PART : PHYSICS

1. If electric field is given as $E = \left[-\frac{a}{r^3}\hat{i} + \frac{b}{r^2}\hat{j}\right]$. Then find the dimensions of a and b.

(1) $[ML^2T^{-3}A^{-1}]$, $[ML^3T^{-3}A^{-1}]$
(2) $[ML^4T^{-3}A^{-1}]$, $[ML^3T^{-2}A^{-1}]$
(3) $[ML^4T^{-3}A^{-1}]$, $[ML^3T^{-3}A^{-1}]$
(4) $[ML^4T^{-3}A^{-1}]$, $[ML^3T^{-3}A^{-3}]$

Ans. (3)

Sol. From principle of homogeneity :

Dimension of [E] = Dimension of $\left[\frac{a}{r^3}\right]$

$$[E] = \frac{F}{Q} = \frac{[MLT^{-2}]}{[AT]} = [MLT^{-3}A^{-1}]$$

$$[MLT^{-3}A^{-1}] = \frac{[a]}{[L^3]}$$

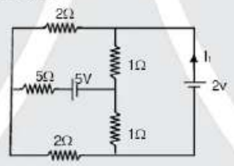
$\therefore$ $[a] = [ML^4T^{-3}A^{-1}]$

Similarly for b

$$[MLT^{-3}A^{-1}] = \frac{[b]}{[L^2]}$$

$[b] = [ML^3T^{-3}A^{-1}]$

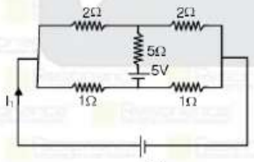
2. In the given circuit calculate the current I_1



(1) 1.5 A
(2) 2.5 A
(3) 3.5 A
(4) 4.5 A

Ans. (1)

Sol. Given circuit



$\Rightarrow$ Balance wheat stone bridge, in 5W resistance current will be zero.

So, we can remove 5Ω resistance then circuit will be

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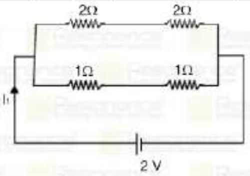
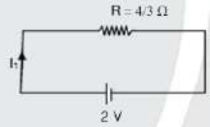


Then,

$$R_{eq} = \frac{4\times2}{4+2} = \frac{8}{6} = \frac{4}{3}\ \Omega$$



$\therefore \quad I_1 = \frac{V}{R} = \frac{2\times3}{4}$

$I_1 = 1.5$ A

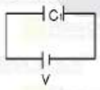
3. A capacitor of capacitance 600 μF is charged by a battery of EMF 100V for along time. After charging, capacitor is disconnected from the battery, and connected by another capacitor with same capacitance. Find the loss in potential energy of the system.

(1) 1.5 J (2) 4.0 J (3) 5.0 J (4) 7.0 J

Ans. **(1)**

Sol. $C_1 = 600\ \mu F$

$E = 100V$



$Q_1 = C_1V$

$Q_1 = (600 \times 10^{-6})\ 100 = 6 \times 10^{-2}$ C

Initial Energy $= \frac{Q_1^2}{2C_1} = \frac{(6\times10^{-2})^2}{2\times600\times10^{-6}} = 3J$

Now after disconnecting battery –

Given $C_2 = 600\mu F$

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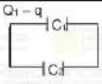


Charge 'q' will flow till the potential drop across the capacitors become same.

$Q = CV \Rightarrow \frac{(Q_1 - q)}{C_1} = \frac{q}{C_2}$

$Q_1 - q = q$

$Q_1 = 2q$

$q = \frac{Q_1}{2} = \frac{6\times10^{-2}}{2} = 3 \times 10^{-2} C$

Finally charge on C_1 and C_2 is 3×10^{-2} C

Then final energy $= \frac{q^2}{2C_1} + \frac{q^2}{2C_2} = \frac{2q^2}{2C_1} = 1.5$ J

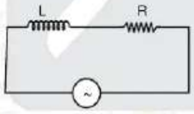
Loss $= E_{initial} - E_{final} = 3 - 1.5 = 1.5$ J

4. L – R circuit in which $X_L = R$ is connected to an DC source the a power factor $P_1 = \cos\theta$, Now a capacitor is added in the same circuit for which $X_L = X_C$ has new power factor $P_2 = \cos\theta_2$ calculate the ratio of old power factor to new power factor.

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

Ans. **(2)**

Sol.



