

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.

The number of marks carried by a question/part is indicated against it.

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:

20×3=60

- (a) A parallel laser beam is incident perpendicularly on a photographic plate. An object is placed at a distance a in front of the photographic plate. Discuss the recording from the plate. If the plate is illuminated by the same light, what is expected and why?
- (b) A star of the size of our sun having a radius of 7×10^5 km and having a mass 2 times as that of the sun is rotating at a speed of one revolution every 10 days. If the star undergoes a gravitational collapse to a neutron star of radius 10 kms, assuming that the star is a uniform sphere at all times, calculate the rotation speed of the neutron star. The moment of inertia of solid about its diameter is $\frac{2}{5}MR^2$ where M and R are the mass and radius of the solid sphere respectively.
- (c) The mass of muon at rest is $207 m_e$ where m_e is the electron rest mass (0.511 MeV). The mean life time at rest for muon is $2.2 \mu\text{s}$. The life time of muon emerging from an accelerator is measured in the laboratory as $6.9 \mu\text{s}$. Estimate the speed of these muons in the laboratory.
- (d) A system with 2 independent coordinates x_1 and x_2 has the following Lagrangian

$$L = \frac{1}{2}(\dot{x}_1)^2 / (\alpha + \beta x_2) + \frac{1}{2}(\dot{x}_2)^2 - \gamma x_2$$
 α, β, γ being constants. Obtain the Lagrangian equation of motion.

2. (a) Determine equation of trajectory for a particle under central force 'F', the magnitude of which is given by

$$F = -A/r^2 + B/r^3$$

where A and B are positive constants.

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- (b) Obtain the equation of motion of a particle moving relative to a rotating frame of reference. Explain the term representing coriolis force in this expression. **20**
- (c) Define scattering cross-section. A charged particle of mass m and charge Z_e is scattered by another charged particle of charge Z_e at rest. Deduce the expression for the scattering cross-section. **20**

3. (a) A person in a spaceship is holding a rod of length of 0.5 m, the space ship is cruising at a speed V parallel to the earth's surface. What does the person in the space ship notice as the rod is rotated from parallel to perpendicular to the space ships motion? What does an observer on earth's surface notice? **20**

- (b) Certain string has a linear mass density of 0.25 kgm^{-1} and stretched with a tension of 25 N. One end is given a sinusoidal motion, its frequency 5 Hz and amplitude 0.01 metre. If at $t = 0$, the end has zero displacement and is moving along the positive Y direction, derive the wave speed, the wavelength and the wave equation of the wave in the string. 20
- (c) The phase velocity in a material is $\sqrt{g/k}$ where k is the propagation constant. Prove that the group velocity will be half of the phase velocity. 20
4. (a) Parallel rays fall on circular aperture of diameter 1 mm. At a certain position of the screen one gets a dark spot on an axial point. When the screen is moved by 12.5 cm, one again gets a dark spot. Determine λ (wavelength). 20
- (b) Monochromatic light from a distance source of wavelength λ falls on a double slit. A glass plate of thickness t is inserted between one slit and the screen. Calculate the intensity at the central point as the function of thickness t . 20
- (c) Why does one get polarised light from a Nicol's prism? How should one adjust the polariser and analyser, so that an intensity of the incident light is reduced by a factor of 0.25? 20

SECTION 'B'

5. Answer any three of the following:

20×3=60

- (a) What value of inductance has to be used so that a lamp with rating of 200 volt and 10 Amperes lights the same way with 250 V source at 50 Hz.
- (b) What is gauge transformation? Define coulomb gauge. Derive the equation for vector potential under coulomb gauge.
- (c) Calculate the increase in entropy when 1 kg ice melts at zero degree centigrade. The Latent heat of fusion of ice is 3.36×10^{-5} joules/kg. (Assume that the melting is an isothermal reversible process)
- (d) Calculate the electric field as a function of position due to a dipole whose potential is given by

$$V = P \cos \theta / 4\pi \epsilon r^2 \text{ where } r = \sqrt{(x^2 + y^2)}$$

The dipole is located at the origin of the x, y axis system.

6. (a) An inductance is connected to 6 volt [?] battery through a resistance R. What is the steady state current in the circuit? After what time the battery would be delivering one half its steady state current? 20
- (b) Explain the use of a parallel resonance circuit (i) as a rejector circuit (ii) for current amplification. 20
- (c) A conducting sphere of radius 'a' is placed in a uniform electric field E_0 . Using the method of images, show that the potential function is given by $\phi = -E_0(r - a^3/r^2) \cos \theta$. 20
7. (a) Define scalar and vector potentials. Recast Maxwell's equations in terms of these potentials. 20
- (b) Derive the energy continuity equation for electromagnetic waves using the poynting vector. 20
- (c) From Planck's radiation law, derive Wien's displacement law and Rayleigh Jean's law. 20
8. (a) Derive an expression for the Maxwellian distribution of velocities for the molecules of an ideal gas. 20
- (b) Obtain van der waals' equation of state for real gases. What is the value of critical coefficient for an ideal gas? Show that the value of the critical coefficient for van der Waals' gas is independent of the type of gas. 20
- (c) How can one obtain a temperature and identify the elements in stellar bodies using Saha's thermal ionisation equation? 20