferred to the food, thus allowing it to cook much more rapidly. a) Reflector b) collector c) Skewer d) None of the above		

2	U value is reciprocal of___________ a) Electrical resistance b) Electrical Conductance c) Thermal conductance d) Thermal resistance		
3	In adsorption cooling system, adsorbent temperature _____________, which induces a pressure ___________, from the evaporation pressure up to the condensation pressure. This period is equivalent to the "compression" phase in compression cycles. a) Increases, increase b) Decreases, decrease c) Increases, decrease d) Decreases, increase		
4	Water movement through a membrane from low salinity side to the high salinity side is a) Osmosis b) Reverse osmosis c) Thermal Vapor Compression d) Mechanical Vapor Compression		
5	Molecular oxygen is broken down in the ___________ by solar radiation to yield atomic oxygen, which then combines with molecular oxygen to produce ozone. The ozone is then destroyed by chlorine atoms. a) Exosphere b) Thermosphere c) Stratosphere d) Troposphere		
6	Wein's law relates a) The wavelength of peak emission and temperature b) Wavelength of peak emission and scattering angle c) Temperature and reflectance of light d) Intensity of the peak emission and azimuthal angle of irradiance		
7	The maximum thermodynamic efficiency calculated by Shockley-Queisser is a) 11 % b) 25% c) 31% d) 42%		
8	The maximum efficiency that can be attained with a conventional single gap cell is a) 10.2% b) 25.7% c)63.2% d) 40.7%		
9	The average value of irradiance per year is called a) solar flux b) solar constant c) solar power d) solar specific energy		
10	10.Unit of cumulative irradiance is a) Watt per m2 b) Watt-hour per m2 c) lumen per Watt d) lumen per Watt-hour		
11	11.Heliostats made from low iron float glass have a reflectivity 0.903. However, dirt reduces reflectivity to ___________ a) 0.85 b) 0.82 c) 0.87 d) will not reduce		

12	____________ salt mixtures can be used as both a heat transfer fluid and a storage medium at temperatures of up to 565°C in CPS. a) Chloride salt b) Iodine salt c) Nitrate salt d) Bromide salt		
13	$\tau + \alpha + \rho =$ a) 0 b) 1 c) 10 d) 100		
14	If the aperture area is increasing, the concentration ratio of collector will ______________________ a) Increase b) decrease c) will not change d) drops to zero		
15	How the collector efficiency and the solar radiation are related a) Directly proportional b) Inversely proportional c) Directly proportional to the square of the solar radiation d) Not related		
16	A __________________ is a passive solar building design where a wall is built on the winter sun side of a building with a glass external layer and a high heat capacity internal layer separated by a layer of air. a) Mullion wall b) Shear wall c) Trombe wall d) Pony wall		
17	Solar saving fraction is the amount of energy provided by the solar technology divided by _____________________ a) Total energy required b) Total Energy provided c) Total energy wastedd) Total energy transmitted		
18	Power loss in solar collector QL equals to a) UA(Tc-Ta) b) U/A(Tc-Ta) c) UA(Ta-Tc) d) $UA(Ta-Tc)^2$		
19	CPC stands for a) Concentrated Parabolic Collector b) Compound Parabolic Collector c) Cumulative Parabolic Collector d) Centered Parabolic Collector		
20	Turbines are placed ________________ in chimney, ____________ in the collector. In order to obtain maximum energy from the warmed air, turbines blades should cover all the cross-sectional area of the chimney. a) Vertically, horizontally b) Vertically, vertically c) Horizontally, vertically d) Horizontally, horizontally		
	PART – B Short Answer **Marks:8 x 5 = 40**		
21	A) What is photovoltaic cell? Explain briefly about the different generations of solar cell technology. (5) or B)		

