U.G. 1st Semester Examination - 2022

PHYSICS

[HONOURS]

Generic Elective Course [GE]

Course Code : PHY-H-GE-T-01(A),(B)&(C)

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.

Answer all the questions from selected Option.

OPTION-A

PHY-H-GE-T-01(A)

(Mechanics)

GROUP-A

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

   a) State generalised Hooke's law.

   b) Show that the motion represented by $x = 3\sin\omega t + 4\cos\omega t$ is simple harmonic. What is the amplitude of oscillation?

   c) A body undergoing SHM is characterised by $x = a\cos\omega t$. Find the displacement at which kinetic energy is equal to half the total energy.

[Turn over]

d) What is the relative speed of photon with respect to another photon moving towards it?

e) Lorentz transformation equations reduce to Galilean transformation equations when $v \ll c$. Explain.

f) Solve the equation $\left(D^2 - 4D + 4\right)y = 0$ given that y=1 and Dy=3 when t=0 .(Here $D = \frac{d}{dt}$)

g) A particle moves from point (3, –4, –2) to a point (–2, 3, 5) under the influence of a force F= (2i+3j+4k) N. Calculate the work done by the force.

h) Find the speed of light at which the mass of an electron is double its rest mass.

GROUP-B

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

a) Show that the kinetic energy for a system of particles is equal to the kinetic energy of single particle of total mass M situated at the centre of mass, together with K.E of the system of particles with the motion relative to the C.M.

5

b) Establish a relation among Young's modulus(Y), bulk modulus (K), and Poisson's ratio (σ) of a rigid body. What are the limiting value of 'σ'? 4+1

c) Calculate the torque necessary to produce a twist of one radian in wire of length 'l' and radius 'r'. 5

d) A cubic box of side 'a' and mass 'm' vibrates vertically on a liquid of density 'ρ'. Show that time period of vibration is $\frac{2\pi}{a}\sqrt{\frac{m}{\rho g}}$. 5

GROUP-C

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

a) Show that central force is a conservative force. Show areal velocity is constant. Calculate the kinetic energy of a rotating rigid body. 3+3+4

b) Show that for a particle undergoing S.H.M, the average value of kinetic energy and potential energy are the same and each equal to half of total energy.

A wooden cylinder of mass ***m*** and area of cross section ***A*** is floating in equilibrium vertically

on a liquid of density ρ. If the cylinder is depressed slightly and then released, show that the cylinder undergoes a S.H.M with a time period. 5+5

c) Solve: $\frac{d^2y}{dx^2} - \frac{dy}{dx} - 2y = \sin 2x$

Find the projection of $\boldsymbol{A = i - 2j + k}$ on vector $\boldsymbol{B = 4i - 4j + 7k}$. 6+4

d) Write down the Lorentz transformation equations. Using them, obtain the rules for length contraction and time dilation. 2+4+4

OPTION-B

PHY-H-GE-T-01(B)

(Thermal Physics and Statistical Mechanics)

(Symbols have their usual meaning)

GROUP–A

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

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

b) Write down differences between one boson and one fermion. Give example of each.

c) What are the basic assumptions for the kinetic theory of gas?

d) State and explain the Law of equipartition of energy.

e) What is black body radiation? What is the emissivity of an ideal black body?

f) Explain Joule-Thompson Effect.

g) What is an isenthalpic process?– Discuss with an example.

h) State and explain Second law and Entropy.

GROUP-B

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

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

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 $W=-\dfrac{P_iV_i-P_fV_f}{\gamma-1}$. 2+3

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

d) Represent a Carnot cycle on (i) p–v diagram, (ii) S-T diagram. Write Bose-Einstein distribution law and Fermi-Dirac distribution law explaining each term with diagram. $2+1\frac{1}{2}+1\frac{1}{2}$

GROUP-C

3. Answer any **two** questions: 10×2=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 5000°C. 5+2+3

c) Write down the Maxwell-Boltzmann molecular velocity distribution law explaining all the symbols used. 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? State and explain 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-H-GE-T-01(C)

(Electricity and Magnetism)

(Symbols have their usual meaning)

GROUP–A

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

   a) Find the projection of the vector $\vec{A}=\hat{i}-2\hat{j}+\hat{k}$ on the vector $\vec{B}=4\hat{i}-4\hat{j}+7\hat{k}$.

   b) Determine the value of 'a' so that $\vec{A}=2\hat{i}+a\hat{j}+\hat{k}$ and $\vec{B}=4\hat{i}-2\hat{j}-2\hat{k}$ are perpendicular.

   c) Define Electrical susceptibility and Dielectric constant.

   d) What is the physical significance of $\vec{\nabla}.\vec{B}=0$?

   e) Write the Lenz's law of electromagnetic induction.

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

   g) Define polarization vector of a dielectric. What is it's physical significance?

GROUP-B

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

a) Write the Biot-Savart's law. Apply this law to find the magnetic field at a distance r due to a straight current-carrying conductor of finite length. 2+3

b) Write the differences between dia-, para-and ferro magnetic materials. Define Poynting vector. 3+2

c) Derive the expression of Potential and Electric Field of a dipole . Define displacement current. 4+1

d) Write the Maxwell's equations of electromagnetic theory. What is reciprocity theorem? 4+1

GROUP-C

3. Answer any **two** questions: 10×2=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) Write the Ampere's Circuital law.

ii) Applying this law to find the magnetic field inside a long solenoid.

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? Explain hysteresis in a ferromagnetic material in terms of B-H loop.

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 $\vec{\omega}$ a constant vector.

ii) Using Gauss's theorem of electrostatics find the electric field inside and outside of a uniformly charged sphere of radius 'r'.

iii) Starting from the expression of magnetic vector potential $\vec{A} = \frac{\mu_0 I}{4\pi} \int \frac{\vec{di}}{r}$, obtain the expression $\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{\vec{di} \times \vec{r}}{r^2}$, where $\vec{B} = \vec{\nabla} \times \vec{A}$. 3+4+3
