Time : 3 hours

Full Marks : 300

The figures in the right-hand margin indicate marks.

*Candidates should attempt Q. No. 1 from Section – A and Q. No. 5 from Section – B which are compulsory and **three** of the remaining questions, selecting at least **one** from each Section.*

SECTION – A

1. Answer any **three** of the following : $20 \times 3 = 60$

   (a) What is Galilean transformation ? A frame of reference S' which is moving with constant velocity to another frame. Explain the transformations of x, y, z, t to x', y', z', t' in a Galilean frame. What will happen at time $t = 0$? Also explain, non-inertial and fictitious forces.

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(b) What is working principle of a rocket ? Derive the differential equation representing rate of gain of speed by a rocket. Show that when the rocket speed is equal to exhaust speed when the ratio $M_o/M = e$.

(c) (i) Discuss the theory of forced vibrations of a clamped system. What is sharpeners of resonance ?

(ii) An elementary particle called the neutrino is moving with the speed of light c. An observer is travelling with velocity v towards the neutrino. According to moving observer, what is the velocity of the neutrino ?

(d) (i) Write details of Fraunhofer diffraction pattern of a single slit. How does this pattern differ from that due to straight edge ?

(ii) If in a doubly refracting crystal optic axis and incident ray are parallel to each other, find the direction of emergent ordinary and extraordinary ray.

2. (a) Define Euler's equation of motion. Obtain the condition that a heavy symmetrical top in a gravitational field which starts spinning initially with its symmetry axis vertical may continue to spin in the same way for an indefinite period. 30

(b) What are fictitious forces ? How are these related to non-inertial frames ? Prove that the observed acceleration due to gravity $g\varphi$ at the latitude φ is related to its real value g by the relation $g^2\varphi = (g\cos\varphi - \omega^2 R\cos\varphi)^2 + (g\sin\varphi)^2$. 30

3. (a) What is relativistic energy ? Prove relation $E^2 - p^2c^2 = m_0^2c^4$ and show that $E^2 - p^2c^2$ is invariant under Lorentz transformation. 30

(b) What are phase and group velocities ? Light of a known frequency ν is allowed to fall on a diffraction grating underwater. The wavelength λ is thus determined and the product $\nu\lambda$ is calculated. Is this the wave speed or group speed ? Explain. 30

4. (a) Explain multiple beam interference and working of a Fabry-Perot interferometer. Deduce measurement of the difference in wavelength by Fabry-Perot. 30

(b) Describe three level schemes for laser operation, main features and conditions of action and merits and demerits. Is energy conservation violated in laser? 30

SECTION – B

5. Answer any **three** of the following: $20 \times 3 = 60$

(a) Explain electric multipole. Obtain the expression for the potential and field due to linear quadrupole.

(b) What is dipole moment? Obtain expression for the potential and field due to an electric dipole.

(c) Derive van der Waals equation of state and obtain expressions for the critical temperature and volume in terms of the constants of the van der Waals equation.

(d) Write down Maxwell's field equations and sate Ampere's circuital law and discuss why and how it was modified to include the displacement current.

6. (a) Write briefly that the Coulomb's law in electrostatics is physical reality while Gauss' law and Laplace-Poisson's equations are simple mathematical expressions. Explain dipole interaction and field expression for the force and torque and force on a dipole in the field of the other. 30

(b) (i) State and explain the laws of Faraday and Lenz relating to electromagnetic induction, hence prove the relation between inducement and the rate of change of lines of magnetic force through a circuit. 15

(ii) Discuss the series resonant circuit. Why is this called acceptor circuit ? Find the expression for the true average power dissipated in an AC circuit. 15

7. (a) Discuss Wien's displacement law. What were the defects involved in it and how Rayleigh-Jeans overcame in their formula, explain it. What was the major assumption Planck put forth in Jean's law? 30

(b) A plane electromagnetic wave is incident on a dielectric surface. Find the amplitude of the reflected and refracted wave and discuss their phase change. 30

8. (a) State Dulong-Petit Law. Discuss the variation of specific heat capacity of solids with temperature and give Einstein's theory to explain it. 30

(b) (i) What do you understand by a reversible process? Enunciate and prove Carnot's theorem. 15

(ii) Describe a Diesel engine and deduce an expression for its efficiency. Can the Carnot's engine be realised in practice? 15

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