	Write short notes on any two of the following: (5) a) Solar energy. b) Solar radiation. c) Atmospheric effects on solar radiation		
22	A) What are the solar derived renewable energy Sources? Describe the characteristics of incident solar radiation.? (5) or B) Define solar a) Irradiance b) Irradiation c) Insolation. Explain the various factors which limits the efficiency of solar cell. (5)		
23	A) a) Define briefly about the solar cooker with neat diagram?(2) b) Draw the schematic diagram of the solar heating collector and explain each section in detail? (3) or B) a) Define solar thermal energy and its applications? (2) b)How does solar thermal system work. (1) c) What are the different types of solar thermal systems? (2)		
24	A) a) What are Heliostats, describe heliostat errors (3) b) What is cosine effect in Heliostats (2) or B) a) Describe about industrial solar system with heat storage and industrial solar system without heat storage (3) b) What are solar ponds (2)		
25	A) a) Describe in detail the working principle of solar Chimneys, and its different parts. (5) **or** a) What are thermosiphon systems, describe the principle of thermosiphon systems (3) b) Write about the characteristics of concentrated solar power (2)		
26	A) a) What is a Trombe wall (2) b) Describe about solar hot water collectors (3) or B) a) Describe about passive solar heating (3) b) What are the elements of passive solar design.? (2)		
27	A) a) Describe the formation and the depletion of ozone layer in the atmosphere. (5)		

	or B) a) How does drying preserves food? What are the steps for success in drying food?(3) b) Describe solar drying and their importance (2)		
28	A) a) What is solar cooling. What are the main components of solar cooling (3) b) What are the advantages of solar cooling (2) or B) a) What is solar heat gain coefficient (1) b) What is the difference between U factor and R value (1) c) Describe about visible transmittance, air leakage, and condensation resistance (3)		

- **Course Content**

Course Code: PHY E015 **Course Title: -** NONLINEAR DYNAMICS		**Theory**	**Credits: 4**
Units	**Content**		**Hrs.**
I	Linear and Nonlinear systems - Mathematical models examples – Mathematical Implications of Nonlinearity: superposition principle and its validity-Examplesandproblems-linearandnonlinear oscillators – Resonance and Hysteresis - Examples andproblems-Autonomousandnonautonomoussystems-Phaseplanetrajectories-stability, attractors and repellers - limit cycle - Examples and problems - Phase space - classification of equilibrium points - stabilityoffixedpoints- Examplesandproblems		12
II	Bifurcation - the logistic map – period doubling phenomenon- onset of chaos- other routes to chaos -Lorentz systems - Sensitive dependence on initialcondition-controllingofchaos-bifurcationscenarioinDuffingoscillator-Examplesandproblems		**12**
III	Linear and nonlinear dispersive wave propagation - Fourier transformation and solution of initialvalue problem - wave packet and dispersion - Nonlinear dispersive system - Korteweg-de Vriesequation and the solitary waves and Cnoidal waves - Scott Russel's phenomenon and Korteweg-de Vries equation - Fermi-Pasta-Ulam lattice problem - FPU recurrence phenomenon - numericalexperimentofZabuskyandKruskal- birth ofsoliton.		**12**
IV	Integrability and methods to solve soliton equations - The notion of integrability –multiple scale perturbation method - soliton solutions of perturbed nonlinear Schrödinger equation - Hirota's direct method and 'N' soliton solutions – Painleve's analysisanditsapplicationtoKorteweg-deVries equation, nonlinearSchrödinger equation-Lax pairfor Korteweg-deVriesequation.		**12**

V	Applications of Nonlinear dynamics - soliton applications in all optical communication - Energytransfer proteinandDNA- Functionofsolitoninneuronal microtubules - Ion-acoustic solitons in plasma: an application to Saturn'smagnetosphere- Pulse solitonsin blood circulatorysystems.	12
	Tasks and Assignments: **References:**	

- **Course Outcome (CO)**

	Course Outcome	Level
CO 1	To be able to understand basic concepts of dynamical system and nonlinearity with superposition principle and describing the linearand nonlinear oscillators, Resonance and occurrence of Hysteresis with problems. To understand and solve the problems related to stability,attractors and repellers, limit cycle, equilibriumpoints, stabilityoffixedpoints and phase space.	Remember
CO 2	To be able to analyse changes (i.e. bifurcations) to dynamical systems as system parameters are varied with the proper explanation of concept of logistic map, period doubling phenomenon and the bifurcation in of duffing oscillator.	Understand
CO 3	To understand the propagations of linear and nonlinear dispersive waves with various phenomenon such as Korteweg-de Vriesequation and the solitary waves and Cnoidal waves, Scott Russel's phenomenon and Korteweg-de Vries equation, Fermi-Pasta-Ulam lattice problem, FPU recurrence phenomenon,etc..	Apply
CO 4	To analyse the integrability the nonlinear system and applying various numerical methods such as multiple scale perturbation method, Hirota's direct method and 'N' soliton solutions to solve the nonlinear equations (KdV and NLS) for soliton solution. To apply the Painleve's analysis to the Korteweg-deVriesequation,nonlinearSchrödinger equation and analysing theLax pairfor Korteweg-deVriesequation.	Analyze
CO 5	To study the applications of nonlinear dynamics and soliton application in optical communication, DNA, neuronal microtubules, plasma physics, Saturn'smagnetosphere and - Pulse solitonsin blood circulatorysystems.	Skill

