2017
PHYSICS - PAPER-I

BM- (O) PS- I/17

Time Allowed : 3 Hours

Full Marks : 200

If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.

Answers may be written either in <u>English</u> or in <u>Bengali</u> but all answers must be in one and the same language.

Group A
Answer any three questions

1. (a) Mention the advantages of Lagrangian formulation over Newtonian mechanics   6

   (b) Two particles of masses 500 gm and 5kg collide elastically. At the time of collision, the velocity of the first particle was 50 m/sec, while the latter particle was at rest. Find the velocity of the two particles after collision.   8

   (c) What is meant by central force?   Prove that if a central force acts on a particle, its angular momentum will remain constant.   10

   (d) Explain inertial and non-inertial frames of reference   4

   (e) Explain elastic and inelastic collision.   4

   (f) Write down the four equations for Lorentz transformations and discuss them.   8

2. (a) Discuss the mass energy relation and its significance.   8

   (b) Write down the Maxwell's four field equations. Discuss them.   Establish Maxwell's first field equation.   10

   (c) Define moment of inertia of a body about an axis. What is meant by radius of gyration of a body.   4

   (d) Explain the theorem of parallel axes for a laminar body in finding out the moment of inertia of the same.   6

   (e) Find the moment of inertia of an annular ring about an axis passing through its centre and perpendicular to its plane.   6

   (f) What are the postulates of the special theory of relativity?   6

3. (a) Explain the term: "number of degrees of freedom of a system". What will be its value if a particle moves in a (i) plane and (ii) space.   4

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(b) Explain absolute viscosity and dynamic viscosity. What are their units in CGS and SI units? 8

(c) Draw curves to show how viscosity varies with temperature for liquid and gas. Explain the curves with proper explanation.

8

(d) Draw a Saybolt viscometer and explain its operations. Mention any formula that is used.

8

(e) Explain (i) scalar potential of a vector field (ii) vector potential of a vector field. 6

(f) Distinguish between streamline flow and turbulent flow. Discuss Reynolds number. 6

4. (a) Calculate the entropy of one mole of an ideal gas.

4

(b) Define a simple harmonic motion. What are its characteristics? 6

(c) What is the differential equation form of a SHM? Find its solution. 6

(d) The expression for displacement of a particle executing SHM is of the form:
$y = 10 \sin[(\pi/3)t - \pi/12]$ m. Calculate the following: (i) amplitude (ii) angular velocity (iii) maximum velocity and acceleration (iv) epoch (v) the kinetic energy and potential energy of the particle when its displacement is 0.05 m.

10

(e) A particle, executing SHM, is under the influence of damping. Plot a curve between amplitude and frequency for small, medium and heavy damping. Comment on the nature of the plots so obtained.

6

(f) What is a progressive wave? Deduce an equation of a progressive wave moving along the positive x axis.

8

5. (a) Explain Joule-Thomson effect.

6

(b) What is meant by surface tension. Mention its unit in CGS. Why some liquid surfaces in contact with its container are concave and for some others, it is convex? Explain.

8

(c) What will be the energy loss when 800 drops of water coalesce to form a large drop. Surface tension of water is 72 dynes /cm and diameter of each drop is 1 mm.

6

(d) State and prove Bernoulli's theorem for an incompressible fluid.

10

(e) For a fluid, state the equation of continuity. Explain the same.

4

(f) Define Poisson's ratio. What are its maximum and minimum values. Draw and explain the stress versus strain curve for a metal wire fixed at the upper end and an increasing load is applied at the lower end.

6

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6. (a) Explain the operation of a Carnot cycle with the help of P-V diagram. Find also its efficiency.

10

(b) A wire of diameter 2 mm and an initial length of 100 cm is to be stretched by another 2 mm. Given Y and α of the wire as 17×10^{10} N/m^2 and 1×10^{-5}/$^\circ$C respectively. Calculate the additional weight to be attached to realize the above.

8

(c) Find the ratio of specific heat of a gas of initial volume 1050 cc at a pressure 85 cm and allowed to expand adiabatically to a final volume of 1220 cc and pressure 65 cm.

6

(d) Discuss displacement current. Explain the same.

4

(e) Tabulate the differences between displacement current and conduction current.

6

(f) A series circuit consists of a resistance and an inductance and is connected to an AC source at t=0. Find an expression for current in the circuit for t $\geq$ 0.

6

Group B
Answer any two questions

7. (a) Define electric potential at a point in an electric field.

2

(b) A point charge of 10 μC is located at the point P (1,2,3) in cartesian coordinates. Calculate V_{AB} if coordinates of A are (2,2,3) and those of B are (-2,3,5).

8

(c) What is Gauss' law of electrostatics? Express the same in differential form.

6

(d) Find the electric field intensity due to a spherical shell of inner and outer radii a_1 and a_2 when it is charged with a uniform volume charge density σ throughout the thickness of the shell.

10

(e) State Biot-Savart's law. Express the law in vector form.

6

(f) Apply Biot-Savart's law to find the magnetic field of induction due to a long straight wire at a distance R from the wire.

8

8. (a) Distinguish between Fresnel's diffraction and Fraunhoffer diffraction.

4

(b) Draw the Fraunhoffer diffraction pattern due to a single slit. Also show that the resultant disturbance on a screen is a also a simple harmonic vibration.

12

(c) Explain the term polarization of light. What conclusion can be drawn that a light wave can be polarized?

4

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(d) State Brewster's law. Explain the same with the help of a diagram.

6

(e) Discuss chromatic and spherical aberration with relevant diagrams. Compare the two.   6

(f) Find the focal length of a convex lens, having radii of curvatures r_1 and r_2 and refractive index n.

8

9. (a) Draw the B-H characteristics curve for a magnetic material. Explain the linear and non-linear zones of the B-H curve from the magnetic dipole concept. Explain, with proper reasoning, which part of the curve would fit in properly for a (i) transformer (ii) inductance.

12

(b) Mention the properties of an ideal transformer. Draw the diagram of an ideal transformer and deduce the expressions for rms induced voltages in both primary and secondary.

12

(c) A series RLC circuit is supplied with an AC voltage source. Draw its vector diagram. Find its resonance frequency. Write down expressions of voltage drops across R, L and C. Draw the resonance curves showing variation of current with frequency for (i) small and (ii) large value of R.

12

(d) Define RMS value of an AC. How it is calculated?

4

10. (a) A circuit consists of a resistance 4Ω, an inductance of value $5\Omega +j0$, a capacitance of value $7\Omega -j0$, all in series with a voltage source $100+j0$. Calculate the series current and the voltage across each element. Also, calculate the total power consumed in the circuit.

8

(b) What is meant by Q factor of a coil? Give its expression. Draw a curve showing the response of the coil with different frequencies. Mention whether a low or high value of Q is desirable for a coil and explain the reason behind the logic.

8

(c) State and explain Lenz's law. Explain self and mutual inductance.

6

(d) State Poynting theorem and prove it.

12

(e) For a liquid-vapour inter phase remaining in equilibrium, find the Clausius-Clapeyron equation.

6