U.G. 5th Semester Examination-2022

PHYSICS

[PROGRAMME]

Discipline Specific Elective (DSE)

Course Code : PHY-G-DSE-T-01(A-D)

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

Symbols have their usual meaning.

Answer all the questions from selected Option.

OPTION-A

PHY-G-DSE-T-01

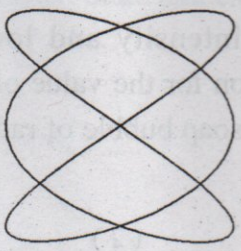
(Waves & Optics)

GROUP-A

1. Answer any **five** questions : 2×5=10

a) State and explain Fourier's theorem.

b) Determine the ratio of the frequencies in horizontal and vertical direction for the given Lissajous figure:



c) A particle is executing S.H.M. with a time period of 2 sec. After how much time its displacement will be half of its amplitude?

d) What do you mean reverberation and reverberation time?

e) State and explain Huygens principle.

f) Determine the thickness of a half wave plate and quarter wave plate for light wave of $\lambda = 6000\text{Å}$; given $\mu_0 = 1.65$ and $\mu_e = 1.55$.

g) What do you mean by visibility of fringes of an optical instrument?

h) What do you mean by coherent sources of light? Give example.

GROUP-B

2. Answer any **two** questions: $5 \times 2 = 10$

a) For a ray of light falling in the interface of two materials of different refractive indices and transmission coefficients, derive the Stokes relations: $t^2t + r^2 = 1$ and $r = -r^2$; the symbols have their usual meanings. What is zone plate? Write down its one application. $3+1+1=5$

b) Define intensity and loudness. Derive the expression for the value of the excess pressure inside a soap bubble of radius r. $2+3=5$

c) Explain the nature of Lissajous figure obtained due to superposition of the waves $x = a \sin \omega t$ and $y = b \cos \omega t$.

64 tuning forks are arranged in such a way that any two successive tuning forks produce 4 beats per second. If the frequency of the last tuning fork is the double of the first one. Determine the frequencies of the first and last tuning fork. 2+3=5

d) What is wavefront? Establish the laws of reflection from Huygen's principle. 1+4=5

GROUP-C

3. Answer any **two** questions: 10×2=20

a) Two coherent sources are 0.2 mm apart and the fringes are observed on a screen 80cm away. It is found that with a certain monochromatic light the fifth bright fringe is situated at a distance of 12 mm away from the central fringe. Find the wavelength of light. Explain briefly how the small wave length difference of two components of a light can be determined using Michelson's Interferometer. State and explain Malus' law. 4+4+2=10

b) What do you mean by positive and negative crystal? Write a short note on Nicol prism. Define angle of contact. What do you mean by synclastic and anticlastic surface?

2+4+2+2=10

c) A displacement curve is given by $f(t) = A$ for $0 < t < T/2$ and $f(t) = -A$ for $T/2 < t < T$; Where A is a constant. Draw the graph of $f(t)$ and obtain the Fourier series expansion for $f(t)$. Define bel and phon.

6+4=10

d) State the laws of transverse vibrations of a stretched string. Considering necessary assumptions derive Sabine's formula of optimum reverberation. What is the difference between Fresnel and Fraunhofer diffraction?

3+5+2=10

OPTION-B

PHY-G-DSE-T-01

(Thermal Physics and Statistical Mechanics)

GROUP- A

1. Answer any **five** questions: $2\times5=10$

   a) Write down the first law of thermodynamics explaining each term.

   b) Name one boson and one fermion.

   c) What are the basic assumptions for the kinetic model of gaseous system?

   d) One mole of an ideal gas at $0^{o}C$ is isothermally expanded from 1 litre to 2 litre. Find the work done.

   e) What is black body radiation?

   f) Represent a Carnot cycle on: i) p - v diagram, ii) S - T diagram.

   g) What is an isenthalpic process, discuss with an example.

   h) Write down the Maxwell Boltzmann molecular velocity distribution law explaining all the symbols used.

GROUP-B

2. Answer any **two** questions. 5×2=10

a) Define mean free path of gas molecules. Show that the probability of gas molecule traveling a distance x without collision, is $e^{x/\lambda}$ where λ is the mean free path of the gas molecule. 1+4=5

b) Discuss the concept of quasistatic process in thermodynamics. During a quasistatic adiabatic expansion of an ideal gas, the pressure at any moment is given by the equation $PV^{\gamma} = K$ where γ and K are constants. Show that the work done in expanding from a state (P_i, V_i) to a state (P_f, V_f) is $W = -\dfrac{P_i V_i - P_f V_f}{\gamma - 1}$. 2+3=5

c) A Carnot engine operates between T_1 and T_2 with gas as working substance whose equation of state is given by $P(V-b)=RT$ Work out expression for heat absorbed and the work done in each part of the cycle and show that the efficiency $\eta = 1 - \dfrac{T_2}{T_1}$. 2+2+1=5

d) What do you mean by phase space? Write Bose-Einstein distribution law and Fermi- Dirac distribution law explaining each term. $2+1\frac{1}{2}+1\frac{1}{2}=5$

