351001

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.

(4) The symbols used in the question paper have their usual meanings.

(5) Relevant constants and their approximate values for use in the calculation:

Velocity of light, $c = 3\times10^8$ m/sec; *Stefan-Boltzmann constant,* $\sigma = 5.67\times10^{-8}\text{Wm}^{-2}\text{K}^{-1}$
Room temperature, $T_0 = 300$ K; *Radius of* Earth, $R_e = 6400$ km;
Acceleration due to gravity, $g = 10$ m/sec^2.

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

(a) Describe the conditions for the conservations of linear momentum and angular mementum of a moving body.

(b) Calculate the Coriolis force experienced by a particle of unit mass moving with velocity vector $\vec{v} = 2\hat{i} + 3\hat{j} + 4\hat{k}$ in the frame rotating with angular velocity $\vec{\omega} = 3\hat{k}$.

(c) What are the distinctive features of the laboratory frame of reference and centre of mass frame of reference?

(d) Can the second law of thermodynamics be related to the concept of entropy?

(e) State the basic assumptions in the development of the kinetic theory of gases.

(f) The phase velocity and the group velocity of waves can be different. How?

(g) Define scattering cross-section. State its unit of measurement.

(h) Is the interference phenomenon equivalent to the diffraction by double slits? Explain.

(i) "The resolving power of an optical instrument is x mm." Explain the statement.

(j) What is meant by solar constant? State if it varies during the course of the day.

(k) Discuss the conditions for a streamline motion of fluids to become turbulent.

(l) State the basic postulates of the special theory of relativity.

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

(a) Check if the force vector $\vec{F} = x^2\hat{i} + y^2\hat{j} + z^2\hat{k}$ represents a central force.

(b) Give an interpreation of temperature in the kinetic theory of gases.

(c) What is a gyroscopic motion?

(d) A hollow iron pipe is more difficult to twist compared to a solid iron rod of the same mass and length. Why?

(e) How much thermal energy will be radiated by a blackbody per unit surface area at a temperature of 350 K?

(f) In the Rutherford experiment, most of the alpha particles could be detected behind the gold foil. Why?

(g) What happens to the interference pattern, when a white light is used in the Newton ring experiment?

(h) What is Debye temperature?

(i) State the differences between reasonance and beat formation.

(j) Calculate the energy available on conversion of 1 gm of a given rest mass.

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

(a) "The rocket motion is essentially different from the motion of a rigid body". Justify the statement.

(b) Geostationary satellites move round the earth at an altitude of about 36000 kms. Why?

(c) State and explain Joule-Kelvin effect.

(d) Out of the isothermal and adiabatic processes, which process is related to the curve with greater slope in the PV diagram? Why?

(e) Explain the different quantities involved in the propagation of a wave represented by the wave equation $\frac{d^2(100y)}{dx^2} - \frac{d^2y}{dt^2} = 0$

(f) Describe the behaviour of a polarized light wave with suitable diagram.

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

(a) A body moving with speed 1 m/s, collides with another body of equal mass at rest. If the bodies stick together on collision, find the speed of the body after the collision.

(b) Explain the role of equipartition theorem in finding the specific heat of solid bodies.

(c) What is the colour of the central fringe in the Newton ring interference experiment?

(d) Show that under low velocity assumption, the results of Lorentz Transformation reduce to Galilean Transformation laws.

(e) Illustrate how adiabatic demagnetization can be used to achieve low temperature.

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

(a) Establish that the sum of the kinetic energy and the potential energy of a particle executing simple harmonic motion is always a constant.

(b) A body moves with relativistic velocity such that the mass of the body is twice its rest mass. Calculate the velocity of the moving body.

(c) The relation between the heat capacities for an ideal gas is given $C_p - C_v = R$. If $\frac{C_p}{C_v} = \gamma$, show that under adiabatic conditions, the gas law is given by $PV^{\gamma} =$ Constant.

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

(a) A constant torque of 10N-m is applied to a body for 5 seconds, raising its angular momentum to 80 kg m^2/sec. Find the initial angular momentum of the body.

(b) Illustrate the different stages of a Carnot cycle for adiabatic change.

(c) Describe Planck's radiation formula and establish Wien's displacement law.

(d) How can unpolarized beams of light be transformed to circularly polarized and elliptically polarized light?

(e) Describe the principle of Holography. Draw a neat diagram of the holographic process.

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

(a) How are Kepler's laws of planetary motion deduced from Newton's laws? Comment, if the Kepler's laws of planetary motion can be applied universally.

(b) Describe the light amplification and population inversion in lasers. Discuss Ruby laser as an optically pumped solid state laser.

(c) Discuss the Fraunhofer class of diffraction of a monochromatic light by a single slit. What will happen when white light is used for such diffraction?

8. Answer the following questions : 40

(a) An artificial satellite is placed at a height of 660 km above earth's surface. Calculate the orbital speed and the frequency of revolution of the satellite round the earth.

(b) For steady motion of fluids, obtain Bernoulli's equation. Explain the vertical lift of an aeroplane in terms of Bernoulli's equation.

9. Answer the following questions : 40

(a) Which thermodynamical quantities are related by the Clausius-Clapeyron equation? Obtain Clausius-Clapyeron equation from the second law of thermodynamics.

(b) What are Maxwell's relations in thermodynamics? Deduce Maxwell's relations from the first and the second law of thermodynamics.

10. Answer the following questions : 40

(a) Deduce the equation for a damped harmonic oscillator and find the condition for critically damped motion.

(b) What is a grating? Discuss the Rayleigh criterion for the resolving power of a grating.

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