AIEEE Entrance Test - 2005

PHYSICS SOLUTIONS

1. Out of the following pair, which one does not have identical dimensions is

(1) moment of inertia and moment of a force (2) work and torque

(3) angular momentum and Planck's constant (4) impulse and momentum

Sol: Ans [1]

$\tau = I\alpha$ $\Rightarrow$ moment of force and moment of inertia will not have same dimensions.

2. The relation between time t and distance x is $t = ax^2 + bx$ where a and b are constants. The acceleration is

(1) $-2av^3$ (2) $2av^2$ (3) $-2abv^2$ (4) $2bv^3$

Sol: Ans [1]

$$\frac{dt}{dx} = 2ax + b \quad \Rightarrow \quad \frac{dx}{dt} = \frac{1}{(2ax+b)}$$

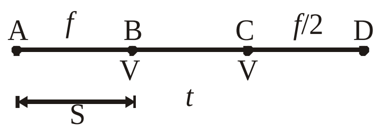
$$\frac{d^2x}{dt^2} = -(2ax+b)^{-2} \cdot 2a\frac{dx}{dt} = -2av^3$$

3. A car starting from rest, accelerates at the rate f through a distance S, then continues at constant speed for time t and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance traversed is 15 S, then

(1) $S = \frac{1}{2}ft^2$ (2) $S = \frac{1}{2}ft^2$ (3) $S = \frac{1}{4}ft$ (4) $S = \frac{1}{6}ft^2$

Sol: Ans []

$S = \frac{V^2}{2f}$ (i)



$S_2 = BC = V\cdot t$ (ii)

$CD = S_3 = \frac{V^2}{f} = 2S$ (iii)

$\Rightarrow$ $S_2 = 15\,S - [AB + CD] = 12\,S$ (iv)

Solving (i) - (iv), $S = \frac{f}{72}t^2$

There is no alternative matching

4. A particle is moving eastwards with a velocity of 5 ms^{-1}. In 10 seconds the velocity changes to

$5\ ms^{-1}$ northwards. The average acceleration in this time is

(1) zero

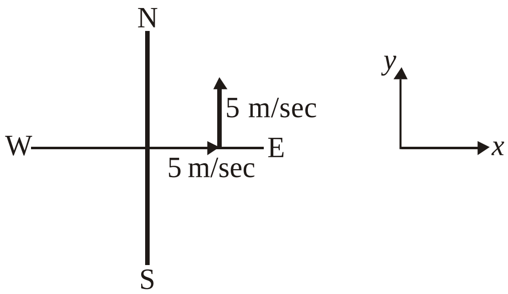
(2) $\frac{1}{\sqrt{2}}\ ms^{-2}$ towards north-west

(3) $\frac{1}{\sqrt{2}}\ ms^{-2}$ towards north-east

(4) $\frac{1}{2}\ ms^{-2}$ towards north

Sol: Ans [2]

$$\mathbf{a}_{avg} = \frac{\mathbf{v}_f - \mathbf{v}_i}{\Delta t} = \frac{5\mathbf{j} - 5\mathbf{i}}{10} = \frac{1}{2}(-\mathbf{i} + \mathbf{j})$$



Average acceleration will be $\frac{1}{\sqrt{2}}$ m/sec^2 in North-West direction

5. A projectile can have the same range R for two angles of projection. If t_1 and t_2 be the times of flights in the two cases, then the product of the two time of flights is proportional to

(1) $\frac{1}{R}$

(2) R

(3) R^2

(4) $\frac{1}{R^2}$

Sol: Ans [2]

At complementary angle of projection i.e., $\theta_1 + \theta_2 = 90°$, ranges are same.

$$t_1 = \frac{2u \sin\theta_1}{g};\ t_2 = \frac{2u \sin\theta_2}{g} = \frac{2u \sin(90 - \theta_1)}{g} = \frac{2u \cos\theta_1}{g}$$

$$t_1 t_2 = \frac{4u^2 \sin\theta_1 \cos\theta_1}{g} = \frac{2\,R}{g}$$

6. An angular ring with inner and outer radii R_1 and R_2 is rolling without slipping with a uniform angular speed. The ratio of the forces experienced by the two particles situated on the inner and outer parts of the ring, $\frac{F_1}{F_2}$ is

(1) 1

(2) $\frac{R_1}{R_2}$

(3) $\frac{R_2}{R_1}$

(4) $\left(\frac{R_1}{R_2}\right)^2$

Sol: Ans [2]

There will be only centrifugal acceleration of all particles because angular speed is constant

$F_1 = ma_A = mR_1w^2$

$F_2 = ma_B = mR_2w^2$

$\Rightarrow \quad \frac{F_1}{F_2} = \frac{R_1}{R_2}$

(Masses of particles are not mentioned in the question. This answer is subject to mass of particles is same)

7. A smooth block is released at rest on a 45° incline and then slides a distance d. The time taken to slide is n times as much to slide on rough incline than on a smooth incline. The coefficient of friction is

(1) $\mu_s = 1 - \frac{1}{n^2}$ (2) $\mu_s = \sqrt{1 - \frac{1}{n^2}}$ (3) $\mu_k = 1 - \frac{1}{n^2}$ (4) $\mu_k = \sqrt{1 - \frac{1}{n^2}}$

Sol: Ans [3]

Let length of incline is d

For smooth inclined plane $d = 0 + \frac{1}{2} \times g \sin 45° \, t_1^2$ (i)

For rough inclined plane $d = 0 + \frac{1}{2}(g \sin 45° - \mu_k g \cos 45°) \cdot t_2^2$ (ii)

