16. A body A of mass M while falling vertically downwards under gravity breaks into two parts; a body B of mas $\frac{1}{3}$ M and a body C of mass $\frac{2}{3}$ M. The centre of mass of bodies B and C taken together shifts compared to that of body A towards

1) does not shift
2) depends on height of breaking
3) body B
4) body C

Sol: 1)

does not shift as no external face acts.

17. The moment of inertia of a uniform semicircular disc of mass M and radius r about a line perpendicular to the plane of the disc through the centre is

1) $\frac{2}{5}Mr^2$
2) $\frac{1}{4}Mr^2$
3) $\frac{1}{2}Mr^2$
4) Mr^2

Sol: 3)

$\frac{1}{2}Mr^2$

18. The change in the value of 'g' at a height 'h' above the surface of the earth is the same as at a depth 'd' below the surface of earth. When both 'd' and 'h' are much smaler than the radius of earth, then which one of the following is correct?

1) $d = \frac{3h}{2}$
2) $d = \frac{h}{2}$
3) d = h
4) d = 2 h

Sol. 4)

$g_h^{1} = g\left[1 - \frac{2h}{R}\right]; \; g_d^{1} = g\left[1 - \frac{d}{R}\right]$

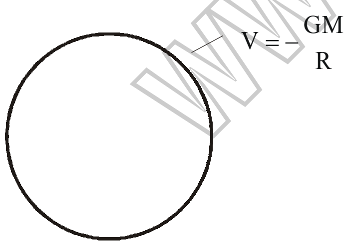
$\therefore d = 2h$

19. A particle of mass 10 g is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done against the gravitational force between them to take the particle far away from the sphere

(you may take $G = 6.67 \times 10^{-11}\ Nm^2 / Kg^2$)

1) 3.33×10^{-10} J
2) 13.34×10^{-10} J
3) 6.67×10^{-10} J
4) 6.67×10^{-9} J

Sol. 3)



$V = -\frac{GM}{R} = -\frac{6.67 \times 10^{-11} \times 100}{0.1}$

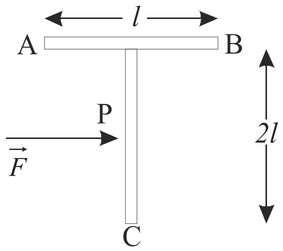
$= -6.67 \times 10^{-8}$

'V' at infinity (at large distance) = 0

$\omega = m \times v = \frac{10}{1000} \times 6.67 \times 10^{-8}$

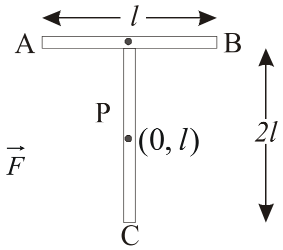
$= 6.67 \times 10^{-10}$ J

20. A 'T' shaped object with dimensions shown in the figure, is lying on a smooth floor. A force '$\vec{F}$' is applied at the point P parallel to AB, such that the object has only the translational motion without rotation. Find the location of P with respect to C.



1) $\frac{3}{2}l$ 2) $\frac{2}{3}l$ 3) l 4) $\frac{4}{3}l$

Sol. 4)



To have linear motion. The force $\vec{F}$ has $0.2l$ to be applied at centre of mass.

i.e. the paint 'p' has to centre of mass

$= Y = \frac{2l \times l + l \times 2l}{l + 2l} = \frac{4l^2}{3l} = \frac{4l}{3}$

21. Which of the following is **incorrect** regarding the first law of thermodynamics?

1) It is a restatement of the principle of conservation of energy
2) It is not applicable to any cyclic process
3) It introduces the concept of the entropy
4) It introduces the concept of the internal energy

Sol. 2)

22. Consider a car moving on a straight road with a speed of 100 m/s. The distance at which car can be stopped is $[\mu_k = 0.5]$

1) 1000 m 2) 800 m 3) 400 m 4) 100 m

Sol. 1)

$v^2 - u^2 = 2as$

$0 - u^2 = 2(-\mu g)s$

$-100^2 = 2 \times -\frac{1}{2} \times 10 \times s$

s = 1000 m

23. A body of mass m is accelerated uniformly from rest to a speed v is a time T. The instantaneous power delivered to the body as a function of time is given by

1) $\frac{mv^2}{T^2}.t^2$ 2) $\frac{mv^2}{T^2}.t$ 3) $\frac{1}{2}\frac{mv^2}{T^2}.t^2$ 4) $\frac{1}{2}\frac{mv^2}{T^2}.t$

Sol: 2)

$u = 0; v = u + aT; v = a.T.$

Instantaneous power = F x v = m.a.v = m.a.at = $m.a^2.t$

$\therefore$ instantaneous power $= m\frac{v^2}{T^2}t$

24. Average density of the earth

1) is a complex function of g
2) does not depend on g
3) is inversely proportional to g
4) is directly proportional to g

Sol: 4)

$$g = \frac{Gm}{R^2} = \frac{G\rho \text{ x v}}{R^2}$$

$$g = \frac{G \times P \times \frac{4}{3}\pi R^3}{R^2}$$

$$g = \frac{4}{3}\rho\pi \text{ G.R.}$$

$\rho \rightarrow$ average density

$$\rho = \left(\frac{3g}{4\pi G R}\right)$$

'ρ' is directly profactional to (g)

