U.G. 5th Semester Examination-2023

PHYSICS

[PROGRAMME]

Discipline Specific Elective (DSE)

Course Code : PHY-G-DSE-T-01(A-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.

Symbols have their usual meaning.

Answer all the questions from selected Option.

OPTION-A

PHY-G-DSE-T-01

(Electricity and Magnetism)

GROUP-A

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

a) Derive Coulomb's law from Gauss' law.

b) Show that $\vec{\nabla} r^n = nr^{n-2}\vec{r}$.

c) Write down the Gauss' law of electrostatics and its physical significance.

d) What do we mean by the statement that the 'dielectric constant of glass is 8.5'?

e) Show that $\oint \vec{B}.\overrightarrow{dS} = 0$, where $\vec{B}$ is the magnetic field and S is a closed surface.

f) What is the difference between the conduction current and the displacement current?

g) Write down the integral form of the Biot-Savart law and its physical significance.

h) What do you mean by the term self-inductance? Write down the SI unit of self-inductance.

GROUP–B

Answer any **three** questions: 10×3=30

2. a) Find a unit normal to the surface $z^2 = x^2 - y^2$ at the point (1, 0, –1).

b) Show that the force

$$\vec{F} = \left(2xy + z^3\right)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$$

is conservative. If this force acting on a particle displaces it from the point (0, 1, 2) to (4, 2, 3), calculate the work done.

c) If $\vec{\nabla}.\vec{E} = 0$, $\vec{\nabla}.\vec{B} = 0$, $\vec{\nabla}\times\vec{E} = -\frac{\partial \vec{B}}{\partial t}$, $\vec{\nabla}\times\vec{B} = -\frac{\partial \vec{E}}{\partial t}$, then show that $\vec{E}$ and $\vec{B}$ satisfy $\nabla^2\psi = \frac{\partial^2\psi}{\partial t^2}$.

3+(2+2)+3

3. a) What is an irrotational or lamellar vector field?

b) Using Gauss' law, determine the electric field intensity due to a long thin wire of uniform linear charge density.

c) What are polar and non-polar dielectrics? What is meant by polarization of dielectric?

$2+5+(1\frac{1}{2}+1\frac{1}{2})$

4. a) Show that $\vec{D}=\varepsilon_0\vec{E}+\vec{P}$, where the symbols have the usual meaning.

b) The polarizability of a gas is 0.35×10^{-40} Fm^2. If the gas contains 2.7×10^{25} atoms/m^3 at 0°C and one atmospheric pressure, calculate its relative permittivity.

c) State Poynting theorem and its physical significance.

$5+3+2$

5. a) By applying Ampere's circuital law, find out magnetic field due to a long solenoid at a point (i) inside the solenoid, and (ii) outside the solenoid.

b) No two equipotential surfaces intersect each other. Why?

c) Define and discuss the term coefficient of coupling. How does this term lead to an upper limit for M, in terms of L_1 and L_2? Here, L_1 and L_2 are the self-inductance of two coils and M is their mutual-inductance. (2+2)+2+(2+2)

6. a) State Lenz's law. Explain it from the principle of conservation of energy.

b) What is Poynting vector? Show that Poynting vector measures the flow of energy per unit area per second in an electromagnetic wave. (1+4)+(1+4)

OPTION-B

PHY-G-DSE-T-01

(Mechanics)

GROUP-A

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

a) For which value of λ, the vector $\vec{A}=2i+\lambda j-3k$ will be a unit vector?

b) State the order and degree of differential equation

$$\frac{d^4y}{dx^4}+\left(\frac{dy}{dx}\right)^3+x^2y=0.$$

c) Write the definition of inertial and non-inertial frame.

d) State and prove work energy theorem.

e) Assuming the moon describe a circular orbit of radius 4×10^5 km round the earth in 27.3 days, calculate periodic time of an artificial satellite near the earth's surface (radius of the earth 6400 km).

f) If the displacement of a particle at any instant time t is given by $x=a\sin\omega t+b\cos\omega t$. Show that the motion of the particle is simple harmonic.

g) What is poisson's ratio? Show that $\sigma \leq 0.5$ for solid cylinder.

h) Write down the postulates of special theory of relativity.