Using (i) & (ii), $\frac{1}{2} g \sin 45° \, t_1^2 = \frac{1}{2} g(\sin 45° - \mu_k \cos 45°) t_2^2$

$$\frac{1}{\sqrt{2}} t_1^2 = \frac{1}{\sqrt{2}}(1 - \mu_k) \cdot n t_1^2$$

$$\Rightarrow \quad (1 - \mu_k) = \frac{1}{n^2}$$

$$\Rightarrow \quad \mu_k = \left(1 - \frac{1}{n^2}\right)$$

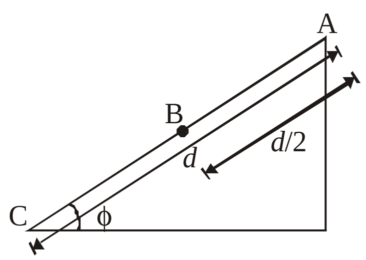
8. The upper half of an inclined plane with inclination ϕ is perfectly smooth while the lower half is rough. A body starting from rest at the top will again come to rest at the bottom if the coefficient of friction for the lower half is given by

(1) $2 \tan \phi$ (2) $\tan \phi$ (3) $2 \sin \phi$ (4) $2 \cos \phi$

Sol: Ans [1]

Let AB is smooth, BS is rough

Applying work energy theorem between A and C



$KE_i = 0, KE_f = 0 \quad \Rightarrow \quad \Delta KE = 0$

$W_{mg} = mgd \cdot \sin\phi$

$W_{friction} = -(\mu mg \cos \phi) \times \frac{d}{2}$

$\Rightarrow \quad mgd\sin\phi - \mu mg\cos\phi\,\frac{d}{2} = 0,\ 2\tan\phi = \mu$

9. A bullet fired into a fixed target loses half of its velocity after penetrating 3 cm. How much further it will penetrate before coming to rest assuming that it faces constant resistance to motion?

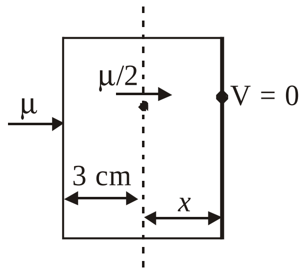
(1) 1.5 cm (2) 1.0 cm (3) 3.0 cm (4) 2.0 cm

Sol: Ans [2]

Using work energy theorem

$$\frac{1}{2}m\left(\frac{u}{2}\right)^2 - \frac{1}{2}mu^2 = -F\times 3$$

or $\frac{3}{8}mu^2 = F \times 3$ (i)



Also

$$\frac{1}{2}m(0)^2 - \frac{1}{2}m\left(\frac{u}{2}\right)^2 = -Fx \text{ or } \frac{mu^2}{8} = -Fx \qquad \text{(ii)}$$

Using equation (i) & (ii)

$$\frac{3}{1} = \frac{3}{x} \quad \Rightarrow \quad x = 1 \text{ cm}$$

10. A parachutist after bailing out falls 50 m without friction. When parachute opens, it decelerates at 2 m/s^2. he reaches the ground with a speed of 3 m/s. At what height, did he bail out?

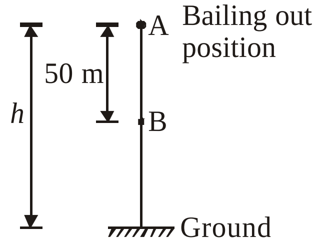
(1) 293 m (2) 111 m (3) 91 m (4) 182 m

Sol: Ans [1]

Applying work energy theorem

$W_{net} = mg \times 50 - m \times 2 \times (h - 50)$

$\Delta KE = \frac{1}{2}m(2)^2 - 0$



$\Rightarrow \quad mg \times 50 - m \times 2(h - 50) = \frac{1}{2}m(2)^2 \Rightarrow h = 293\ m$

11. A particle of mass 0.3 kg is subjected to a force $F = -kx$ with $k = 15$ N/m. What will be its initial acceleration if it is released from a point 20 cm away from the origin?

(1) 5 m/s^2 (2) 10 m/s^2 (3) 3 m/s^2 (4) 15 m/s^2

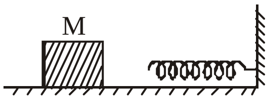
Sol: Ans [2]

At $x = 20\text{cm},\ a = \frac{15\times 0.2}{0.3} = 10\text{m/sec}^2$

12. The block of mass M moving on the frictionless horizontal surface collides with the spring of spring constant K and compresses it by length L. The maximum momentum of the block after collision is

(1) zero (2) $\frac{ML^2}{K}$

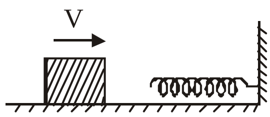
(3) $\sqrt{MK}\ L$ (4) $\frac{KL^2}{2\,M}$



Sol: Ans [3]

Using conservation of energy

$$\frac{1}{2}mv^2 = \frac{1}{2}Kx^2$$



$$\Rightarrow \quad \frac{(m\,v)^2}{2m} = \frac{1}{2}K\,x^2$$

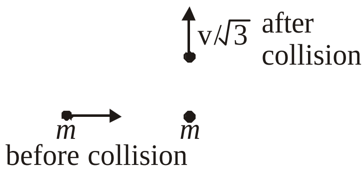
Maximum momentum

$$mv = \sqrt{KM}\ L \ \ (\text{given } x = L)$$

13. A mass *m* moves with a velocity v and collides inelastically with another identical mass. After collision the 1st mass moves with velocity $\frac{v}{\sqrt{3}}$ in a direction perpendicular to the initial direction of motion. Find the speed of the 2nd mass after collision

(1) $\frac{2}{\sqrt{3}}v$ (2) $\frac{v}{\sqrt{3}}$

(3) v (4) $\sqrt{3}\,v$



Sol: Ans [1]

Since there is no external force acting therefore momentum will be conserved in all direction

Conserving momentum along *x*-axis :