25. If 'S' is stress and 'Y' is Young's modulus of material of a wire, the enrgy stored in the wire per unit volume is

1) $\frac{S^2}{2Y}$
2) $2S^2Y$
3) $\frac{S}{2Y}$
4) $\frac{2Y}{S^2}$

Sol. 1)

Energy stored per unit volume

$$\left[\because Y = \frac{\text{Stress}}{\text{Strain}}\right]$$

$$\left[\because \text{Strain} = \frac{\text{Stress}}{Y}\right]$$

$$= \frac{1}{2} \text{ x stress x strain}$$

$$= \frac{1}{2} \text{ x stress x } \frac{\text{strain}}{Y}$$

$$= \frac{1}{2}.\frac{S^2}{Y}$$

26. A 20 cm long capillary tube is dipped in water. The water rises up to 8 cm. If the entire arrangement is put in a freely falling elevator the length of water column in the capillary tube will be

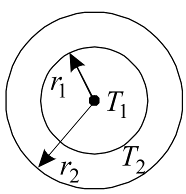
1) 10 cm
2) 8 cm
3) 20 cm
4) 4 cm

Sol. 3)

Water fills the tube entirely in gravity less condition.

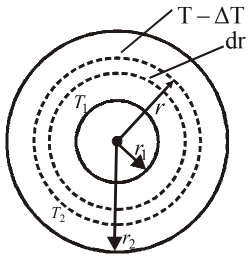
$\therefore$ 20 cm.

27. The figure shows a system of two concentric spheres of radii r_1 and r_2 kept at temperatures T_1 and T_2, respectively. The radial rate of flow of heat in a substance between the two concentric spheres is proportional is



1) In $\left(\frac{r_2}{r_1}\right)$ 2) $(r_2 - r_1) / (r_1 r_2)$ 3) $(r_2 - r_1)$ 4) $\frac{r_1 r_2}{(r_2 - r_1)}$

Sol: 4)



Consider a shall of thickness (dr) and of radii (r).

It the temperature of inner and outer surfaces of this shell be

T, (T -dT)

$\frac{d\theta}{dt}$ = rate of flow of heat though it

$$= \frac{kA((T - dT) - T)}{dr}$$

$$= \frac{-kA - dt}{dr} = -4\pi kr^2 \frac{dT}{dr}$$

$$dt = \frac{-(dr/dT)}{4\pi k} \frac{dr}{r^2}$$

integrating between the proper limits

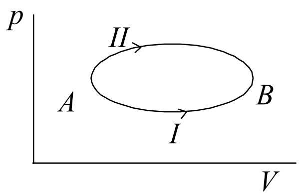
$$\int_{T_1}^{T_2} dt = -\left(\frac{dQ}{dt}\right) \frac{1}{4\pi K} \int_{r_1}^{r_2} \frac{dr}{r^2}$$

$$(T_2 - T_1) = -\frac{dQ}{dt.4\pi k}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\frac{dQ}{dt} = \frac{4\pi K\, r_1 r_2 (T_1 - T_2)}{r_2 - r_1}$$

$$\therefore \frac{dQ}{dt} \text{ x } \frac{r_1 r_2}{r_2 - r_1}$$

28. A system goes from A to B via two processes I and II as shown in figure. If ΔU_1 and ΔU_2 are the changes in internal energies in the processes I and II respectively, then



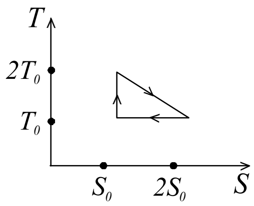
1) relation between ΔU_1 and ΔU_2 can not be determined
2) $\Delta U_1 = \Delta U_2$
3) $\Delta U_2 < \Delta U_1$
3) $\Delta U_2 > \Delta U_1$

Sol: 2)

As in a cyclic process, net internal energy is zero

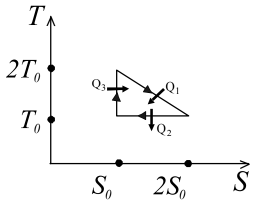
$\Delta U_1 = \Delta U_2$

29. The temperature-entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is



1) $1/4$ 2) $1/2$ 3) $2/3$ 4) $1/3$

Sol. 4)



$$Q_1 = T_oS_o + \frac{1}{2}T_oS_o = \frac{3}{2}T_oS_o$$

$$Q_2 = T_oS_o$$

$$Q_3 = 0$$

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{2}{3} = \frac{1}{3}$$

$\therefore$ (4) is correct

30. If radius of the $^{27}_{13}$Al nucleus is estimated to be 3.6 Fermi then the radius of $^{125}_{52}$Te nucleus be nearly

1) 8 fermi 2) 6 fermi 3) 5 fermi 4) 4 fermi

Sol. 2)

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \left(\frac{27}{125}\right)^{1/3} = \frac{3}{5}$$

$$R_2 = \frac{5}{3} \text{ x } 3.6 = 6 \text{ fermi}$$