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	2	**0**	**3**	**3**
CO2	**3**	**1**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**2**
CO4	**2**	**1**	**3**	**2**	**3**
CO5	**0**	**3**	**3**	**3**	**2**

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	2	2	2
Seminar	-	-	-	-	-
Test	6	6	6	6	6
Attendance	-	-	-	-	-
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

<u>Model Question Paper</u>

Course: Nonlinear Dynamics **Code: PHY 0E15**

Max. Time: 3 Hrs **Max. Marks: 60**

<u>Answer any ALL questions:</u> **5x16=80**

1. a) (i) Prove Superposition principle is invalid for nonlinear systems. [6 marks]
(ii) Elucidate a broad classification of equilibrium points and support with the phase Portrait for various choices of Eigen values. [6 marks]

(or)

b) (1) Write short notes on
(i) Attractors (ii) Repellers (iii) Limit Cycle [6 marks]
(2) What is an equilibrium point? Explain the classification of equilibrium points with appropriate diagram. [6 marks]

1. a) (i) Obtain the frequency- response relations and draw the primary resonance curves for the Driven van der Pol oscillator [4 marks]

$$\ddot{x}-\alpha\left(1-x\right)^2\dot{x}+\omega_0^2x=f\sin\omega t$$

(ii) Explain on set of chaos in the Logistic Map dynamics. [8 marks]

(or)

b) List down the applications of solitons in. [12 marks]

2. a) Construct one-soliton solution for the Korteweg-de-Vries equation by invoking Hirota’s Bilinearization method. [12 marks]

(or)

b) (i) Construct one-soliton solution for the Nonlinear Schrodinger equation by invoking Hirota’s Bilinearization method. [8 marks]
(ii) Write short notes on Scott-Russell phenomenon. [4 marks]

3. a) Employ the multiple scale perturbation method to solve a perturbed NLS equation

$iq_t + q_{xx} + 2|q|^2 q + \lambda A q_{xx} = 0$ [12 marks]

(or)

b) (i) Employ the Painleve Analysis to the Nonlinear Schrodinger equations and elucidate the complete integrability of the same. [12 marks]

5. a) Discuss the applications of solitons

(i) Optical communication Systems and (ii). Neuronal Microtubules [6+6 marks]

(or)

b) Discuss the applications of solitons

(i) DNA (ii) hydrogen bonded systems and peptides. [6+6 marks]

- **Course Content**

Course Code, Course Title **PHY0E23, Advanced Electromagnetic Theory**		**Theory/Practical**	**Credits 4**
Unit -1	POLARIZATION IN MATTER Electric fields in matter – induced dipoles and electric susceptibility, forces and torques on dipoles in non-uniform fields, Polarization of a medium, field due to polarized object – concept of bound and surface charges, field of an uniformly polarized sphere, electric displacement – Gauss's in the presence of dielectrics, boundary conditions, linear dielectrics, dielectric constant, energy stored in dielectric systems, forces on dielectrics.		Hours* 12
Unit -2	MAGNETIZATION IN MATTER Magnetic fields in matter – magnetic dipoles – forces and torques on magnetic dipoles, induced orbital dipole moment in atoms – origin of diamagnetism, field due to magnetized object – concept of bound and surface currents, field of an uniformly magnetized sphere, Ampere's law in magnetized materials, boundary conditions, linear magnetic media – susceptibility and permeability, energy of a magnetic dipole in magnetic field, interaction energy of two magnetic dipoles		12
Unit -3	POTENTIAL FORMULATIONS OF ELECTRODYNAMICS Scalar and vector potentials in electrodynamics, Gauge transformations, Lorentz gauge, Coulomb gauge, Retarded potentials of continuous charge and current distributions, Jefimenko's equations, Retarded potential and fields of an current carrying wire, Retarded potential of a point charge in motion – LienardWiechert Potentials, Retarded potentials and fields of a moving point charge – uniform linear and circular motion, fields of a line charge in uniform motion.		12
Unit -4	RADIATION Electric dipole radiation – power radiated by dipole oscillations, Magnetic dipole radiation – Intensity of radiation, Radiation from an arbitrary source of charges and currents, fields of quadrupole radiation, power radiated by an accelerated point charge – Larmor formula, Radiation reaction and its physical explanation, Abraham-Lorentz formula, Radiation damping		12