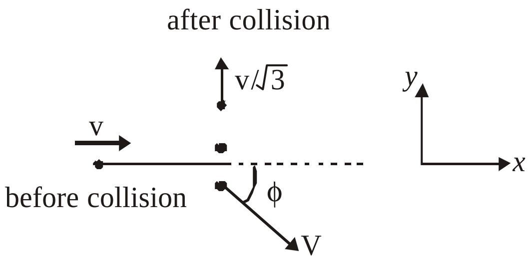
$$mv = mV\cos\phi$$

$$\Rightarrow \quad V\cos\phi = v \qquad \text{(i)}$$

Conserving momentum along *y*-axis :

$$m\frac{v}{\sqrt{3}} = mV\sin\phi$$

$$\Rightarrow \quad V\sin\phi = \frac{v}{\sqrt{3}} \qquad \text{(ii)}$$



From (i) & (ii)

$$V^2 = \frac{4v^2}{3} \quad \Rightarrow \quad V = \frac{2v}{\sqrt{3}}$$

14. A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is

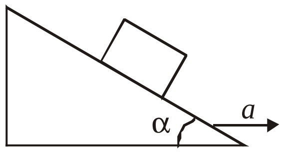
(1) 10 m/s (2) $10\sqrt{30}$ m/s (3) 40 m/s (4) 20 m/s

Sol: Ans [3]

Applying conservation of mechanical energy

$$\frac{1}{2}mv^2 = mg \times 80, \ \ v = 40 \text{ m/sec}$$

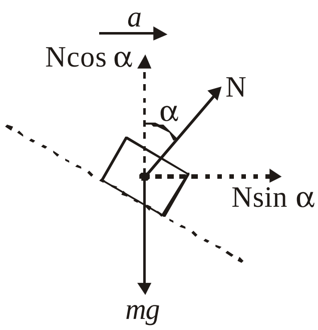
15. A block is kept on a frictionless inclined surface with angle of inclination α. The incline is given an acceleration *a* to keep the block stationary. Then *a* is equal to



(1) g (2) $g \tan\alpha$

(3) $g / \tan\alpha$ (4) $g \operatorname{cosec}\alpha$

Sol: Ans [2]



Net acceleration of block is in horizontal direction

$N \cos\alpha = mg$

$N \sin\alpha = ma$

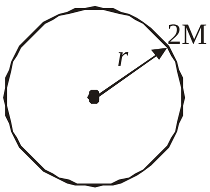
$\Rightarrow \tan\alpha = a/g$

$\Rightarrow a = g \tan\alpha$

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

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

Sol: Ans [2]



$$I = \frac{\frac{1}{2}(2M)r^2}{2} = \frac{1}{2}Mr^2$$

17. A body A of mass M while falling vertically downwards under gravity breaks into two parts: a body B of mass $\frac{1}{3}$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

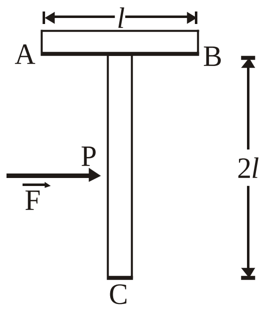
(1) body C (2) body B

(3) depends on height of breaking (4) does not shift

Sol: Ans [4]

When body A breaks into B & C there is no change in external forces and internal forces play no role for motion of centre of mass.

18. 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.



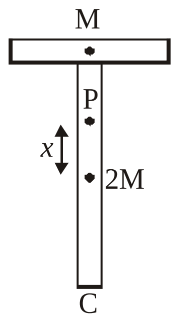
(1) $\frac{4}{3}l$ (2) l

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

Sol: Ans [1]

To have pure translatory motion, F must act at the centre of mass of the body.

Distance of centre of mass from mid-point O.



$$x = \frac{M}{3M} \cdot l = \frac{l}{3}$$

$\Rightarrow$ distance of P from C

$$= l + \frac{l}{3} = \frac{4l}{3}$$

19. 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 smaller than the radius of earth, then which one of the following is correct?

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

Sol: Ans [1]

$$g\left(1 - \frac{2h}{R}\right) = g\left(1 - \frac{d}{R}\right)$$

$\Rightarrow$ $d = 2h$

20. 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) 6.67×10^{-9} J (2) 6.67×10^{-10} J (3) 13.34×10^{-10} J (4) 3.33×10^{-10} J

Sol: Ans [2]

Work done = change in potential energy

$$= 0 - \left[\frac{G \times 100 \times 10 \times 10^{-3}}{0.1}\right]$$

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

21. 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) 4 cm (2) 20 cm (3) 8 cm (4) 10 cm

Sol: Ans [3]

In freely falling elevator effect of gravity will disappear and also angle of contact will become 90°

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

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

Sol: Ans [4]

Formula

23. Average density of the earth

(1) is directly proportional to g (2) is inversely proportionally to g

(3) does not depend on g (4) is a complex function of g

Sol: Ans [1]

$$\rho = \frac{M}{\frac{4}{3}\pi R^3} \times \frac{G}{G} = \frac{3g}{4\pi GR}$$

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

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

Sol: Ans [3]

$$v = 0 + aT \Rightarrow a = \left(\frac{v}{T}\right)$$

Velocity at any time $t = \left(\frac{v}{T}\cdot t\right)$

$$P = F \cdot v = \frac{m\,v}{T} \cdot \frac{v}{T} \cdot t = \frac{m\,v^2}{T^2} \cdot t$$

25. 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) 100 m (2) 400 m (3) 800 m (4) 1000 m

Sol: Ans [4]

Maximum retardation = $-\frac{\mu_k mg}{m} = -\mu_k g$

$0 = (100)^2 - 2 \times \mu_k \times 10 \times S$

$S = 1000$ m

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

(1) It introduces the concept of the internal energy

(2) It introduces the concept of the entropy

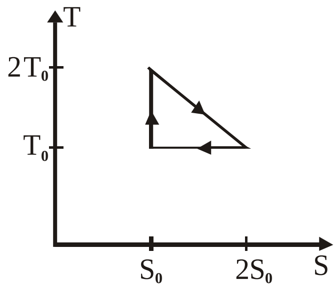
(3) It is not applicable to any cyclic process