If $X_L = R$ (given)

Then power factor

$P_1 = \cos\theta_1 = \frac{R}{Z}$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

$Z = \sqrt{R^2 + R^2} = \sqrt{2}R$

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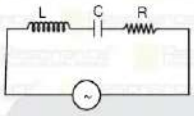
$P_1 = \frac{R}{\sqrt{2}R} = \frac{1}{\sqrt{2}}$

now a capacitor is added in the same circuit



$X_L = X_C$ (given)

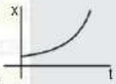
This the resentence condition

$Z = R$

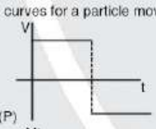
$P_2 = \cos\theta_2 = \frac{R}{R} = 1$

$\frac{P_1}{P_2} = \frac{1}{\sqrt{2}}$

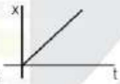
5. Match the Column of position time & velocity time curves for a particle moving in straight line :



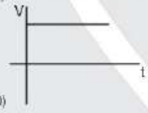
(A)



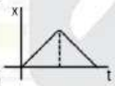
(P)



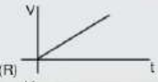
(B)



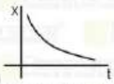
(Q)



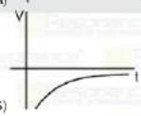
(C)



(R)



(D)



(S)

Choose the correct options

(1) A→R, B→Q, C→P, D→S
(2) A→S, B→Q, C→R, D→P
(3) A→Q, B→R, C→P, D→S
(4) A→P, B→Q, C→R, D→S

Ans. (1)

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6. A capillary tube of uniform cross–section is dipped vertically in liquid A which rises by 5 cm. the surface tension of A is T and density ρ. What will be capillary rise if capillary tube is dipped in liquid B of surface tension 2T and density 2ρ. (Assuming same contact angle in each case)

(1) 10 cm (2) 5 cm (3) 7 cm (4) 3 cm

Ans. (2)

Sol. We know

$h = \frac{2T\cos\theta}{\rho g R}$

$h_A = \frac{2T\cos\theta}{\rho g R}$ ...(1)

$h_B = \frac{2(2T)\cos\theta}{2\rho g R}$ ...(2)

From equation (1) and (2)

$h_B = 5$ cm

7. For an ideal gas if PT^2 = constant, then calculate the coefficient of volume expansion for the gas.

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

Ans. (3)

Sol. If $PT^2 = C$ ...(1)

From ideal gas equation

PV = nRT

$P = \frac{nRT}{V}$

Put value of P in equation (1)

$\left(\frac{nRT}{V}\right)T^2 = C$

$\frac{T^3}{V} = C'$ ...(2)

Differentiating the equation with respect to T

$-\frac{T^3}{V^2}\frac{dV}{dT} + \frac{1}{V}3T^2 = 0$

$\frac{dV}{dT} = \frac{3T^2}{V} \times \frac{V^2}{T^3}$

$dV = \frac{3}{T}VdT$

$dV = \gamma VdT$

Compare both equation

$\gamma = \frac{3}{T}$

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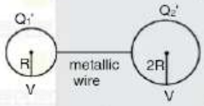
8. Two metallic sphere of radius R and 2R are having same charge density σ. Now these two sphere are connected by a metal wire, due to which the new charge density of bigger sphere is σ'. Calculate the $\frac{\sigma'}{\sigma}$

(1) $\frac{5}{6}$ (2) $\frac{2}{3}$ (3) $\frac{2}{5}$ (4) $\frac{1}{2}$

Ans. (1)

Sol. $Q_1 = \sigma \times 4\pi R^2 = \sigma A$

$Q_2 = \sigma \times 4\pi(2R)^2 = 4\sigma A$



$$Q_2' = \left(\frac{R_2}{R_1+R_2}\right)(Q_{total})$$

$$= \left(\frac{2R}{R+2R}\right)(\sigma A + 4\sigma A) = \frac{2}{3}\times 5\sigma A$$

$$Q_2' = \frac{10}{3}\sigma A$$

$$\sigma_2' = \frac{Q_2'}{4A} = \frac{10}{4\times 3}\sigma = \frac{5}{6}\sigma \Rightarrow \quad \frac{\sigma_2'}{\sigma} = \frac{5}{6}$$

9. Two circular coils A & B whose radius are $R_A = 1m$, $R_B = 2m$ and number of turns are N_A & N_B. The current flow in coil A is I_A and in coil B is I_B magnetic moment of both coils are same. Choose the correct relation given below:

(1) $I_AN_A = I_BN_B$ (2) $I_AN_A = 4I_BN_B$ (3) $4I_AN_A = I_BN_B$ (4) $I_AN_A = 2I_BN_B$

Ans. (2)

Sol. $\vec{M} = N\vec{A}$

$M_A = M_B$

$N_AI_A\pi(1)^2 = N_BI_B\,\pi(2)^2$

$N_AI_B = 4N_BI_B$

10. If charge crossing a cross section of a conductor varies with time t as $q = \alpha t - \beta t^2 + \gamma t^3$. Then find

10. If charge crossing a cross section of a conductor varies with time t as $q = \alpha t - \beta t^2 + \gamma t^3$. Then find minimum current.