Unit -5	RELATIVISTIC ELECTRODYNAMICS Magnetism – Relativistic viewpoint, Transformation of electric and magnetic fields – Lorentz transformation, electric and magnetic fields of a point charge in uniform motion – Gauss's law for charges in motion, relativistic invariance of field quantities, transformations of an electromagnetic plane wave, Electro-magnetic field tensor, electrodynamics in tensor notation, Lorentz-Force law in relativity, Relativistic potentials.	12
	Tasks and Assignments: References: 1. David J. Griffiths, Introduction to Electrodynamics, Pearson Publisher, 4th Edition, 2012. 2. Tai L. Chow, Introduction to Electromagnetic Theory, Jones & Bartlett Publishers, First Edition, 2012. 3. J A Stratton, Electromagnetic Theory, Read Books Publisher, First Edition, 2010. 4. J R Reitz, Foundations of Electromagnetic Theory, Narosa Publisher, Third Edition, 1997. 5. J D Jackson, Classical Electrodynamics, John Wiley, Third Edition, 1998.	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Explain basic processes of electric and magnetic fields in matter by defining polarization and magnetization.	Remember
CO 2	The concept of retarded potentials and radiation from accelerated charges.	Understand
CO 3	Apply the concept of retarded potentials to explain radiation from oscillating electric and magnetic dipoles.	Apply
CO4	Analyze the relativistic effects in electrodynamics to solve advanced problems in physics.	Analyze

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	3
CO2	3	2	2	3	3
CO3	3	2	2	3	3
CO4	3	2	2	3	3

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	Total
Internal	10	10	10	10	40
External	15	15	15	15	60
Total	**25**	**25**	**25**	**25**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4
Assignments	2.5	2.5	2.5	2.5
Seminar	-	-	-	-
Test (Internal 1 & Internal II)	7.5	7.5	7.5	7.5
Attendance	-	-	-	-
Total	10	10	10	10

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	15	15	15	15
Total	**15**	**15**	**15**	**15**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4

2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

End Semester Exam- Model Question Paper

Total Marks: 60 *Duration: 3hrs*
Sub Code:PHY0E23 *Sub Title: Advanced Electromagnetic Theory*

I. Answer in detail (Answer either A* OR *B of Q.Nos 1 to 5. Each Question carries Twelve marks)

1.**A) i)** An atom modelled as consisting of a point charge (+q) surrounded by a uniformly charged
spherical cloud (-q) of radius "a". Calculate the atomic polarizability of such atom.(4 Marks)

ii) A dipole $\vec{p}$ is a distance r from a point charge q, and oriented so that $\vec{p}$ makes an angle θ with the vector $\vec{r}$ from q to $\vec{p}$. Derive an expression for the force acting on $\vec{p}$. (8 Marks)

(OR)

B) i) Derive Gauss's law in presence of dielectrics. (4 Marks)

ii)A sphere of linear dielectric material has embedded in it a uniform free charge density ρ. Find the potential at the center of the sphere (relative to infinity), if its radius is R and its dielectric constant is ε_r. (8 Marks)

2.**A)** Explain the effects of magnetic field on atomic orbitals by considering an electron revolving around in a circle of radius "R". Derive an expression for the dipole moment induced by the magnetic field.