(4) It is a restatement of the principle of conservation of energy

Sol: Ans [2]

Second law of thermodynamics introduces the concept of entropy

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



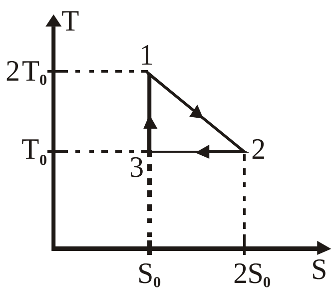
(1) $\frac{1}{3}$ (2) $\frac{2}{3}$

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

Sol: Ans [1]

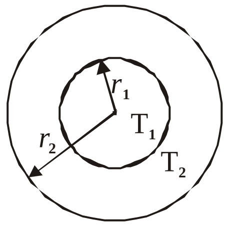
Heat taken from source = Area under curve 1 – 2 = $\frac{3}{2} S_0T_0$

Work done = Area of closed path = $\frac{1}{2} S_0T_0$



$$\eta = \frac{\frac{1}{2}S_0T_0}{\frac{3}{2}S_0T_0} = \frac{1}{3}$$

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



(1) $\frac{r_1 r_2}{(r_2 - r_1)}$ (2) $(r_2 - r_1)$

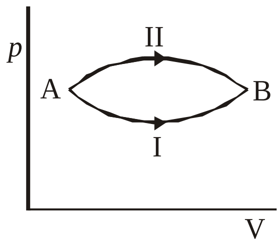
(3) $\frac{(r_2 - r_1)}{r_1 r_2}$ (4) $\ln \frac{r_2}{r_1}$

Sol: Ans [1]

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

$$\Rightarrow \quad \frac{dQ}{dt} \propto \frac{r_1 r_2}{(r_2 - r_1)}$$

29. 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 process I and II respectively, then



(1) $\Delta U_2 > \Delta U_1$

(2) $\Delta U_2 < \Delta U_1$

(3) $\Delta U_1 = \Delta U_2$

(4) relation between ΔU_1 and ΔU_2 can not be determined

Sol: Ans [3]

Change in internal energy is independent of path

30. A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio $\frac{C_p}{c_v}$ of the mixture is

(1) 1.4 (2) 1.54 (3) 1.59 (4) 1.62

Sol: Ans [4]

$$\frac{n_1 + n_2}{\gamma - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}$$

where r is for mixture

$$n_1 = \frac{16}{4} = 4; \; n_2 = \frac{16}{32} = 0.5$$

$$\Rightarrow \quad \frac{4 + \frac{1}{2}}{\gamma - 1} = \frac{4}{\frac{5}{3} - 1} + \frac{\frac{1}{2}}{\frac{7}{5} - 1}; \; \gamma = 1.62$$

31. The intensity of gamma radiation from a given source is I. On passing through 36 mm of lead, it is reduced to $\frac{I}{8}$. The thickness of lead which will reduce the intensity to $\frac{I}{2}$ will be

(1) 18 mm (2) 12 mm (3) 6 mm (4) 9 mm

Sol: Ans [2]

$$I' = Ie^{-\mu x}$$

where μ is coefficient of penetration

$$\frac{I}{8} = Ie^{-\mu \times 36}$$

$$\frac{I}{2} = Ie^{-\mu \cdot x}$$

Solving $x = 12$ mm

32. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap in (eV) for the semiconductor is

(1) 0.5 eV (2) 0.7 eV (3) 1.1 eV (4) 2.5 eV

Sol: Ans [1]

$$\text{Band gap} = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{2580 \times 10^{-9} \times 1.6 \times 10^{-19}} = 0.5 \text{ eV}$$

33. A photocell is illuminated by a small bright source placed 1 m away. When the same source of light is placed $\frac{1}{2}$ m away, the number of electrons emitted by photocathode would

(1) decrease by a factor of 2
(2) increase by a factor of 2
(3) decrease by a factor of 4
(4) increase by a factor of 4

Sol: Ans [4]

No of electrons emitted $(n) \propto \frac{1}{d^2}$

$$\Rightarrow \frac{n_1}{n_2} = \frac{d_2^{\,2}}{d_1^{\,2}}$$

$$n_2 = n_1 \frac{d_1^{\,2}}{d_2^{\,2}} = n_1 \times \frac{1^2}{(1/2)^2} = 4n_1$$

34. Starting with a sample of pure ^{66}Cu, $\frac{7}{8}$ of it decays into Zn in 15 minutes. The corresponding half-life is

(1) 5 minutes (2) $7\frac{1}{2}$ minutes (3) 10 minutes (4) 15 minutes

Sol: Ans [1]

Applying

$N = N_0 e^{-\lambda t}$

$\Rightarrow \frac{1}{8} N_0 = N_0\, e^{-\lambda \times 15}$

$\Rightarrow \lambda \times 15 = \log_e 8$

$\lambda = \frac{3 \times 0.693}{15}$

$T_{1/2} = \frac{0.693}{\lambda} = 5$ min

35. 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

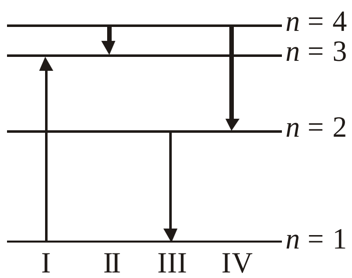
(1) 4 fermi (2) 5 fermi (3) 6 fermi (4) 8 fermi

Sol: Ans [3]

$\because \quad A \propto r^3$

$\Rightarrow \frac{3.6}{r_{Te}} = \left(\frac{27}{125}\right)^{\frac{1}{3}} = \frac{3}{5} \quad \Rightarrow \quad r_{Te} = 6$ fermi

36. The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy?



(1) I (2) II

(3) III (4) IV

Sol: Ans [3]