(1) $\alpha - \frac{3\beta^2}{\gamma}$ (2) $\alpha - \frac{\beta^2}{\gamma}$ (3) $3\alpha - \frac{\beta^2}{\gamma}$ (4) $\alpha - \frac{\beta^2}{3\gamma}$

Ans. **(4)**

Sol. $i = \frac{dq}{dt} = \alpha - 2\beta t + 3\gamma t^2$

$\frac{di}{dt} = -2\beta + 2\gamma t$

$di/dt = 0$

$-2\beta + 6\gamma t = 0$

$t = \beta/3\gamma$

$d^2i/dt^2 = 6\gamma$ which is he

$i_{min} = \alpha - 2\beta\left(\frac{\beta}{3\gamma}\right) + 3\gamma\left(\frac{\beta}{3\gamma}\right)^2$

$-\alpha - \frac{2\beta^2}{3\gamma} + \frac{\beta^2}{3\gamma}$

$i_{min} = \alpha - \frac{\beta^2}{3\gamma}$

11. In Bohr model the velocity of electron in 7^{th} orbit for hydrogen atom is 3.6×10^6 m/s. Then find the velocity of electron in 3^{rd} orbit = ?

(1) 7.4×10^6 m/s (2) 2.4×10^6 m/s (3) 4.4×10^6 m/s (4) 8.4×10^6 m/s

Ans. **(4)**

Sol. $V = V_0 \frac{z}{n}$ m/s

$3.6 \times 10^6 = V_0 \frac{(1)}{7}$ ....(1) [z = 1 for H-atom]

$V_{3rd} = V_0 \frac{1}{3}$ ..(2)

(2)/(1)

$V_{3rd} = V_0 \frac{1}{3}$

$3.6 \times 10^6 = \frac{7}{3} \times 3.6 \times 10^6 = 8.4 \times 10^6$ m/s

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12. A person uses –1D lens to see far objects and +2D lens to see near objects. Find the distance of nearest object which he can see with unaided eye

(1) 20 cm (2) 30 cm (3) 50 cm (4) 35 cm

Ans. (3)

Sol. Let x be the near point distance

$\frac{1}{-25} - \frac{1}{-x} = \frac{1}{50}$ as p = 2D so, f = 1/2 m = 50m

$\frac{1}{x} = \frac{1}{50} + \frac{1}{25}$

$x = \frac{50}{3}$ cm

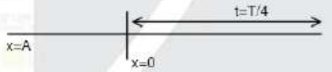
13. For a particle performing SHM the equation of motion is $x = A\sin\omega t$ The potential energy of particle is maximum at $t = \frac{T}{\beta}$. Then calculate β.

(1) 8 (2) 4 (3) 6 (4) 12

Ans. (2)

Sol. $x = A\sin\omega t$

So Here we can see particle is at mean position and going towards right



So the potential Energy will be maximum at x = A (Extreme position)

So time taken by particle to travel x = 0 to x = A in $\frac{T}{4}$, T = Time period.

$\frac{T}{\beta} = \frac{T}{4}$

Hence $\beta = 4$

14. If maximum amplitude of modulated wave is 120 mV and minimum amplitude is 80 mV then find the amplitude of each side band.

(1) 5 mV (2) 15 mV (3) 10 mV (4) 20 mV

Ans. (3)

Sol. Given $A_c + A_m = 120$ ....(1)

$A_c - A_m = 80$ ....(2)

Form equation (1) + (2)

Sol. Given $A_C + A_m = 120$ ....(1)

$A_C - A_m = 80$ ....(2)

Form equation (1) + (2)

$2A_C = 200$

$\Rightarrow A_C = 100 \text{ mV}$

So $A_m = 20 \text{ mV}$

Side band amplitude $= \frac{\mu A_C}{2}$

$$= \frac{\frac{A_m}{A_C} \times A_C}{2} = \frac{20}{2} = 10 \text{ mV}$$

15. If Gravitational field varies with $E = \frac{-K}{r^3}$, where $k = 6 \text{ Nm}^3/\text{kg}$ assuming $r = 2$ as reference. If Gravitational potential at $r = 2$ is 10V, then find the Gravitational potential at $r = 3$.

