U.G. 3rd Semester Examination - 2023

PHYSICS

[HONOURS]

Generic Elective Course (GE)

Course Code : PHY-H-GE-T-03

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-03

(Electricity and Magnetism)

GROUP–A

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

a) Find the angle between the vectors $\vec{A} = -\hat{i} + \hat{j} - \hat{k}$ and $\vec{B} = -\hat{i} - \hat{j} + \hat{k}$

b) State and explain Stokes theorem.

c) Check whether the vector $\vec{E} = y^2\hat{i} + (2xy + z^2)\hat{j} + 2yz\hat{k}$ represents an electrostatics field or not.

d) Explain why the tips of a lightning arrester are kept pointed.

e) Derive the expression for the energy stored in a capacitor.

f) Define paramagnetic, diamagnetic, and ferromagnetic materials.

g) Write down the equation of E.M. wave through isotropic dielectric medium and explain each terms.

h) Why do two magnetic lines of force not intersect each other?

GROUP–B

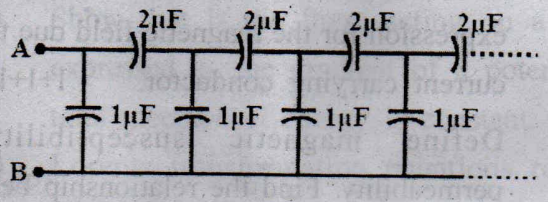
2. Answer any **two** questions: 5×2=10

a) Write down Gauss's theorem of electrostatics. Apply this theorem to calculate the electric field due to a charged infinite plane with a surface charge density σ. 2+3

b) Derive the expression of the torque experienced by an electric dipole kept perpendicular to an electric field $\vec{E}$. Write down the physical significance of $\vec{\nabla}.\vec{B}=0$. 4+1

c) Write Biot-Savart's law. Apply this law to find the magnetic field at a perpendicular distance r from an infinitely long conductor current carrying a current I. 2+3

d) What do you mean by source field and sink field? Find out the equivalent capacitance value between points A and B in the figure below:



2+3

GROUP–C

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

a) State and explain the laws of electromagnetic induction. Define eddy current. Why are transformer cores laminated? What is motional e.m.f.? Define self-inductance and write down its unit. Derive the expression for the self-induction of a very long solenoid.

2+1+1+1+2+3

b) Write down four Maxwell's equations, explaining each term. Write down the equation of continuity. Write down the expression for the velocity of light in free space c in terms of

μ_0 and ε_0. Then find out the value of c in Sl units. Write a short note on Poynting's theorem. 4+1+1+1+3

c) What do you mean by hysteresis and hysteresis loss? What kind of materials will you suggest for the electromagnet and permanent magnet? State and explain Ampere's circuital law. Using this law derive the expression for the magnetic field due to a long current carrying conductor. 1+1+1+1+2+4

d) Define magnetic susceptibility and permeability. Find the relationship between B and H. Define Bohr magneton and find out its value. State and prove Lenz's law. Show that $\vec{\nabla} r^n = n r^{n-2} \vec{r}$. 2+2+2+2+2

OPTION–B

Course Code : PHY-H-GE-T-03

(Mechanics)

GROUP-A

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

a) What is the torque acting on a body with respect to the origin under the influence of the force F=Kr, where K is constant?

b) Show that if the force acting on a particle expressed as the gradient of a potential, the total mechanical energy is constant.

c) Lorentz transformation equations reduce to Galilean transformation equations when v<<c. Explain.

d) What is centre of mass of a system made by two bodies of mass m_1 and m_2 at positions r_1 and r_2 respectively?

e) Briefy explain the outcome of Michelson-Morley Experiment.

f) Define inertia and non-inertia frame of reference.

g) Show that the total linear momentum is zero in the centre of mass frame.

h) Give the basic idea of global positioning system (GPS).

GROUP–B

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

a) Deduce an expression for the torsional rigidity of a wire of length l. radius a and rigidity modulus n.

Show that a shearing strain is equivalent to two equal linear strains of half the magnitude is mutually perpendicular directions. 2.5+2.5

b) i) Find out the couple per unit twist (C) of a cylinder having rigidity modulus n of the material of cylinder, r is the radius of cylinder and L length of the cylinder.

ii) Check whether the three vectors $\hat{i}, \hat{i}+\hat{j}, \hat{i}+\hat{j}+\hat{k}$ are linearly independent. 3+2

c) A string of length L is stretched horizontally with a tension T between two rigid supports. A mass m is attached at a distance a from one end. Show that the Frequency of small vertical oscillation of the mass is

$$f = \frac{1}{2\pi}\sqrt{\frac{TL}{am(L-a)}}$$

Assume that the tension in the string remain constant. 5

d) What are the postulates of Special Theory of Relativity? A thin rod has proper length 10. If the rod is moving at 0.6c in a direction of 300 to its own length, calculate its new length and inclination with respect to the rest frame. 2+3

GROUP–C

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

a) i) Find a distance which an object moves in time t if it starts from rest and has acceleration $\frac{d^2x}{dt^2} = ge^{-kt}$ where k is a constant. Show that for small t the result is $x = \frac{1}{2}gt^2$ and for very large t the velocity is approximately constant.

ii) What is time dilation?

iii) Show that the equation of motion of a free particle does not change its form under Galilean transformation. 4+4+2

b) i) Express the vector field $a = yzi - yj + xz^2k$ in cylindrical polar coordinates.

ii) Show that in case of orbital motion , angular momentum is conserved,

iii) Solve the equation $y'' + 6y' + 8y = 0$ Subject to the condition y = l, $y' = 0$ at x = 0 where $y \equiv \frac{dy}{dx}$ and $y \equiv \frac{d^2y}{dx^2}$.