Maximum energy gap is for transition from $n = 2 \rightarrow$ I

37. If the kinetic energy of a free electron doubles, its deBroglie wavelength changes by the factor

(1) $\frac{1}{\sqrt{2}}$ (2) $\sqrt{2}$ (3) $\frac{1}{2}$ (4) 2

Sol: Ans [1]

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mK}}\ ;\ \ \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{K_2}{K_1}}$$

$$\Rightarrow\ \ \lambda_2 = \frac{\lambda_1}{\sqrt{2}}$$

38. In a common base amplifier, the phase difference between the input signal voltage and output voltage is

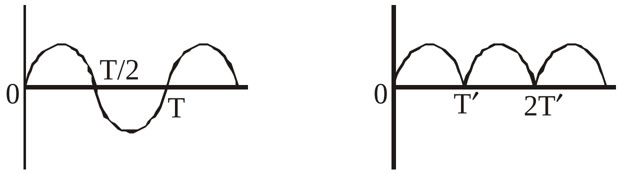
(1) 0 (2) $\frac{\pi}{2}$ (3) $\frac{\pi}{4}$ (4) π

Sol: Ans [1]

39. In a full wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be

(1) 100 Hz (2) 70.7 Hz (3) 50 Hz (4) 25 Hz

Sol: Ans [1]



In full wave rectification frequency doubles

40. A nuclear transformation is denoted by $X(n, \alpha)^{7}_{3}Li$. Which of the following is the nucleus of element X?

(1) $^{9}_{5}B$ (2) $^{11}_{4}Be$ (3) $^{12}C_6$ (4) $^{10}_{5}B$

Sol: Ans [4]

$$^{10}_{5}X + {}^{1}_{0}n = {}^{7}_{3}Li + {}^{4}_{2}He$$

41. The function $\sin^2(\omega t)$ represents

(1) a simple harmonic motion with a period $2\pi/\omega$

(2) a simple harmonic motion with a period π/ω

(3) a periodic, but not simple harmonic motion with a period $2\pi/\omega$

(4) a periodic, but not simple harmonic motion with a period π/ω

Sol: Ans [2]

$$y = \sin^2(\omega t)$$

$$y = \frac{1}{2}(1 - \cos 2\omega t)$$

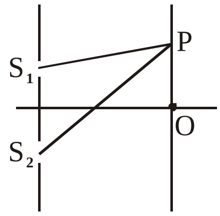
it represents S.H.M. with angular frequency 2ω

$$\Rightarrow \quad T = \frac{2\pi}{2\omega} = \frac{\pi}{\omega}$$

42. A Young's double slit experiment uses a monochromatic source. The shape of the interference fringes formed on a screen is

(1) straight line (2) parabola (3) hyperbola (4) circle

Sol: Ans [3]



$$S_2P - S_1P = n\lambda$$

for a given n, difference of the distance of point P from two fixed points is constant therefore locus of any frinze will be hyperbola

43. Two simple harmonic motions are represented by the equation $y_1 = 0.1 \sin\left(100\pi t + \frac{\pi}{3}\right)$ and $y_2 = 0.1 \cos \pi t$. The phase difference of the velocity of particle 1 with respect to the velocity of particle 2 is

(1) $-\frac{\pi}{3}$ (2) $\frac{\pi}{6}$ (3) $-\frac{\pi}{6}$ (4) $\frac{\pi}{3}$

Sol: Ans [3]

Velocity leads displacement by π/2

$$\Rightarrow \quad V_1 = 0.1 \sin\left(100\pi t + \frac{\pi}{3} + \frac{\pi}{2}\right); \; V_2 = 0.1 \sin\left(\pi t + \frac{\pi}{2} + \frac{\pi}{2}\right)$$

$$\Delta\phi_{12} = \left(\frac{\pi}{3} + \frac{\pi}{2}\right) - \left(\frac{\pi}{2} + \frac{\pi}{2}\right) = -\frac{\pi}{6}$$

44. A fish looking up through the water sees the outside world contained in a circular horizon. If the refractive index of water is $\frac{4}{3}$ and the fish is 12 cm below the surface, the radius of this circle in cm is

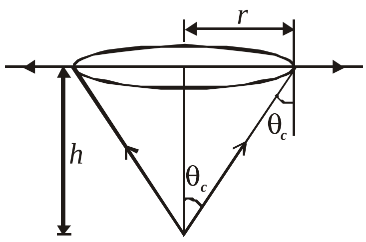
(1) $36\sqrt{5}$ (2) $4\sqrt{5}$ (3) $36\sqrt{7}$ (4) $36/\sqrt{7}$

Sol: Ans [4]

$\tan\theta_c = \frac{r}{h}$

$\Rightarrow \quad r = h \tan q_c$

$\because \quad \sin\theta_c = \frac{1}{\mu}$



$\tan\theta_c = \frac{1}{\sqrt{\mu^2 - 1}}$

$\Rightarrow \quad r = \frac{h}{\sqrt{\mu^2 - 1}} = \frac{12}{\sqrt{\frac{16}{9} - 1}} = \frac{36}{\sqrt{7}}$

45. Two point white dots are 1 mm apart on a black paper. They are viewed by eye of pupil diameter 3 mm. Approximately, what is the maximum distance at which these dots can be resolved by the eye? [Take wavelength of light = 500 nm]

(1) 6 m (2) 3 m (3) 5 m (4) 1 m

Sol: Ans []

46. A thin glass (refractive index 1.5) lens has optical power of 5 D in air. Its optical power in a liquid medium with refractive index 1.6 will be

(1) 25 D (2) –25 D (3) 1 D (4) –1 D

Sol: Ans []

$$-5 = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{(i)}$$

$$P = \left(\frac{3/2}{8/5} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{(ii)}$$

$$\Rightarrow \quad -\frac{5}{P} = \frac{\frac{1}{2}}{-\frac{1}{16}} = -8$$

$P = \frac{5}{8}$ There is no matching alternative

47. When two tuning forks (fork 1 and fork 2) are sounded simultaneously, 4 beats per second are head. Now, some tape is attached on the prong of the fork 2. When the tuning forks are sounded again, 6 beats per second are heard. If the frequency of fork 1 is 200 Hz, then what was the original frequency of fork 2?