(1) $\frac{100}{12}$ (2) $\frac{120}{10}$ (3) $\frac{125}{12}$ (4) $\frac{110}{10}$

Ans. **(3)**

Sol. Given $\rightarrow E = \frac{-k}{r^3}$

$$\frac{-dv}{dr} = -\frac{-k}{r^3}$$

$$\Rightarrow \int_{10}^{V} dv = \int_{2}^{3} \frac{kdr}{r^3}$$

$$\Rightarrow V - 10 = k\left[-\frac{1}{2r^2}\right]_2^3$$

$$= \frac{k}{2}\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$= \frac{k}{2}\left[\frac{1}{4} - \frac{1}{9}\right]$$

$$\frac{k}{2} \times \frac{5}{36} = \frac{6 \times 5}{2 \times 3}$$

$$v - 10 = \frac{5}{12}$$

$$v = 10 + \frac{5}{12} = \frac{125}{12}$$

16. An object P of man m slides through a smooth circular track as shown in figure strikes another object Q at same mass kept at rest. Find the velocity of object Q after collision. Assume perfectly elastic collision:

$v = 10 + \frac{5}{12} = \frac{125}{12}$

16. An object P of man m slides through a smooth circular track as shown in figure strikes another object Q at same mass kept at rest. Find the velocity of object Q after collision. Assume perfectly elastic collision:

(1) 2 m/s (2) 1 m/s (3) 3 m/s (4) 4 m/s

Ans. (1)

Sol. Energy conservation for object P b/w point 1 and 2,

$mgh = \frac{1}{2} mv\, v_{P_2}^2$

$v_{P_2} = \sqrt{2gh}$

$= \sqrt{2 \times 10 \times 0.2}$

$v_{P_2} = 2$ m/r

momentum conservation of the collision

$m_P v_{P_2} = m_Q\, v_{Q_2}$

$m \times 2 = m\, v_{Q_2}$

$v_{Q_2} = 2$m/s

17. Electromagnetic wave beam of power 20 mw is incident on a perfectly absorbing body for 300 ns. The total momentum transferred by the beam to the body is equal to :

(1) 2×10^{-7} N-S (2) 4×10^{-7} N-S (3) 3.5×10^{-7} N-S (4) 3.5×10^{-4} N-S

Ans. (1)

Sol. We know momentum p = E/C
E = Energy
C = speed of light

$p = \frac{p \times t}{C}$

$p = \frac{20 \times 10^{-3} \times 300 \times 10^{-9}}{3 \times 10^{8}}$

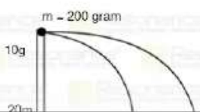
$p = 2 \times 10^{-7}$ N-S

18. A ball of mass 200 gm is placed on the top of a tower, whose height is 20m. A bullet collides with the ball horizontally with some velocity. The mass of the bullet is 10 gm after the collision , ball falls at ground 30m far from the tower and bullet falls 120m far from the tower calculate the velocity of bullet before collision

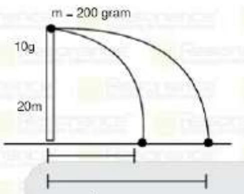
(1) 320 (2) 300 (3) 360 (4) 180

Ans. (3)

Sol.



Sol.



Time of Flight $= \frac{1}{2} g T^2 = H$

$20 = \frac{1}{2} \times 10 \times T^2$

$t = 2$ sec.

speed after collision of ball $30 = V \times 2 \Rightarrow V = 15$ m/ sec.

speed after collision of bullet $120 = V' \times 2 \Rightarrow V' = 60$ m/sec.

an It is elastic collision so initial if momentum final momenta

$10 \times 10^{-3} \times u = 10 \times 10^{-3} \times 60 + 200 \times 10^{-3} \times 15$

$10u = 600 + 3000$

$u = \frac{3600}{10} = 360$

19. A cylindrical rod, whose cross sectional area is A, length is 2m and mass density is d is rotating about an axis which is passing through the centre with kinetic energy E. If angular velocity is $\sqrt{\frac{\alpha E}{A.d}}$, then calculate the value of α.

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

Ans. **(1)**

Sol. $I = \frac{ML^2}{12} = \frac{(d \times A \times 2) \times (2 \times 2)}{12} = \frac{2Ad}{3}$

$K.E = \frac{1}{2} I\omega^2 = \frac{1}{2} \times \frac{2Ad}{3} \times \omega^2 = E$

$\omega = \sqrt{\frac{3E}{Ad}}$

So $\alpha = 3$

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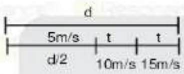
20. A man on horse covered Ist half of total distance of a trip with 5m/s velocity. In second half of trip. If goes with 10 m/s velocity and 15 m/s velocity for equal time to complete the trip If the average velocity of the man is x/ 7 calculate the value of x.