3+2+5

c) i) Write down the equation of motion of a particle of mass m subject to a restoring force proportional to displacement and a frictional force proportional to its velocity and also an external simple harmonic force.

ii) Obtain expression for the amplitude and the phase angle of the displacement in the steady state.

iii) Show that at resonance the phase difference between the driver and driven system is $\frac{\pi}{2}$. 2+3+3+2

d) i) A particle moves in a plane. Find expression for radial and transverse velocity and acceleration of the particle in spherical polar coordinate system.

ii) A particle of mass m_1 moving with a velocity u_1 suffers a perfectly inelastic collision with a particle of mass m_2 at rest. Calculate the K.E of the system before and after collision in the Lab system and C.M system. Show that decrease in K.E is the same in two case.

iii) Show that the square of the period of a planet is proportional to the cube of semi major axis of the elliptic orbit.

4+4+2

OPTION–C

PHY-H-GE-T-03

(Thermal Physics and Statistical Mechanics)

GROUP–A

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

a) Find the temperature at which the RMS velocity of a gas will be 1/4th of that at zero degree Celsius.

b) Deduce the expression for the work done in the adiabatic expansion of a perfect gas in terms of temperature.

c) Calculate what traction of gas molecules dies out in moving a distance of mean free path.

d) Show that an isothermal curve for an ideal gas drawn on a P-V diagram is enthalpic.

e) Why are the Helmholtz function F and Gibbs function G called thermodynamic potentials?

f) What is Wien's Displacement Law in Black body radiation?

g) Calculate the change in entropy when 10 gram of ice at 0°C is convened into the vapour at 100°C.

h) Discuss the changes of entropy in reversible as well as in irreversible processes.

GROUP–B

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

a) State and explain Maxwell's Law of distributions of molecular velocity. Draw the Maxwell's velocity distribution curve at different temperature. Discuss the shifting of the peak of the curve and also the broadening of the curve with temperature variation. 2+2+1

b) Write down the postulates of Planck's Radiation Law in case of Black body radiation. Derive Wein's displacement Law from Planck's Law. 1+4

c) Write down the four Maxwell's equation. Derive the following *TdS* equation. Terms have their conventional meaning. 2+3

$$TdS = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$$

d) What do you mean by quasi static process? An ideal gas undergoes quasistatic adiabatic process, then show that $PV^{\gamma} =$ constant. 2+3

GROUP–C

Answer any **two** questions: 10×2=20

3. a) The thermal conductivity of brass is 0.26. What is meant by that statement?

   b) Explain steady state in case of thermal conduction.

   c) Two slabs both of area A and thickness x_1 and x_2 having thermal conductivities K_1 and K_2 respectively are put in contact face to face. Show that the equivalent thermal conductivity of the composite system is

$$\frac{x_1 + x_2}{\left(\frac{x_1}{K_1} + \frac{x_2}{K_2}\right)}$$

   d) What is diffusion coefficient? How does it relate to the viscosity coefficient according to transport phenomena? 1+2+4+(1+2)

4. a) Plot and compare Fermi-Dirac, Bose-Einstein, and Maxwell-Boltzmann distribution function as a function of energy.

   b) What are the basic postulates used in Bose-Einstein statistics? What is Fermi energy?

   c) Write short notes on Photon gas and Electron gas. 3+4+3

5. a) For a thermodynamic system U=3/2 PV and $P=A\ T^4V$, find the Gibbs' potential G and Helmholtz function F.

b) Calculate the change of the entropy of free expansion of an ideal gas system.

c) What is isenthalpic process?

d) For an isentropie transformation show that,

$$\left(\frac{\partial V}{\partial T}\right)_S = \frac{C_r}{C_P - C_V}\left(\frac{\partial V}{\partial T}\right)_P$$

(2+2)+2+2+2

6. a) From MaxwelI's relations derive the expression

$$C_P - C_V = -T\left(\frac{\partial V}{\partial T}\right)_P^2\left(\frac{\partial P}{\partial V}\right)_T.$$

b) What is inversion curve? Write down the expression for Clausius Clapeyron equation.

c) Find the change in freezing point of water at 0°C for an increase of pressure by 1 atm. At 0°C specific volume of ice is 1.091 cc/g, latent heat of water is 76.9 cal/g and specific volume of water is 1 cc/g. 3+(2+2)+3
