COMBINED COMPETITIVE EXAMINATION (MAIN)

PHYSICS

Paper—I

Time : 3 hours | *Full Marks* : 200

Note : *(1) The figures in the right-hand margin indicate full marks for the questions.*

(2) Attempt ***five*** *questions in all.*

(3) Question No. ***1*** *is compulsory.*

1. Answer any *ten* of the following : 4×10=40

   (a) Show that angular momentum for a body moving under central force is conserved.

   (b) State Keplar's laws for planetary motion.

   (c) Write the assumptions made by van der Waals to obtain an equation of state.

   (d) What is central force? Deduce Keplar's second law.

   (e) What are group velocity and phase velocity of waves?

   (f) Find the ratio $\gamma(C_p / C_v)$ for a diatomic molecule.

   (g) Why is Kelvin scale called absolute scale?

   (h) Show that the torque acting on a body moving under central force is zero.

   (i) Proton and helium nuclei are moving with same momentum. Find the ratio between their kinetic energies.

   (j) Obtain the dimensions of universal gravitational constant.

   (k) What are geostationary satellites?

   (l) Define solar constant.

2. Answer any *eight* of the following : 5×8=40

(a) Kinetic energy of a particle is twice its rest mass. What is its velocity?

(b) State fundamental postulates of special theory of special relativity.

(c) Based on Lorentz transformation equations, explain length contraction.

(d) State and prove Bernoulli's theorem for a liquid in streamline motion.

(e) Define gravitational potential. Derive an expression for the minimum velocity required for a body to escape from a planet.

(f) Define terminal velocity. Derive an expression for terminal velocity of a spherical body if mass of the body is m and density of the medium is d.

(g) Find an expression for mean free path of a gas.

(h) For small oscillations, find the expression for time period of a simple pendulum.

(i) What are free vibration, forced vibration and resonance?

3. Answer any *five* of the following : 8×5=40

(a) State the law of conservation of linear momentum. Derive the law from Newton's laws of motion.

(b) Define angular momentum of a body. Find the relationship between force and torque.

(c) Explain non-inertial frame of reference and fictitious force. Explain that centrifugal is fictitious force.

(d) Show that for a particle undergoing simple harmonic motion, the total energy is conserved.

(e) Show that in interference of light waves, there is no violation conservation energy.

(f) Explain Brewster's law.

(g) Explain isothermal and adiabatic changes.

4. Answer any *four* of the following : 10×4=40

(a) Two bodies of masses m_1 and m_2 are moving with velocities u_1 and u_2 respectively along same straight line. After collision, they stick together and move with common velocity in the same straight line. Show that there is loss in kinetic energy after collision.

(b) A rocket of mass m starts vertically upwards with a speed v_0. Find its speed at an altitude h. Take, g, the acceleration due to gravity on the surface of the earth = GM / R, M is the mass and R is the radius of the earth.

(c) Why are there two specific heats for a gas? Show that the adiabatic relation between pressure P and volume V is PV^{γ} = constant.

(d) In interference, find the condition for bright and dark fringes, and find out fringe width of interference pattern in Young's experiment.

(e) In stretched string, obtain an expression for the velocity of transverse wave and hence derive laws of transverse vibrations of a string.

5. Answer any *two* of the following : 20×2=40

(a) Establish Einstein mass-energy relationship. Explain physical significance of the relationship.

(b) Show how Bernoulli's theorem is applied to measure rate of water discharge through city water supply.

(c) Find an expression for the energy of a gas on the basis of kinetic theory of gases. Explain the concept of temperature on the basis of this theory.

6. Answer any *four* of the following : 10×4=40

(a) Explain Wien's displacement law. Starting from Planck's law, derive Wien's displacement law.

(b) What is central force? Show that energy is conserved for a body moving under central force.

(c) Distinguish between streamline and turbulent flow of a liquid, and explain the significance of Reynolds number.

(d) Distinguish between magnifying power and resolving power. Deduce an expression for the resolving power of a telescope.

(e) Write down the differential equation for a damped harmonic oscillator, and hence obtain its solution.

7. Answer any *two* of the following : 20×2=40

(a) Explain Carnot cycle on a *P-V* diagram for an ideal gas. Derive an expression for the work done in a cycle of operation, and calculate its efficiency.

(b) Discuss Einstein theory of specific heat for solids. What are its merits and demerits?

(c) Explain the working of a transistor receiver.

8. Answer the following questions : 40

(a) Outline the essential features of the kinetic theory of gases. Derive an expression for the pressure of an ideal gas on the basis of the theory.

(b) Discuss Maxwell-Boltzmann law of distribution of velocity for gas molecules. Describe an experiment for the verification of the law.

9. Answer the following questions : 40

(a) Discuss formation stationary waves in a stretched string.

(b) What does acronym LASER stand for? What are the requirements for laser action? Explain the working of ruby laser.

10. Answer the following questions : 40

(a) Explain relativistic variation of mass with speed.

(b) Explain diffraction at straight edge.

★★★