(OR)

B) i) Derive Ampere's law in magnetized material. (4 Marks)

ii)A current "I" flows down a long straight wire of radius "a". If the wire is made of linear material with susceptibility "χ_m", and the current is distributed uniformly, what is the magnetic field at a distance "s" from the axis? Find all the bound currents and check that they add up to zero. (8 Marks)

3.**A)**Determine the retarded potentials for a charge in Hyperbolic motion given by $\vec{w}(t) = \sqrt{b^2 + c^2t^2}\hat{x}$.Assume the point $\vec{r}$is on the x-axis and to the right of the charge.

(OR)

B)An infinite straight neutral wire carries a linearly increasing current $I(t) = \begin{cases} 0 \text{ for t} \leq 0, \\ \text{kt for t} > 0. \end{cases}$
Find the resulting electric and magnetic fields.

4. **A)** Derive an expression for the potential of an oscillating electric dipole. Find the electric field of electric dipole radiation in the far-field zone.

(OR)

B) A current I(t) flows around the circular ring in the xy plane. Find the electric field generated by this configuration in the far-field zone.

5.A) Explainhow electric and magnetic fields change under Lorentz transformation. Derive the transformation relations between them in different frames of reference.

(OR)

B) Express the laws of electrodynamics (Maxwell's equations and Lorentz Force law) in (relativistic) tensor notation.

- **Course Content**

Course Code: PHY0E29 **CourseTitle: Nanomaterials And Nanotechnology**		**Theory**	**Credits 4**
Unit -1	**Introduction** Introduction to nanotechnology, physics of low-dimensional materials, quantum effects, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Zero-, One-, Two- and Three-dimensional structure, Size control of metal nanoparticles and their properties: optical, electronic, magnetic properties; surface plasmon resonance, change of bandgap; Application: catalysis, electronic devices		Hours 12
Unit -2	**Nanofabrication** Importance of size distribution control, size measurement and size selection, assembling and self-organization of nanostructures, Nanofabrication: patterning of soft materials by self-organisation and other techniques, chemical self-assembly, artificial multilayers, cluster fabrication, Langmuir-Blodget growth, Nanolithography, Scanning probe lithography, Micro contact printing.		**12**
Unit -3	**Nanoelectronics and devices** Advantages of nano electrical and electronic devices, micro and nano-electromechanical systems – sensors, actuators, optical switches, bio-MEMS diodes and nano-wire transistors - data memory lighting and displays, filters (IR blocking) – quantum optical devices – batteries - fuel cells and photo-voltaic cells – electric double layer capacitors – lead-free solder – nanoparticle coatings for electrical products		**12**
Unit -4	**Nanocatalysts and Nanoporous materials** Nanocatalyts, smart materials, heterogenous nanostructures and composites, nanostructures for molecular recognition (quantum dots, nanorods, nanotubes) – molecular encapsulation and its applications – nanoporous zeolites – self-assembled nanoreactors - organic electroluminescent displays		**12**

Unit -5	**Nanotechnology for Nanomedince** Drug deliveries, drug delivery system, nanoparticle in drug delivery-available applications, nanotechnology future application understanding for treatment. Manufacture of nanoparticles, nanopowder and nanocrystals, targeting ligands applications of nanoparticle in drug delivery, cancer treatment, tissue regeneration, growth and repair, impact of drug discovery and development.	**12**
	Tasks and Assignments: **Books recommended:** 1. Nanolithography and patterning techniques in microelectronics, David G. Bucknall, Wood head publishing 2005 2. Transport in Nanostructures, D.K. Ferry and S.M. Goodmick, Cambridge university press 1997. 3. Optical properties of solids, F. Wooten, Academic press 1972 4. Micro and Nanofabrication, Zheng Cui, Springer 2005 5. Nanostructured materials, Jackie Y. Ying, Academic press 2001 6. Nanotechnology and nanoelectronics, W.R, Fahrner, Springer 2005 7. Hand book of Nanoscience, Engineering, and Technology, William A. Goddard, CRC press 2003. 8. Nanoelectronics and Information Technology, Rainer Waser, Wiley-VCH 2003. 9. The MEMS Handbook Frank Kreith, CRC press 2002. 10. Charles P. Poole, Jr., Frank J. Owens, “Introduction to nano technology”, Wiley, 2003. 11. Gunter Schmid, “Nanoparticles: From Theory to Applications”, Wiley-VCH Verlag GmbH & Co., 2004. **Supplementary Reading:** 1. Pradeep T “Nano: The Essentials”, Mc Graw Hill Publishing Co. Ltd., 2007 2. Mick Wilson et al, “Nanotechnology”, Overseas Press (India) Pvt. Ltd., 2005. 3. Nanoengineering of structural, functional and smart materials, Mark J. Schulz, Taylor & Francis 2006. 4. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005	

