UG/I/PHS/H/II/16(New)

2016

PHYSICS

[Honours]

PAPER – II

Full Marks : 90

Time : 4 hours

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

[NEW SYLLABUS]

GROUP – A

Answer any **two** questions : 15×2

1. (*a*) If instead of the dyne, the unit force is defined as the gravitational force between

two particles each of mass 1 gm placed 1 cm apart, then obtain the expression of Newton's second law of force. 2

(b) (i) What physical entity remain conserved for a particle moving in a circular orbit and why? 1 + 1

(ii) Obtain the radial and transverse components of velocities and acceleration of a particle moving in a plane with the polar coordinates defined as $r = A \sin Bt$ and $\theta = Ct$, where A, B and C are constants. 2 + 3

(c) Show that the velocity dependent force is not conservative. 2

(d) A particle moves in a field of force given by $F_x = yz\,(1 - 2\phi)$, $F_y = zx\,(1 - 2\phi)$ and $F_z = xy\,(1 - 2\phi)$ with $\phi(x, y, z) = xyz$. Verify whether the force is conservative or not. Find the potential responsible for such force field. 2 + 2

2. (*a*) (*i*) Prove that the position of the centre of mass is irrespective of the origin of chosen coordinate system. 3

(*ii*) What is second moment of mass ? Justify whether it is a scalar quantity or not. 1 + 1

(*b*) Obtain the expression of angular momentum of a system of particles with appropriate physical explanations. 4

(*c*) (*i*) Derive Newton's law of Gravitation from Kepler's laws. 4

(*ii*) Distinguish between geosynchronous and geostationary satellites. 2

3. (*a*) Find out the expression of kinetic pressure for a two dimensional ideal gas with proper assumptions. 5

(*b*) A narrow molecular beam makes it way into a vessel filled with a gas under low pressure. Find the mean free path of the molecules if the beam intensity decreases n-fold over a distance L. 3

(*c*) Density of Helium gas at STP is 178 kg/m^3. Estimate the size of Helium atom if its mean free path at STP is 285 nm and its mass is 6×10^{-27} kg. 4

(*d*) An ideal gas in a cylinder is enclosed by a piston of cross-section α. The atmospheric pressure P_0 is constant. An external force lifts the piston from a height h_1 to h_2 adiabatically. Find the work done by the applied force on the gas. 3

4. (*a*) Derive the expression of potential at a point outside of a linear quadrupole. How does the field vary with distance for the derived potential. 4 + 1

(*b*) Assuming a simple classical model of an atom, derive an expression for the induced dipole moment, and hence, for its polarizability. 2 + 2

(*c*) Find the field inside a solenoid of length L having N turns uniformly wound round a cylinder of radius r and carrying current I. 4

(*Continued*)

(*d*) Distinguish between the laws of electrostatics and magnetostatics in general. 2

GROUP – B

Answer any **five** questions : 8×5

5. (*a*) Briefly discuss the principle of equivalence. 2

(*b*) (*i*) Obtain the equation of motion of rotating earth to discuss the evolution of centrifugal and coriolis forces.

(*ii*) How does the coriolis force affect the wind motion in northern and southern hemispheres ? $4 + 2$

6. (*a*) Distinguish between Laboratory and centre -of-mass frames of reference. $1 + 1$

(*b*) Show that for a system of particles, the angular momentum about a fixed point is equal to that of a single particle of total mass Σm_i situated at the centre of mass plus the angular momentum of the system about the centre of mass. 3

(*c*) Show that the acceleration $\vec{a}$ of a particle which travels along a space curve with velocity $\vec{v}$ is given by

$$\vec{a} = \frac{dv}{dt}\hat{T} + \frac{v^2}{\rho}\hat{N},$$

where $\hat{T}$ and $\hat{N}$ are unit tangent vector and unit principal normal vector respectively, ρ is the radius of curvature. 3

7. (*a*) Find the distance travelled by the axis of a solid circular cylinder of radius *r* and mass *m* after it has rolled down from rest without slipping for time *t* on a plane inclined at an angle θ with the horizontal. 4

(*b*) How would you distinguish a solid sphere from a thick spherical shell of identical outer radius and mass ? 4

8. (*a*) With the proper assumptions derive the interrelation between thermal conductivity and coefficient of viscosity. 6

(*b*) Discuss how does the mean free path change with temperature at low pressure condition ? 2