GROUP-C

3. Answer any **two** questions: $10\times2=20$

a) Write down four Maxwell's relations. Write down the first and second TdS equations. Hence prove the relation $C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$. 4+3+3

b) Derive Planck's radiation law in case of black body radiation. In what conditions that Planck's law reduces to Wein's law and Rayleigh-Jeans law? Calculate the total rate of radiation of energy of a thin circular disc of radius 10 cm, heated at 500°C. 5+2+3

c) What is Joule-Thomson effect? Show that the Joule-Thomson coefficient μ can be derived as $\mu = \left(\frac{\partial T}{\partial P}\right)_H = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]$. Hence show that ideal gas does not show any Joule- Thomson effect. What do you mean by inversion temperature? Write short note on Clausius-Clapeyron equation. $2+3+1+1\frac{1}{2}+2\frac{1}{2}$

d) What is the principle of increase of entropy? Calculate the change of entropy for an ideal gas which undergoes an isothermal expansion. What do you mean by Gibb's free energy? Show that for an infinitesimal reversible process $dG = -SdT + VdP$ (symbols have their usual meaning). Also show that in case of a reversible isothermal and isobaric process Gibb's free energy remains constant. 2+3+1+3+1

OPTION-C

PHY-G-DSE-T-01

(Electricity and Magnetism)

GROUP-A

1. Answer any **five** of the following questions: $2\times5=10$

a) A point charge q is placed at a distance d from an infinite conducting plane. Find the work necessary to move the charge to infinite distance from the plane.

b) Check whether the following represent electrostatic fields or not:

$\vec{E}_1=\left(4y\hat{i}-2x\hat{j}-\hat{k}\right);\ \vec{E}_2=\left(4xy-z^3\right)\hat{i}+2x^2\hat{j}-3xz^2\hat{k}$.

c) State and explain Gauss law in dielectric medium.

d) What is Lorentz force? Explain with diagram.

e) Show that electric field is always perpendicular to the equipotential surface.

f) Write the differential form of Gauss's law for dielectric.

g) Define polarization vector of a dielectric. What is its physical significance?

GROUP-B

2. Answer any **two** of the following questions: $5\times2=10$

a) What is Maximum Power Transfer Theorem? Using this theorem, show that Power Transfer Efficiency cannot exceed 50%. 2+3

b) Write the differences between dia-, para- and ferro magnetic materials. Define Poynting vector. What is reciprocity theorem? 3+1+1

c) Derive the expression of Potential and Electric Field due to an electric dipole of dipole moment "m" at a point at a distance r from it on axis. 5

d) Write the Maxwell's equations of electromagnetic theory and give their physical significance. 5

GROUP-C

3. Answer any **two** questions: $10\times2=20$

a) i) A spherical shell of inner radius r_1 and outer radius r_2 is uniformly charged with charge density ρ. Calculate the electric field and potential at a distance r from the centre of the spherical shell for i) $r > r_2$ ii) $r_1 \leq r \leq r_2$ and iii) $r \leq r_1$.

ii) Derive an expression of Electrostatic energy of a charged sphere.

iii) What is magnetic vector potential?

6+3+1

b) i) State Kirchhoff 's Voltage law. Show that it is consistent with the principle of conservation of energy.

ii) State Faraday's law of electromagnetic induction and express it in differential form.

iii) Derive an expression of capacitance of a cylindrical capacitor whose inner and outer radii are 'a' and 'b' respectively.

2+4+4

c) i) Write down the relation between B, H and M. What is ferromagnetism? Draw magnetization curves for soft iron and steel on the same graph as each is taken through a complete cycle of magnetic field.

ii) Show that the hysteresis loss per unit volume per cycle of magnetization is equal to the area enclosed by the B-H loop.

iii) Derive an expression of Magnetic force on a current carrying wire. (1+1+2)+3+3

d) i) If $\vec{v} = \vec{\omega} \times \vec{r}$ prove that $\vec{\omega} = \frac{1}{2} curl\, \vec{v}$ where $\vec{\omega}$ is a constant vector.

ii) Prove that for parallel LCR circuit at resonance the impedance of the circuit is maximum.

iii) Starting from the expression of magnetic vector potential $\vec{A} = \frac{\mu_0 I}{4\pi} \int \frac{\overline{di}}{r}$, obtain the expression

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{\overline{dl} \times \vec{r}}{r^2}, \text{ where } \vec{B} = \vec{\nabla} \times \vec{A}.$$