(1) 196 Hz (2) 204 Hz (3) 200 Hz (4) 202 Hz

Sol: Ans [1]

When tape is attached to the tuning folk its frequency decreases, therefore frequency of 2, should be

$$= 200 - 4 = 196 \text{ Hz.}$$

48. If a simple harmonic motion is represented by $\frac{d^2x}{dt^2} + \alpha x = 0$, its time period is

(1) $2\pi\alpha$ (2) $2\pi\sqrt{\alpha}$ (3) $\frac{2\pi}{\alpha}$ (4) $\frac{2\pi}{\sqrt{\alpha}}$

Sol: Ans [4]

Comparing with $\frac{d^2x}{dt^2} + \omega^2 x = 0$

$$\omega^2 = \alpha \quad \Rightarrow \quad T = \frac{2\pi}{\sqrt{\alpha}}$$

49. The bob of a simple pendulum is a spherical hollow ball filled with water. A plugged hole near the bottom of the oscillating bob gets suddenly unplugged. During observation, till water is coming out, the time period of oscillation would

(1) remain unchanged

(2) increase towards a saturation value

(3) first increase and then decrease to the original value

(4) first decrease and then increase to the original value

Sol: Ans [3]

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where *l* is distance between point of suspension and centre of mass of the body.

As water leaks out *l* increase and once ball is empty centre of mass comes to initial point.

50. An observer moves towards a stationary source of sound, with a velocity one-fifth of the velocity of sound. What is the percentage increase in the apparent frequency?

(1) 5 % (2) 20 % (3) zero (4) 0.5 %

Sol: Ans [2]

$$f' = f\left(\frac{v - v_0}{v - v_s}\right)$$

$$f' = f\left(\frac{v + v/5}{v}\right) = \left(\frac{6f}{5}\right)$$

$$\frac{f'}{f} = \frac{6}{5} \quad \Rightarrow \quad \frac{\Delta f}{f} = \frac{1}{5}$$

$$\%\ \text{change} = \frac{\Delta f}{f} \times 100 = 20\%$$

51. If I_0 is the intensity of the principal maximum in the single slit diffraction pattern, then what will be its intensity when the slit width is doubled?

(1) I_0 (2) $I_0/2$ (3) $2I_0$ (4) $4I_0$

Sol: Ans [1]

Intensity is independent of width of slit

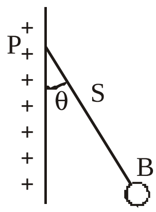
52. When an unpolarized light of intensity I_0 is incident on a polarizing sheet, the intensity of the light which does not get transmitted is

(1) zero (2) I_0 (3) $\frac{1}{2}I_0$ (4) $\frac{1}{4}I_0$

Sol: Ans [3]

Average intensity transmitted through polarizer is $I_0/2$, where I_0 is intensity of unpolarized high.

53. A charged ball B hangs from a silk thread S, which makes an angle θ with a large charged conducting sheet P, as shown in the figure. The surface charge density σ of the sheet is proportional to



(1) sin θ (2) tan θ

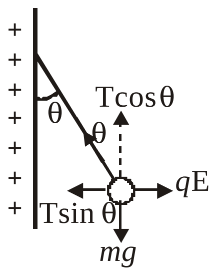
(3) cos θ (4) cot θ

Sol: Ans [2]

For equilibrium

$T\cos\theta = mg$

$T\sin\theta = qE$



$\Rightarrow \quad \tan\theta = \frac{qE}{mg}$

$\Rightarrow \quad mg\tan\theta = q\frac{\sigma}{2\varepsilon_0}$

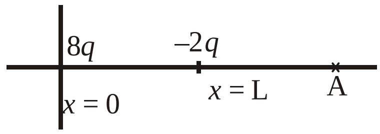
$\Rightarrow \quad \sigma \propto \tan\theta$

54. Two point charges $+8q$ and $-2q$ are located at $x = 0$ and $x = L$ respectively. The location of a point on the x-axis at which the net electric field due to these two point charges is zero is

(1) $8L$ (2) $4L$ (3) $2L$ (4) $\frac{L}{4}$

Sol: Ans [3]

Let E = 0 at point A;



$$\Rightarrow \frac{K \times 8q}{x^2} = \frac{K \times 2q}{(x-L)^2}$$

$$\pm \frac{2}{x} = \frac{1}{x-L}$$

$$\Rightarrow x = 2L, \frac{2L}{3}$$

55. Two thin rings each having a radius R are placed at a distance d apart with their axes coinciding. The charges on the two rings are $+q$ and $-q$. The potential difference between the centres of the two rings is

(1) zero

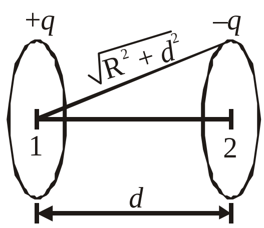
(2) $\frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right]$

(3) $\frac{Q}{4\pi\varepsilon_0 d^2}$

(4) $\frac{Q}{2\pi\varepsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right]$

Sol: Ans [4]

Potential at 1



$$V_1 = \frac{Kq}{R} + \frac{-Kq}{\sqrt{R^2+d^2}}$$

$$V_2 = \frac{-Kq}{R} + \frac{Kq}{\sqrt{R^2+d^2}}$$

$$\Rightarrow V_1 - V_2 = \frac{2Kq}{R} - \frac{2Kq}{\sqrt{R^2+d^2}}$$

56. A parallel plate capacitor is made by stacking n equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is C then the resultant capacitance is

(1) C (2) nC (3) $(n-1)$C (4) $(n+1)$C

Sol: Ans [3]