(1) 50 (2) 70 (3) 30 (4) 80

Ans. (1)

Sol.



arg. velocity = $\dfrac{d}{\dfrac{d/2}{5}+2t}$

$\Rightarrow \dfrac{d}{2} = 10t + 15t$

d = 50t

$\therefore 2t = \dfrac{d}{25}$

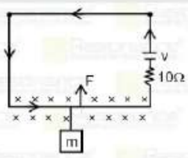
avg velocity = $\dfrac{d}{\dfrac{d/2}{5}+\dfrac{d}{25}} = \dfrac{d}{d\left[\dfrac{1}{10}+\dfrac{1}{25}\right]}$

$= \dfrac{250}{35} = \dfrac{50}{7}$

$\Rightarrow \dfrac{x}{7} = \dfrac{50}{7}$

x = 50

21. A square loop with side length of 10 cm is placed in a magnetic field in such way that only one side of it is in magnetic field of 10^3 gauss which is perpendicular to the plane in inward direction. A mass of 1 gram is attached to side in the field and mass is in equilibrium calculate the emf of the battery



(1) 20 Volt (2) 30 Volt (3) 25 Volt (4) 10 Volt

Ans. (4)

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Sol. Given B = 10^3 Gauss = $10^3 \times 10^{-4}$T

Sol. Given $B = 10^3$ Gauss $= 10^3 \times 10^{-4}$T

$B = 0.1$ T , $R = 10\Omega$, $\ell = 10$ cm, $m = 1$ gm.

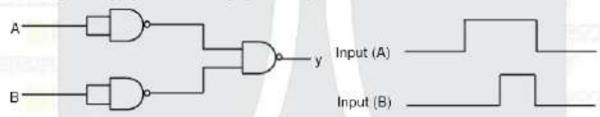
$\therefore F = i\ell B$

$mg = i\ell B$

$1 \times 10^{-3} \times 10 = \frac{V}{R} \times 10 \times 10^{-2} \times 10^{-1}$

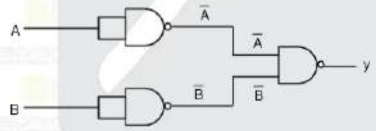
$V = 10$ Volt

22. For the given logic gate, draw the graph for output.



Ans. (1)

Sol.



$\overline{A.A} = \overline{A}$

$y = \overline{\overline{A}.\overline{B}}$

$y = A + B$

23. What is the relation between Young's modulus (Y) modulus of Rigidity (G) Bulk modulus (K) and poison ratio (σ)?

(1) $\sigma = \frac{Y(K-2G)}{18KG}$ (2) $\sigma = \frac{Y(3K-4G)}{12KG}$ (3) $\sigma = \frac{Y(3K-2G)}{18KG}$ (4) $\sigma = \frac{3Y(K-2G)}{18KG}$

Ans. (3)

Sol. $Y = 2G(1 + \sigma)$ ...(1)

$Y = 3K(1 - 2\sigma)$ ...(2)

From equation (1) & (2)

$2G(1 + \sigma) = 3K(1 - 2\sigma)$

3K 3σK

Ans. (3)

Sol. $Y = 2G(1+\sigma)$ ...(1)

$Y = 3K(1-2\sigma)$ ...(2)

From equation (1) & (2)

$2G(1+\sigma) = 3K(1-2\sigma)$

$1+\sigma = \frac{3K}{2G} - \frac{3\sigma K}{G}$

$\sigma = \left(\frac{3K-2G}{2G}\right)\left(\frac{G}{G+3K}\right)$

$\sigma = \frac{3K-2G}{2(G+3K)}$ ...(3)

We know that $Y = \frac{9KG}{3K+G}$

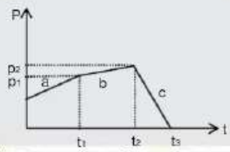
$3K+G = \frac{9KG}{Y}$

Put the above value in equation (3)

$\sigma = \frac{3K-2G}{2\left(\frac{9KG}{Y}\right)}$

$\sigma = \frac{Y(3K-2G)}{18KG}$

24. For the given linear momentum vs time graph. Find location of maximum and minimum force. $t_1 > (t_2 - t_1)$, $(p_2 - p_1) < p_1$



(1) c, b (2) a, b (3) a, c (4) b, a

Ans. (1)

Sol. $F = \frac{dP}{dt}$ = slope

$F_{max} = c$
$F_{min} = b$

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