

PHYSICS (Paper I)

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

All questions carry equal marks.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following:
 - (a) The tides in oceans on Earth are produced by gravitational pull of the Sun and the Moon. The pull due to Sun is much greater than the pull due to Moon. Explain, why tides due to Sun are only about 0.4 times as high as that due to Moon. The mass of the Sun is 2×10^6 times the mass of the Moon and the distance between Sun and Earth is 400 times the distance between Moon and Earth. The radius of the Earth is 6.4×10^6 m.
 - (b) What is spatial coherence? Considering Young's two slit experiment, prove that the distance between the slits must be sufficiently less than (λ/θ) for obtaining fringes of good contrast. λ is the wavelength of light used and θ is the angle subtended by the source at the slits.
 - (c) In a hydrogen atom for the $2p \rightarrow 1s$ transition the probability per unit time is $6 \times 10^8 \text{ s}^{-1}$. Calculate the angular frequency of the emitted photons and the order of Einstein's coefficient B_{21} .
 - (d) A gas at a pressure P and temperature T has a density ρ . The velocity of sound in this gas is v . Obtain an expression for the degrees of freedom of the gas molecules. At STP, $\rho = 1.3 \text{ kg m}^{-3}$ and $v = 330 \text{ ms}^{-1}$. Calculate the degrees of freedom.
2.
 - (a) A particle is moving under a central force field. Obtain the equations of motion and prove that in such a field the areal velocity of the particle remains constant.
 - (b) Explain precessional motion of a top. A solid sphere of radius 2 cm and mass 50 gm has a thin nail of length 5 mm fixed perpendicular to its surface. When this sphere spins like a top with a speed of 20 rev./second, what will be its precessional speed?
 - (c) In the ammonia molecule the three hydrogen atoms form an equilateral triangle. The distance between the centre of this triangle from each hydrogen atom is 0.939 Å. The nitrogen atom is at the apex of the pyramid with the three hydrogen atoms forming the base. The distance between the hydrogen and nitrogen atoms is 1.014 Å. Find the position of the centre of mass relative to the nitrogen atom.
3.
 - (a) Moving in a closed elliptical orbit, Halley's comet goes round the Sun once every 75 years. At its point of closest approach its distance from the Sun is 8.9×10^7 km. If mass of the Sun is 2×10^{30} kg. what will be the greatest distance of the comet from the Sun?
 - (b) Define Helmholtz free energy F and Gibbs free energy G . What does decrease in F and G signify? Show that the internal energy U at temperature T is given by

$$U = F - T \left(\frac{\partial F}{\partial T} \right)_V$$

- (c) A uniform rope of mass M and length L is hanging from a rigid support. A transverse wave travels along the rope. Calculate the speed of the wave at a distance x from the free end the time taken by the wave to travel the whole length.
4. (a) Using a Carnot cycle obtain the Clausius Clayperon equation. At normal pressure the ratio of densities of ice and water is 9:10. When 1 kilo-mole of ice is melted, the change in entropy is $22.2 \times 10^3 \text{ JK}^{-1}$. If the external pressure is increased by 10^5 Nm^{-2} , what will be the change in the melting point of ice?
- (b) Derive the distribution law which explains the black body spectrum over the entire wavelength region. Using this relation determine the value of Wiens constant b .
- (c) Show the distribution of velocities for temperatures T_1 , T_2 and T_3 ($T_1 > T_2 > T_3$) of gas molecules according to the Maxwell-Boltzmann law. Using this law prove that the most probable velocity is $\sqrt{2/3}$ times the root-mean-square velocity.

SECTION 'B'

5. Answer any three of the following:
- (a) Distinguish between streamline and turbulent motion. Define Reynolds number. When a sphere of radius 1.2 mm moves in glycerine, the laminar flow observed if the velocity of sphere does not exceed 0.23 ms^{-1} . At what minimum velocity of sphere of radius 5.5 cm will the flow in water become turbulent? The viscosities of glycerine and water are 13.9 P and 0.011 P respectively. The density of glycerine is $1.2 \times 10^{-3} \text{ Kg/m}^3$.
- (b) Obtain an expression for the mean free path. Mention the correction introduced by Maxwell. Calculate the value of Avogadro's number if the mean free path of nitrogen molecules at STP is $6.85 \times 10^{-8} \text{ m}$. The molecular diameter is 3.5 Å.
- (c) A 3 MW laser beam which has a diameter of 1 cm is focussed by a lens of focal length 5 cm. The wavelength of laser is 10,000 Å. Calculate the intensity of the focal plane of the lens.
- (d) The amplitude of damped oscillator of frequency 300 Hz reduces one-tenth of its initial amplitude after 3000 oscillations. Calculate the damping constant and the time in which its energy will reduce to one-tenth of its initial energy.
6. (a) What is a quarter plate? A phase retardation plate of quartz has a thickness 0.1436 mm. Calculate the wavelength in the visible region for which this plate will act as a quarter for plate [?]. The refraction indices of quartz for ordinary and extraordinary rays are 1.5443 and 1.5533 respectively.
- (b) A plane transmission grating has 6000 lines per cm. Determine the angular separation between the two lines of sodium of wavelengths 5896 Å and 5890 Å in the second order spectrum. If the width of the grating is 2.5 cm, will these lines be resolved?
- (c) Why does a soap film appear coloured when is viewed by reflected white light? A thin film is illuminated by sodium light of wavelength 5900 Å. Its refractive index is 1.42. Calculate its minimum thickness so that it appears dark in reflected light.
7. (a) Obtain the relativistic transformation relation for density in inertial frames. Why is the equivalent energy corresponding to 1 amu of mass?
- (b) What is population inversion? Mention the methods of achieving population inversion. Explain the concept of negative temperature.
- (c) Give the concept of Fresnel's half period zones. Describe the salient features of Fresnel's diffraction pattern due to a straight edge, showing the intensity distribution. How are these features explained?
8. Write short notes on any three of the following:
- (a) Coriolis force and its effects

- (b) Motion of rocket
- (c) Law of equipartition of energy
- (d) Debye theory of specific heat of solids
- (e) He-Ne laser
- (f) Phase and group velocities in dispersive media