No of capacitor = $(n - 1)$ connected in parallel

$C_{eq} = (n - 1)C$

57. A fully charged capacitor has a capacitance C. It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity *s* and mass *m*. If the temperature of the block is raised by ΔT, the potential difference V across the capacitance is

(1) $\frac{ms\Delta T}{C}$ (2) $\sqrt{\frac{2ms\Delta T}{C}}$ (3) $\sqrt{\frac{2mC\Delta T}{s}}$ (4) $\frac{mC\Delta T}{s}$

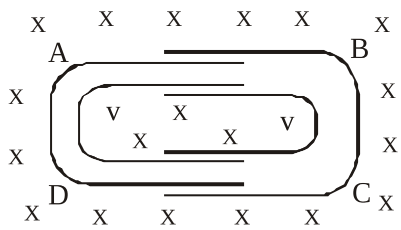
Sol: Ans [2]

Energy stored in capacitor is converted into heat by resistance, which further increases the temperature of block.

$$\Rightarrow \frac{1}{2}CV^2 = mS\Delta T$$

$$V = \sqrt{\frac{2mS\Delta T}{C}}$$

58. One conducting U tube can slide inside another as shown in figure, maintaining electrical contacts between the tubes. The magnetic field B is perpendicular to the plane of the figure. If each tube moves towards the other at a constant speed V, then the emf induced in the circuit in terms of B, *l* and V where *l* is the width of each tube, will be



(1) zero (2) $2BlV$ (3) BlV (4) $-BlV$

Sol: Ans [2]

Induction is due to change in area.

$$\frac{d\phi}{dt} = B\frac{dA}{dt}$$

$$= B \cdot 2 \cdot l \cdot V \quad \text{(Because relative velocity = 2V)}$$

59. A heater coil is cut into two equal parts and only one part is now used in the heater. The heat generated will now be

(1) one fourth (2) halved (3) doubled (4) four times

Sol: Ans [3]

∵ $R \propto l$ therefore resistance will reduce to half

∵ $P = \frac{V^2}{R}$

⇒ Power or heat will double

60. Two thin, long, parallel wires, separated by a distance d carry a current of i A in the same direction. They will

(1) attract each other with a force of $\mu_0 i^2/(2\pi d^2)$ (2) repel each other with a force of $\mu_0 i^2/(2\pi d^2)$
(3) attract each other with a force of $\mu_0 i^2/(2\pi d)$ (4) repel each other with a force of $\mu_0 i^2/(2\pi d)$

Sol: Ans [3]

Formula (force is per unit length)

61. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milliampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 volt, the resistance in ohms needed to be connected in series with the coil will be

(1) 99995 (2) 9995 (3) 10^3 (4) 10^5

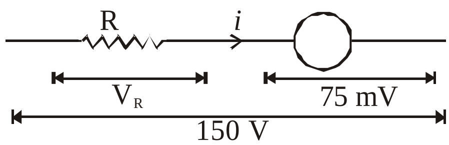
Sol: Ans [2]

Maximum current through galvanometer = 15 mA (150/10)

Maximum voltage across galvanometer = 75 mV(150/2)

To have 1 division/volt, Range of galvanometer = 150 V

$V_R = 150 - 0.075 = 149.925$ volt



⇒ $R = \frac{149.925}{15 \times 10^{-3}} = 9995\ \Omega$

62. Two voltameters, one of copper and another of silver, are joined in parallel. When a total charge q flows through the voltammeters, equal amount of metals are deposited. If the electrochemical equivalents of copper and silver are z_1 and z_2 respectively the charge which flows through the silver voltameter is

(1) $q\frac{z_1}{z_2}$ (2) $q\frac{z_2}{z_1}$ (3) $\frac{q}{1+\frac{z_1}{z_2}}$ (4) $\frac{q}{1+\frac{z_2}{z_1}}$

Sol: Ans [4]

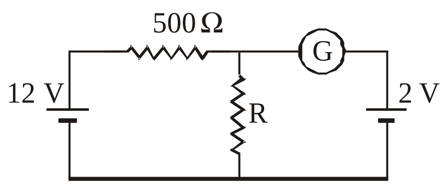
∵ $m = z\,q$

$z_1 q_1 = z_2 q_2$ (mass deposited is same)

⇒ $1 + \frac{q_1}{q_2} = \frac{z_2}{z_1} + 1$

$\Rightarrow \quad q_2 = \dfrac{z_1}{z_1 + z_2} q$

63. In the circuit, the galvanometer G shows zero deflection. If the batteries A and B have negligible internal resistance, the value of the resistor R will be

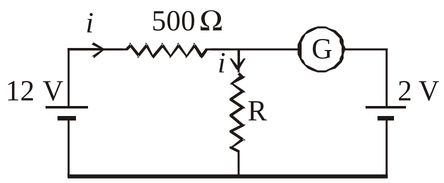


(1) 500 Ω (2) 1000 Ω

(3) 200 Ω (4) 100 Ω

Sol: Ans [4]

If there is no current through 2 V battery voltage across R = 2 volt



$i = \dfrac{12}{500 + R}$

$\Rightarrow \quad R \times \dfrac{12}{500 + R} = 2$

$\Rightarrow \quad R = 100\ \Omega$

64. Two sources of equal emf are connected to an external resistance R. The internal resistances of the two sources are R_1 and R_2 ($R_2 > R_1$). If the potential difference across the source having internal resistance R_2 is zero, then

(1) $R = \dfrac{R_1 R_2}{(R_1 + R_2)}$ (2) $R = \dfrac{R_1 R_2}{(R_2 - R_1)}$

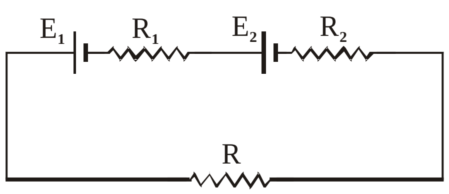
(3) $R = R_2 \times \dfrac{(R_1 + R_2)}{(R_2 - R_1)}$ (4) $R = R_2 - R_1$