3+4+3

OPTION-D

PHY-G-DSE-T-01

(Mechanics)

GROUP–A

1. Answer any **five** of the following questions: $2\times5=10$

a) Prove that

$$\vec{A}\times\left(\vec{B}\times\vec{C}\right)+\vec{B}\times\left(\vec{C}\times\vec{A}\right)+\vec{C}\times\left(\vec{A}\times\vec{B}\right)=0$$

b) State the postulates of Einstein's special theory of relativity.

c) A particle of mass 10 gm lies in a potential field $V=\left(32x^2+200\right)ergs/gm$. What is its frequency of oscillation'?

d) Find the order and degree of the equation $\left(\frac{d^2y}{dx^2}\right)^2+\left(\frac{dy}{dx}\right)^5+3=0$.

e) Show that the *escape velocity* from the surface of the earth is $\sqrt{2}$ times the velocity of projection of an artificial satellite orbiting close around the earth.

f) Show that the theoretical limiting values of Poisson's ratio are –1 and 0.5.

g) Show that whereas length (or distance) and acceleration are invariant to Galilean transformation, velocity is not.

h) What is thc particular advantage in taking a centre of mass frame of reference?

GROUP-B

2. Answer any **two** questions: 5×2=10

a) i) Prove that the vector $2\hat{\imath} - \hat{\jmath} + \hat{k}, \hat{\imath} + 2\hat{\jmath} + 3\hat{k}$ and $3\hat{\imath} - 4\hat{\jmath} + 5\hat{k}$ are coplanar.

ii) The proper mean life-time of *pions* is 2.5×10^{-8} sec. At what velocity will they appear to have a mean life-time of 2.5×10^{-7} sec? 2+3

b) i) A lift is ascending at acceleration of 3 m/s^2. What is the period of oscillation of a simple pendulum of length one metre suspended in the lift?

ii) Solve $(x^2 - y^2)dx + 2xydy = 0$. 2+3

c) i) A circular hollow rod and a circular solid rod of same length and same mass are to be twisted by same amount. Which one will be more difficult to perform?

ii) The maximum and minimum distances of a comet from the sun are 1.4×10^{12} m and 7×10^{10} m. If its velocity nearest to the sun is 6×10^{4} m/sec, what is its velocity when farthest?

Assume in both positions that the comet is moving in a circular orbit. 3+2

d) i) A particle of mass m_1 moving with velocity v collides *head on* against a particle of mass m_2 at rest. Taking the collision to be an *elaslic* obtain the velocities of the two particles and the fraction of the total kinetic energy acquired by the second particle after the collision. How will this fraction change if $m_1 = m_2$?

ii) Give the basic idea of global positioning system (GPS). 2+1+2

GROUP-C

3. Answer any **two** questions 10×2=20

a) i) A rigid body is spinning with an angular velocity of 4 radians about an axis parallel to $3\hat{j}-\hat{k}$ passing through the point

$\hat{i}+3\hat{j}-\hat{k}$. Find the velocity of the particle at the point $4\hat{i}-2\hat{j}+\hat{k}$.

ii) What are damped vibrations? Establish the differential equation of motion for a damped harmonic oscillator and obtain an expression for displacement.

iii) For a particle of mass $m=10.0\ gm$, position $\vec{r}=10\hat{i}+6\hat{j}$ cm and velocity $v=5\hat{i}\ cm/sec$, calculate the angular momentum about the origin. 2+(1+4)+3

b) i) Using the basic postulates of the special theory of relativity obtain the expression for Lorentz transformation.

ii) Obtain the complete solution of the differential equation

$$\frac{d^2y}{dx^2}-7\frac{dy}{dx}+6y=e^{2x},$$

and determine the constant so that y = 0 when x = 0.

iii) If Y,η and K represent Youngs modulus, coefficient of rigidity and bulk modulus respectively, prove that $\frac{9}{Y}=\frac{3}{\eta}+\frac{1}{K}$.

c) i) Explain the terms 'gravitational potential' and 'gravitational field'. Obtain expressions for the gravitational potential and gravitational field at a point (A) inside. (B) Outside a hollow spherical shell.

ii) A particle is moving along a curve in a plane. Derive expression for its radial and transverse components of velocity and acceleration. (3+3)+4

d) i) Show that when the vector sum of the external forces acting upon a system of particles equals zero. the total linear momentum of the system remains constant.

ii) An empty rocket weighs 5000 kg and contains 40,000 kg fuel. If exhaust velocity of the fuel is 2.0 km/sec, calculate the maximum velocity gained by the rocket.

iii) Define angular momentum $\vec{j}$ and torque $\vec{\tau}$. What are their units? Show that torque is given by the time rate of change of angular momentum. 4+3+3