- **Course Outcome (CO)**

	Course Outcome	Level
CO 1	To get brief introduction about the nanomaterials and nanotechnology. Also understand the size and shape dependent on the physical properties of materials at nanoscale.	Acquire, Understand, Apply, Skill
CO 2	Gain knowledge about the importance of size distribution, size selectivity, self-assembly on properties of nanoscale materials. Understand various nanofabrication techniques used to synthesis nanomaterials.	Remember, Evaluate, Analyze, Skill

CO 3	Analyze the advantages of using nanotechnology for various electronic applications.	Remember, Understand, Analyze, Apply
CO 4	Understand molecular recognition, molecular encapsulation, nanocomposites, nanoreactors, nano porous materials for catalysis and smart applications.	Acquire, Understand, Apply, Skill
CO 5	Gain knowledge about nanomedicine, targeted drug delivery, diagnosis and treatment. Understand bio-inspired, bio-mimicking and bio-compatible nano-materials.	Understand,Analyze, Apply.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	2	3	3	1	1
CO3	3	1	3	3	3
CO4	3	3	2	3	3
CO5	3	2	3	3	2

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	3	3	-	-	3
Seminar	-	-	3	3	-
Test	5	5	5	5	5
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Part – C (Essay-5 x 12 = 30 marks)	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organization** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- **Course Content**

Course Code, Course Title PHY0E30- Physics of Magnetism and Spintronics		**Theory/~~Practical~~**	**Credits 4**
Unit -1	**Fundamental of Magnetism** Origin of permanent magnetic dipoles; Quantum theory of the magnetic moment; Hund's rules. Classical and quantum aspects of diamagnetism; paramagnetism; Curie law; formula of Van Vleck; Crystal field: d-f-metals, magnetic anisotropy; adiabatic demagnetization; Ferromagnetism; Weiss theory; domains; Bloch wall; Hysteresis;		Hours* 12
Unit -2	**Magnetic Interactions and Relaxation** Exchange interaction, super-exchange, double exchange. Band magnetism. Collective excitation; Long-range order: Mean field theory: the theory of Weiss (Neel). Molecular field. Order parameter. Ferro-, antiferro-, iron-		12

	magnetism, other types of order. Spin glass, Magnetic domains. Hard & soft materials. Domain Theory; Exchange bias. Spin –latttice relaxation; spin-spin relaxation	
Unit -3	**Nano-magnetism**. Single-domain particle; Super-paramagnetism; Nanoparticles & molecular magnets.Stoner Wohlfarth model; Landau-Lifschitz-Gilbert Model; Neel-Brown model. Nanoscale magnetisam in small particles; thin films; wires; needles and bulk nanostructures	12
Unit -4	**Spintronics**: Spin polarized currents; magnons; Spin-orbit interaction; Spin relaxation; Spin dependent Scattering and Transport; Spin dependent tunneling and Transport; Spin valve; Giant Magneto Resistance; Magnetic Random Access Memory; spin torque; Spin transfer oscillators; spin transistors	12
Unit -5	**Molecular magnetism:** High-spin, low spin molecules; quantum theory of molecular magnetisam: tunneling of magnetization; other functionalities of molecular nanomagnets: magneto caloric effect;	12
	Tasks and Assignments: **References:**	

- **Course Outcomes**

	Course Outcome	Level
CO 1	Identify different kinds of magnetism in solids.	Remember
CO 2	Understanding fundamentals of magnetism; magnetic anisotropy, magnetic domain kinetics; magnetic hysteresis.	Understand
CO 3	Description of long range magnetic order and of magnetic phenomena at the nanoscale and at molecular and atomic level; Various spin dependent transport phenomena; magnetoresistance effect; Spin-torque transfer phonemena	Understand
CO4	Compare the materials with regards to their magnetic and transport properties and analyse their relevance in relation to technological applications;	Analyze
CO5	Generalize device concepts, theories and materials requirements for spintronic devices	Skill

- **Program Outcomes (PO)**

PO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines.
PO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PO5	Provide value based and ethical leadership in the professional and social life.

