This question paper contains 8 printed pages]

CODE : FS-17

PHYSICS

Time : 3 *Hours* *Maximum Marks* : 200

Note :— (1) Question paper consists of *two* parts viz. Part I and Part II. Each part contains *four* questions. The paper as a whole carries eight questions. Question Nos. **1** and **5** are compulsory. The candidates required to attempt *three* more questions out of the remaining six questions taking at least *one* question from each part i.e. this is in addition to the compulsory question of each part. Attempt *five* questions in all. *All* questions carry equal marks. The part of a question are to be attempted at one place in continuation. Answer should be brief and to the point.

P.T.O.

(2) Parts of same questions must be attempted together and not to be attempted in between the answers to other questions.

Part-I

1. (*a*) For an isolated system, give examples to illustrate the following laws :

(*i*) law of conservation of linear momentum,

(*ii*) law of conservation of angular momentum.

(*b*) What is a geostationery orbit ? Obtain the necessary conditions for an artificial satellite to be in a geostationery orbit.

(*c*) Briefly describe the difference between Bose-Einstein and Fermi-Dirac distributions laws. Give examples from phenomena in nature where these are applicable.

(*d*) Distinguish between phase velocity and group velocity. Under what conditions can both velocities be equal ? Which of the two is relevant to transmit signals and why ?

(*e*) Describe the phenomena of polarisation of a wave by reflection. 8×5

2. (*a*) For a thin rod of mass M and length L, find the moment of inertia of the rod about an axis passing through the centre and perpendicular to the length of the rod. 8

(*b*) Describe briefly the effect of coriolis force on the wind patterns and climate. 8

(*c*) Show that Kepler's second law is a consequence of conservation of angular momentum. 6

(*d*) Define Reynold number and describe its utility for studying fluid motion. 8

P.T.O.

(*e*) Briefly describe the differences between principles of special theory of relativity and principles of general theory of relativity. 10

3. (*a*) One mole of an ideal Helium gas at normal temperature and pressure (NTP) expands adiabatically. The pressure decreases to 0.4 atm. Find the resultant volume, temperature and the total work done by the gas. (wherever necessary, make approximate calculations). 20

(*b*) Two black bodies at temperatures T_1 and T_2 radiate maximum energy density at wavelengths λ_1 and λ_2 respectively. If $\lambda_1 = 2\lambda_2$, then find the ratio of total energy radiated by the body at T_1 with respect to energy radiated by the body at temperature T_2. 10

(*c*) Describe briefly any *two* methods of utilisation of solar energy. 10

4. (*a*) A spring of force constant k is fixed at one end and is attached to a mass m at the other end. The mass can oscillate along the x-direction. A force $F_x = F_0 \sin \omega t$ is applied to the mass, Write the equation of motion of the mass. Assume there is a damping force, the magnitude of which is proportional to the velocity $|F| = bv$, where b is some constant. Write the equation of motion. Solve for the amplitude of the forced oscillations. Find the frequency when the amplitude is maximum. Make approximate plots of the amplitude as a function of applied frequency for different values of b. 25

(*b*) Explain the difference between the magnification of a telescope and a microscope. What is the limiting factor for the maximum magnification of a telescope. 15

Part-II

5. (*a*) Show that the function $f(x, y) = \ln (x^2 + y^2)$ satisfies Laplace's equation in two dimensions.

(*b*) The wavefunction of a particle in a one-dimensional quantum harmonic oscillator is $\Psi = A \exp(-ax^2)$. What are the dimensions of A and a ?

(*c*) Give *two* reasons that show that the nucleus does not contain electrons.

(*d*) Briefly describe the differences in the mechanism of production of energy in nuclear fission and in nuclear fusion.

(*e*) Draw a circuit diagram that can be used to obtain the voltage-current characteristics of a semiconductor diode. Show the direction of current in the circuit in both cases of forward and reverse bias. 8×5

6. (*a*) The radius of a long straight wire of circular cross section is R. The wire is carrying a current I. Using Ampere's law, find the magnetic field at any distance from the axis of the wire for $r < R$ and for $r > R$. 8

(*b*) The surface charge density on the plates of a parallel plate capacitor, separated by a distance d, is $+\sigma$ and $-\sigma$. The space between the plates is filled with two dielectric slabs, each of thickness $d/2$, and, dielectric constants K_1 and K_2. Find the electric displacement D, electric field E and polarisation P in each slab. Find the potential difference between the two plates. 20

(*c*) Briefly describe the distinguishing features of diamagnetic, paramagnetic and ferromagnetic materials. 12

7. (*a*) The ionisation energy of H-atom is 13.6 eV. Find the energy of the photon emitted when an electron makes a transition from $n = 4$ to $n = 2$ state in the atom. 8

(*b*) An X-ray photon of frequency 3×10^{19} Hz collides with an electron and is scattered through 90 degrees. If the Compton wavelength of the electron is 0,024 Angstrom, find the frequency of the scattered X-ray photon. 20

(*c*) Briefly describe the relation between symmetry and physical laws of nature. Illustrate by giving *two* examples. 12

8. (*a*) State the Child-Langmuir law. If the anode voltage increases 4 times in a plane-parallel vacuum diode, what is the corresponding increase in the current density. 8

(*b*) Briefly describe the differences in the electrical properties of metals, semiconductors and insulators using their band structure. Explain why metals are opaque to visible light. 20

(*c*) Describe briefly the salient features of transmission and reception of radio waves. 12