GROUP–B

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

a) Solve the following differential equation:

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

A particle is moving along a straight line from (3, 2, –1) to (2, 1, 4) in a given force field $\vec{F} = 4\hat{i} - 3\hat{j} + 4\hat{k}$. Find the work done. 3+2

b) Find the relation among Young's modulus (Y), Bulk modulus (K) and Rigidity modulus (n). 5

c) Three particle of masses 4 gm, 2 gm and 2 gm are at point (2, 1, 0), (1, 2, 3) and (2, –1, 0) respectively. Find the coordinate of center of mass. The equation of a simple harmonic oscillator is given by $3\frac{d^2x}{dt^2} + 27x = 0$. Calculate the mass of the particle and time period. 3+2

d) Using Lorentz transformation equation, obtain the rules for length contraction and time dilation. $2\frac{1}{2}+2\frac{1}{2}$

GROUP–C

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

3. a) If $\vec{A}$ is a constant vector, show that $\vec{A}$ is perpendicular to $\frac{d\vec{A}}{dt}$.

b) A particle moves along a curve whose parametric equations are $x=e^{-t}$, $y=2\cos 3t$ and $z=2\sin 3t$. Find the velocity and acceleration at time $t = 0$.

c) Show that $\vec{A}.(\vec{B}\times\vec{C})=\vec{B}.(\vec{C}\times\vec{A})=\vec{C}.(\vec{A}\times\vec{B})$.

2+4+4

4. a) Write down the Keplar's law of planetary motion.

b) Show that angular momentum of a particle under central force field is constant.

c) What is Geostationary satellite? Find the height of Geostationary satellite from the earth surface. (Radius of the earth R=6400 km).

3+3+1+3

5. a) Write down the differential equation of damped vibration and explain each term.

b) Solve the differential equation for oscillatory damping (damping factor < frequency of oscillation).

c) Draw the displacement vs time graph for this case.

2+6+2

6. a) What is Young's modulus?

b) Deduce an expression for work done per unit volume on an elastic body experiencing longitudinal strain.

c) Two photon are moving towards each other in free space. Calculate the relative speed of any photon with respect to other.

d) Write the Lorentz transformation equations.

1+4+3+2

OPTION-C

PHY-G-DSE-T-01

(Thermal Physics Statistical Mechanics)

GROUP-A

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

a) What are extensive and intensive variables in thermodynamics? Give example of each.

b) Draw curves showing the distributions of energy for the particles obeying B-E and F-D statistics.

c) Draw the trajectory in the phase space of (i) a particle moving simple harmonically in a straight line and (ii) a free particle moving in a straight line.

d) A Carnot engine operating between a hot reservoir at 500K and cold reservoir at 300K. Calculate the percentage change in efficiency of that engine when the temperature of the hot reservoir is dropped down to 450K.

e) What is meant by root mean square velocity of gas molecules? Calculate the root mean square velocity of air molecules at N.T.P; Density of air is 1.29 kg/m^3.

f) What is Newton's Law of Cooling?

g) What is Enthalpy? Explain the fact that during an isobaric process the change in enthalpy is equal to the total heat transferred into the system.

h) What are reversible and irreversible thermodynamic processes? Give example of each.

GROUP–B

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

a) State the law of equipartition of energy. Discuss the dependence of coefficient of viscosity of a gas on pressure and temperature. 2+3

b) State zeroth law of thermodynamics and hence explain how this law is used to understand temperature as thermodynamic parameter. Draw p - V indicator diagram for (i) isochoric, (ii) isothermal, (iii) adiabatic and (iv) cyclic processes. 3+2

c) State the principle of unattainability of absolute zero. Why it can be regarded as an alternative statement of third law of thermodynamics? Calculate the change in entropy when 3 g of ice melt into water at the same temperature. Latent heat of ice is 80 cal/g. 1+2+2

d) State and prove Carnot's theorem. 2+3

GROUP–C

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

a) Using the fact that dS is an exact differential then obtain the first energy relation $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$. For Van der Waals's gas prove that $\left(\frac{\partial U}{\partial V}\right)_T = \frac{a}{V^2}$. Calculate latent heat of vaporisation of water at 100°C. Given: specific volume $v_1 = 1$ cc., $v_2 = 1674$ cc. and $\frac{dP}{dT} = 27.1$ mm of Hg/°c. 4+4+2

b) What is Black Body Radiation? Deduce Stefan Boltzmann Law from Planck's Law of Black body radiation. Draw the energy distribution curves of a perfect black body maintained at two different temperatures. Calculate the Stefan constant of a 40W tungsten filament bulb of temperature 2170°C with effective area 0.66 cm^2. The emissive power of the filament is 0.31. 1+4+2+3

c) Which should be the spin angular momentum of a system of particles obeying B-E and F-D statistics? What is photon gas? Apply B-E distribution law to a photon gas and obtain Planck's law of black body radiation. In how many ways two bosons can be distributed in three energy levels? 2+2+4+2

d) What is meant by entropy of a thermodynamic system? Discuss entropy changes of reversible and irreversible processes. What is state function?–give examples. What are the essential differences between isothermal and adiabatic processes? Which of the following remains constant in Joule-Thomson effect?

i) Entropy,

ii) Enthalpy,

iii) Helmholtz free energy and

iv) Gibbs free energy. 2+3+2+2+1