- **Mapping of Program Outcomes with Course Outcomes**

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	1
CO2	3	3	2	3	1
CO3	3	3	3	2	3
CO4	3	3	2	3	2
CO5	3	3	3	3	2

- **Evaluation Scheme**

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

- **Mapping Course Outcome with Internal Assessment (40 Marks)**

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test (Internal 1 & Internal II)	6	6	6	6	6
Attendance	-	-	-	-	-
Total	8	8	8	8	8

- **Mapping Course Outcome with External Assessment (60 Marks)**

Category	CO1	CO2	CO3	CO4	CO5
Part – A **Essay Type (Either/OR-type Question)** **12 x 5 = 60 Marks**	12	12	12	12	12
Total	**12**	**12**	**12**	**12**	**12**

- **Rubric for Assignments**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence &facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5

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- **Rubric for Seminar**

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

- **End Semester Examination- Model Question Paper**

तमिलनाडु केन्द्रीय विश्वविद्यालय

(संसद द्वारा पारित अधिनियम 2009 के अंतर्गत स्थापित)

A

CENTRAL UNIVERSITY OF TAMIL NADU

(Established by an Act of Parliament, 2009)

नीलक्कुड़ी परिसर/Neelakudi Campus, कंगलान्चेरी/Kangalancherry, तिरुवारूर/Thiruvarur - 610 101

End Semester Examinations- Nov/Dec- 2016

Integrated M.Sc- IV Year- Semester- VII

PHY0E30 PHYSICS OF MAGNETISAM AND SPINTRONICS

Reg. No:

Total Marks: 60
Duration: 3 Hour

ANSWER ALL **5 X 12= 60**

Note: Please answer all parts of question at one place only

Q1-A **(a)** Define magnetic susceptibility. Derive the expression for magnetic susceptibility for a diamagnetic material based on quantum theory **(8M)**

(b) Derive Pauli spin magnetization of the conduction electrons for $K_BT \ll \epsilon_f$ **(4M)**

(OR)

Q1-B **(a)** Derive the expression for magneto caloric effect **(6M)**

(b) Define the magnetic susceptibility and explain how it vary in different type of magnetic substances and draw a schematic diagrams how it vary with temperature in dia, para and ferromagnetic materials **(6M)**

Q2-A **(a)** What is ferromagnetic order? Using mean field approximation derive the expression for Curie temperature and magnetic susceptibility at $T > T_c$ **(8M)**

(b) Describe the Landau theory of ferromagnetism **(4M)**

(OR)

Q2-B **(a)** Derive the magnon dispersion relation for a spin 'S' on a simple cubic lattice, Z = 6 **(6M)**

(b) Derive Bloch $T^{3/2}$ law using concept of thermal excitation of magnons **(6M)**

Q3-A **(a)** Discuss the nuclear magnetic resonance and derive the expression for resonance frequency **(6M)**

(b) Explain the concept of longitudinal and transverse relaxation processes **(6M)**

(OR)

Q3-B **(a)** Explain the effect of

I. Hyperfine splitting
II. Motional narrowing
III. MASER action
IV. Exchange narrowing on magnetic resonance **(12M)**

Q4-A **(a)** Describe the formation of Bloch domains walls and derive the expression for wall thickness and wall energy. Discuss how wall thickness depend on anisotropic and exchange energies through the schematic diagram **(8M)**

(b) Explain soft and hard magnetic materials and their applications **(4M)**

(OR)

Q4-B **(a)** Discuss various methods to observe the domain patterns in magnetic materials **(8M)**

(b) Show that hysteresis loss is equal to area of B-H curve **(4M)**

Q5-A **(a)** Describe the working principle of spin field effect transistor through the schematic diagram **(6M)**

(b) Descibe different conduction meachanisms assocaited with spin polarizatin currents **(6M)**

(OR)

Q5-B **(a)** Explain Giant magneto resistance (GMR) and **(b)** Tunnel magneto resistance (TMR) **(8M)**

(c) Explain the spin transfer torque **(4M)**

************************* **END** *********************************