9. (*a*) Define thermometric conductivity and thermal resistivity. 2 + 2

(*b*) A number of slaps n each of area A, but of different materials and thickness are placed side by side in contact. If the temperature of the composed face of the first slab is θ_1 and that of the exposed face of the n-th slab is θ_{n+1}, show that, in steady state, the heat conducted per second per unit area is

$$\frac{1}{A}\frac{dQ}{dt} = U\left(\theta_1 - \theta_{n-1}\right).$$

U is the over all coefficient of heat transfer and is given by

$$\frac{1}{U} = \frac{x_1}{K_1} + \frac{x_2}{K_2} + \cdots + \frac{x_n}{K_n}$$

wher x_i is the thickness of the ith slab of conductivity K_i. 4

10. (*a*) State and establish Clausius' theorem for cyclic process. Show that this theorem leads to a 'state function' called entropy. 3 + 3

(*b*) Under constant atmospheric pressure 100 kg of water at 27 °C is converted into superheated steam at 200 °C, Compute the change in entropy. Given : specific heat of water = 4180 J/kg^{-1}/K specific heat of water vapour at T Kelvin is given by $(1670 + 0{\cdot}49\ T)$ J kg^{-1}/K and latent heat of vaporisation = 23×10^5 J kg^{-1}. 2

11. (*a*) For a conducting sphere lying in a uniform electric field, find out the potential and field at the vicinity of the sphere. Hences obtain the induced charge density. 3 + 2 + 1

(*b*) When a neutral dielectric is polarized, the polarization volume and surface charges appear. Show that the net charge remains zero. 2

12. (*a*) Define magnetomotive force and reluctance in a magnetic circuit. 2

(*b*) The volume of the core of a transformer is 1000 cm^3. It is fed with a.c. of 50 Hz. If the loss of energy due to hysteresis per hour is 36 Joules, calculate the area of B-H loop. 3

(*c*) A current carrying solenoid produces a magnetising field of 150 A/m inside it. If an iron core of susceptibility 2000 is placed within this solenoid, what would be the magnetic induction B in the core ? 3

GROUP – C

Answer any five questions : 4×5

13. Two binary stars of masses 2×10^{21} kg and 3×10^{21} kg are 10^6 km apart and are rotating about their centre of mass. Find the angular velocity w. Given $G = 6{\cdot}67 \times 10^{-11}$ $Nm^2 kg^{-2}$. 4

14. Consider a system of N identical particles each of mass M separated by a distance R from each other. Find the simplified expression of gravitational potential energy of the system. 4

15. For the given equation of state :

$$\left(p+\frac{a}{TV^2}\right)(V-b)=RT,$$

obtain the critical coefficient and the Boyle temperature. Here, the terms in the above equation are of usual meaning with the constants a and b. 4

16. (a) Write Planck's formula of energy distribution in black body radiation at an absolute temperature T. Draw distribution curve. 2

(b) A spherical black body of 5 cm radius is at a temperature 327 °C. What is the power radiated ? At what wave length is the maximum energy radiated ? Given $\sigma = 5{\cdot}672 \times 10^{-8}$ SI unit. 2

17. Find the efficiency of a reversible Carnot cycle in respect of T-S-diagram [T and S refer to absolute temperature and entropy respectively]. Justify whether it is a practical steam engine cycle or not. 3 + 1

18. For a two-phase system in equilibrium, p is a function of T only so that

$$\left(\frac{\partial p}{\partial T}\right)_V = \left(\frac{\partial p}{\partial T}\right)_S.$$

If E_S be the adiabatic elasticity, show that

$$E_S C_V = TV\left(\frac{\partial p}{\partial T}\right)^2$$

irrespective of the type of transition that occurs. Here, the terms in the above equation are of usual meaning. 4

19. A dipole of moment p is placed with its axis vertical at a distance d from an infinite conducting horizontal grounded plane. Calculate the force exerted on the plane by the dipole with proper explanation. 4

20. (*a*) What is meant by hysteresis ? Compare the hysteresis curves for soft iron and steel.

(*b*) The core of a transformer is made of soft iron of mass 10 kg and density 7500 kg/m^3. If the area of the hysteresis loop represents a loss of 250 Jm^{-3} cycle^{-1}, find the hourly loss of energy when the transformer is used for operation in an ac of frequency 50 Hz. 1 + 1 + 2
