MIZORAM PUBLIC SERVICE COMMISSION

MIZORAM CIVIL SERVICES (COMBINED COMPETITIVE) MAIN EXAMINATION, 2023

PHYSICS PAPER-I

Time Allowed : 3 hours FM : 100

Marks for each question is indicated against it.

Attempt any 5 (five) questions taking not more than 3 (three) questions from each Part.

PART - A

1. (a) A particle is subjected to a central force, prove that **(4+4+4=12)**

(i) the angular momentum of the particle is a constant of motion

(ii) the particle moves in a fixed plane

(iii) the areal velocity of the radius vector remains constant

(b) Deduce the relation between scattering angles in laboratory and centre of mass frames for particles undergoing elastic collision. **(4)**

(c) Explain Coriolis force and show that it owes its existence to the motion of the particle with respect to a rotating frame of reference. **(4)**

2. (a) Derive the equations for the motion of a body rotating with a constant angular acceleration. **(7)**

(b) Obtain an expression for the periodic time of precessional motion of a gyroscope. **(6)**

(c) A particle of mass m_1 suffers a perfectly elastic collision with another of mass m_2 initially at rest. After scattering m_1 and m_2 move at angles a_1 and a_2 with respect to the original direction of m_1. How does the collision appear in c.m frame? **(7)**

3. (a) Derive the law of addition of relativistic velocities. Use it to prove that under Lorentz transformation no two velocities can add up to more than the value of speed of light. **(12)**

(b) Show that for very small velocity ($\upsilon \square\ c$), the equation for kinetic energy, $K = \Delta mc^2$ becomes $K = \frac{1}{2} m_0 \upsilon^2$. **(8)**

4. (a) What is Clausius-Clapeyron equation? Write its mathematical form. Given a liquid that has a normal boiling point of 41.0°C and a P_{vap} = 400 mmHg at 22°C. What is the heat of vaporization in KJ/mol? **(7)**

(b) State and derive the Stefan's-Boltzmann law. **(7)**

(c) State the essential requirements of Fermi-Dirac statistics and hence deduce Fermi-Dirac distribution law. **(6)**

PART - B

5. (a) Newton's rings are observed between a spherical surface of radius of curvature 100 cm and a glass plate. The diameters of the 4^{th} and the 15^{th} fringes are 0.314 cm and 0.574 cm respectively. Calculate the wavelength of light used and the diameter of the 24^{th} fringe. **(10)**

(b) Show that two convex lenses of the same material kept separated by a distance a, which is equal to the average of two focal lengths $[a = \frac{f_1 + f_2}{2}]$, may be used as an achromatic combination. **(10)**

6. (a) What are Einstein coefficients A and B? With the help of a suitable diagram describe the construction and working of a He-Ne laser. **(8)**

(b) In a He-Ne laser, transition from 3s to 2p level gives a laser emission of wavelength 632.8 nm. If the 2p level has energy equal to 15.2×10^{-19} J, calculate the pumping energy required if there is no energy loss. **(4)**

(c) Explain with neat diagrams, the phenomena of absorption, spontaneous emission and stimulated emission of radiation. **(8)**

7. (a) Write Poisson's and Laplace's equations. Check if the function, $f(x,y)=x^2-7y^2$ satisfies two dimensional Laplace's equation. **(7)**

(b) Two tiny spheres, each having masses *m* kg and charge *q* coulombs, are suspended by two insulating threads each of length/m having negligible mass. When the system is in equilibrium each string makes an angle with the vertical. Prove that $q^2 = [4mg/^2 \sin^2 u \tan u]\, 4pe_0$. **(7)**

(c) What is an electrical image? A point charge +q is placed at a distance of d from an infinite plane earthed conductor. Calculate the field at any point on the conductor. **(6)**

8. (a) Using Maxwell's field equations for a homogenous non-conducting medium, derive the wave equation for the electric field. Calculate the velocity of EM wave in free space. **(12)**

(b) Explain the terms: **(8)**

(i) Displacement current

(ii) Skin depth

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