Sol: Ans [4]

$\because$ Terminal voltage across $E_2 = 0$

$\Rightarrow \quad 0 = E_2 - iR_2 \qquad \Rightarrow \quad i = E_2/R_2 = E/R_2$

Also, $\quad i = \dfrac{E_1 + E_2}{R_1 + R_2 + R} = \dfrac{2E}{R_1 + R_2 + R}$



$\Rightarrow \quad \dfrac{2E}{R_1 + R_2 + R} = \dfrac{E}{R_2}$

$\Rightarrow \quad R = R_2 - R_1$

65. Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. 3 ampere and 4 ampere are the currents flowing in each coil respectively. The magnetic induction in Weber/m^2 at the centre of the coils will be ($\mu_0 = 4\pi \times 10^{-7}$ Wb/A·m)

(1) 5×10^{-5} (2) 7×10^{-5} (3) 12×10^{-5} (4) 10^{-5}

Sol: Ans [1]

Magnetic induction at the centre of the coil is along axis of the coil, therefore B due to each coil will be perpendicular at their common centre

$$B = \sqrt{B_1^2 + B_2^2} = \sqrt{\left(\frac{\mu_0 \times 3}{2 \times 2\pi \times 10^{-2}}\right)^2 + \left(\frac{\mu_0 \times 4}{2 \times 2\pi \times 10^{-2}}\right)^2}$$

$= 5 \times 10^{-5}\ W/m^2$

66. A charged particle of mass *m* and charge *q* travels on a circular path of radius *r* that is perpendicular to a magnetic field B. The time taken by the particle to complete one revolution is

(1) $\frac{2\pi q B}{m}$ (2) $\frac{2\pi m}{q B}$ (3) $\frac{2\pi m q}{B}$ (4) $\frac{2\pi q^2 B}{m}$

Sol: Ans [2]

Formula

67. In a potentiometer experiment the balancing with a cell is at length 240 cm. On shunting the cell with a resistance of 2 Ω, the balancing length becomes 120 cm. The internal resistance of the cell is

(1) 4 Ω (2) 2 Ω (3) 1 Ω (4) 0.5 Ω

Sol: Ans [2]

$$r = R\left(\frac{l_1}{l_2} - 1\right) = 2\left(\frac{240}{120} - 1\right) = 2\,\Omega$$

68. The resistance of hot tungsten filament is about 10 times the cold resistance. What will be the resistance of 100 W and 200 V lamp when not in use?

(1) 400 Ω (2) 200 Ω (3) 40 Ω (4) 20 Ω

Sol: Ans [3]

Resistance of lamp when in use

$$R = \frac{V^2}{P} = \frac{200 \times 200}{100} = 400\,\Omega$$

Resistance when filament is cold (i.e. lamp is not in use) = $\frac{400}{10}$ = 40 Ω

69. A magnetic needle is kept in a non-uniform magnetic field. It experiences

(1) a force and a torque (2) a force but not a torque

(3) a torque but not a force (4) neither a force nor a torque

Sol: Ans [1]

Force on needle = $M\frac{dB}{dl}$

Where $\frac{dB}{dl}$ is rate of variation of B along magnetic moment

It shows that in non uniform field force is not zero. Torque acts irrespective of nature of field.

70. A uniform electric field and a uniform magnetic field are acting the same direction in a certain region. If an electron is projected along the direction of the fields with a certain velocity then

(1) it will turn towards right of direction of motion

(2) it will turn towards left of direction of motion

(3) its velocity will decrease

(4) its velocity will increase

Sol: Ans [3]

Magnetic force = 0

Electric force will be opposite to E i.e., opposite to velocity in this case therefore there will be retardation.

71. A coil of inductance 300 mH and resistance 2 Ω is connected to a sources of voltage 2 V. The current reaches half of its steady state value in

(1) 0.15 s (2) 0.3 s (3) 0.05 s (4) 0.1 s

Sol: Ans [4]

$$i = i_0 \, e^{-\frac{R}{L}t}$$

$$\frac{1}{2} i_0 = i_0 \, e^{-\frac{2}{300\times10^{-3}}t}$$

$\Rightarrow$ t = 0.1 sec.

72. The self inductance of the motor of an electric fan is 10 H. In order to impart maximum power at 50 Hz, it should be connected to a capacitance of

(1) 1 μF (2) 2 μF (3) 4 μF (4) 8 μF

Sol: Ans [1]

For maximum power: $\omega = \frac{1}{\sqrt{LC}}$

$$\Rightarrow \quad 2\pi \times 50 = \frac{1}{(10 \times C)^{1/2}}$$

$\Rightarrow$ C = 1 μF

73. An energy source will supply a constant current into the load if its internal resistance is

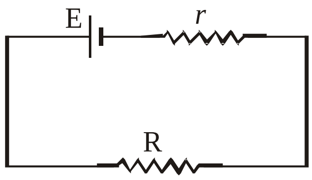
(1) zero

(2) non-zero but less than the resistance of the load

(3) equal to the resistance of the load

(4) very large as compared to the load resistance

Sol: Ans [4]



$$i = \frac{E}{R + r} = \frac{E}{r\left[1 + \frac{R}{r}\right]}$$

if $r >> R$ $\Rightarrow$ $i \approx \frac{E}{r}$ i.e., current is independent of load resistance.

74. A circuit has a resistance of 12 ohm and an impedance of 15 ohm. The power factor of the circuit will be

(1) 1.25 (2) 0.125 (3) 0.8 (4) 0.4

Sol: Ans [3]

$$\cos\phi = \frac{R}{z} = \frac{12}{15} = 0.8$$

75. The phase difference between the alternating current and emf is $\frac{\pi}{2}$. Which of the following cannot be the constituent of the circuit?

(1) L, C (2) L along (3) C alone (4) R, L

Sol: Ans [4]

For non resistance circuit; ϕ is always $\pi/2$.