CSM : 24

PHYSICS PAPER - I

Time Allowed : 3 hours | Maximum Marks : 100

QUESTION PAPER SPECIFIC INSTRUCTIONS

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

There are eight (8) questions - four (4) questions each in Part A & B. Each question carries 20 marks.

Marks for each question is indicated against it.

Compulsory questions :

(a) Question No. 1 from Part-A and

(b) Question No. 5 from Part-B

[Compulsory questions No. 1 & 5 have 4 (four) Sub-questions carrying 5 marks each.]

Total No. of questions to be attempted :

5 (five) questions.

[A candidate shall attempt 2 (two) compulsory questions from Part A and B. Out of the remaining 6 (six) questions, 3 (three) are to be attempted taking at least 1 (one) but not more than 2 (two) questions from each Part]

Word Limit:

(a) Compulsory questions carrying 5 marks shall have a limit of 150 words.

(b) There shall be no word limit for the remaining questions.

PART - A

1. Answer the following questions: **(4×5=20)**

   (a) What do you mean by reduced mass? Derive an expression for the reduced mass of a two body system.

   (b) Explain Euler's theorem in the context of rigid body dynamics. Derive the relationship between angular velocity and angular momentum for a rotating rigid body.

   (c) Derive the relativistic relation between energy and momentum.

   (d) Compare the operations of the Otto engine and the Diesel engine.

2. (a) State Kepler's laws of planetary motion. Derive Kepler's third law of planetary motion showing the relationship between the orbital period of a planet and the semi-major axis of its orbit. **(5+5=10)**

   (b) Define gravitational field and gravitational potential. Derive the expressions for the gravitational field and potential at a distance 'r' from the center of a uniform spherical body of mass 'M' and radius 'R'. Discuss the behavior of these quantities for regions outside and inside the sphere. **(2+6+2=10)**

3. (a) Define Moment of inertia and hence explain the theorems of parallel and perpendicular axis. Deduce an expression for the moment of inertia of a solid sphere about an axis parallel to its diameter. **(1+4+5=10)**

   (b) State Hooke's law. Define the different elastic constants for an isotropic solid. Derive the interrelationship between the different elastic constants for an isotropic solid. **(1+3+6=10)**

4. (a) Discuss Einstein's and Debye's theories of specific heat. Compare their predictions at low temperatures and explain the significance of the temperature dependence of specific heat in solids. **(7+3=10)**

   (b) Derive the Maxwell-Boltzmann distribution law for the velocities of particles in an ideal gas. Using Maxwell Boltmann's distribution law establish the law of equipartition of energy. **(5+5=10)**

PART - B

5. Answer the following questions: **(4×5=20)**

(a) Briefly discuss the construction and working of a Fabry-Perot interferometer.

(b) Explain the basic principle of holography. How does it differ from traditional photography in terms of capturing and reconstructing images? Mention two simple applications of holography in modern technology.

(c) State Kirchhoff's current law and Kirchhoff's voltage law. Explain the physical significance of each law. Using Kirchhoff's laws, calculate the currents in a simple circuit consisting of two resistors R_1 and R_2 in series with a battery of voltage V.

(d) What is displacement current? Explain its significance in the context of Maxwell's equations and how it contributes to the continuity of current in varying electric fields.

6. (a) Derive an expression for the intensity of Fraunhofer diffraction pattern due to a single slit. Discuss the conditions for maxima and minima and explain how the diffraction changes with the slit width and the wavelength. **(7+2+1=10)**

(b) What do you mean by linearly and circularly polarized light? Describe how a quarter-wave plate is used to convert linearly polarized light into circularly polarized light. A plane-polarized light of wavelength 600 nm passes through a quarter-wave plate. If the plate has a thickness of 1.5 μ m, calculate the refractive index difference between the fast and slow axes of the wave plate. **(2+4+4=10)**

7. (a) Derive the Poisson's and Laplace's equations in electrostatics. Determine the electric field and potential for a charged sphere at a point outside the sphere. **(5+5=10)**

(b) What are series and parallel LCR circuits? Derive expressions for the resonant frequency for a parallel LCR circuit.

A parallel LCR circuit with inductance L = 100 mH, capacitance C = 10 μ F and resistance R = 50 Ω is connected to an AC voltage source with an angular frequency ω = 1000 rad/s. Calculate the impedance Z of the circuit and determine the resonant frequency f_0 of the circuit. **(2+6+2=10)**

8. (a) State and prove Poynting's theorem for electromagnetic waves. Discuss the physical significance of the Poynting vector and explain the energy conservation in electromagnetic wave propagation. **(5+5=10)**

(b) Derive the wave equation for electromagnetic waves propagating in an isotropic dielectric medium. Derive the expressions for the reflection and the transmission coefficients for electromagnetic waves incident on the boundary between two media. **(3+7=10)**

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