JEE (Main)

PAPER-1 (B.E./B. TECH.)

2023

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 30 January, 2023 (SHIFT-2) | TIME : (3.00 p.m. to 6.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

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PART : PHYSICS

1. Match list I with List II :

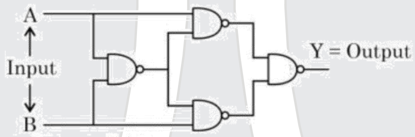
List-I		List-II	
(A)	Torque	I	kg m^{-1} s^{-2}
(B)	Energy density	II.	kg ms^{-1}
(C)	Pressure gradient	III.	kg m^{-2} s^{-2}
(D)	Impulse	IV.	kg m^2 s^{-2}

Choose the correct answer from the options given below :

(1) A-IV, B-I, C-III, D-II (2) A-I, B-IV, C-III, D-II (3) A-IV, B-III, C-I, D-II (4) A-IV, B-I, C-II, D-III

Ans. **(1)**

2. The output Y for the inputs A and B of circuit is given by



Truth table of the shown circuit is

(1)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

(2)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(3)

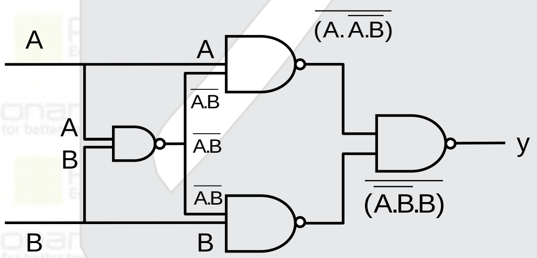
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

(4)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Ans. **(1)**

Sol. We can write this by using demorgn theorm



$$y = \left(\overline{\overline{A.\overline{A.B}}}\right) + \left(\overline{\overline{\overline{A.B}.B}}\right) \quad \text{as} \quad \overline{\overline{x}} = x$$

$$y = \left(A.\overline{A.B}\right) + \left(\overline{A.B}.B\right) = A.\left(\overline{A} + \overline{B}\right) + \left(\overline{A} + \overline{B}\right).B = A.\overline{A} + A.\overline{B} + \overline{A}.B + \overline{B}.B$$

=

A	B	$\overline{A.B}$	$A.\overline{A.B}$	$\overline{A.B}.B$	y
0	0	1	0	0	0
0	1	1	0	1	1
1	0	1	1	0	1
1	1	0	0	0	0

3. Given below are two statements : One is labelled as **Assertion A** and the other is labelled as **Reason R**

Assertion A : The nuclear density of nuclides ${}^{10}_{5}B, {}^{6}_{3}Li, {}^{56}_{26}Fe, {}^{20}_{10}Ne$ and ${}^{200}_{83}Bi$ can be arranged as $\rho^N_{Bi} > \rho^N_{Fe} > \rho^N_{Ne} > \rho^N_B > \rho^N_{Li}$.

Reason : The radius R of nucleus is related to its mass number A as $R = R_0A^{1/3}$, where R_0 is a constant.

In the light of the above statements, choose the correct answer from the options given below :

(1) Both A and R are true and R is the correct explanation of A

(2) A is false but R is true

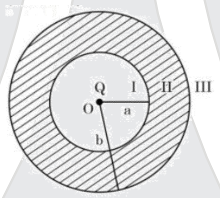
(3) Both A and R are true but R is NOT the correct explanation of A

(4) A is true but R is false

Ans. **(2)**

Sol. Nuclear density is same for all nucleus.

4. As shown in the figure, a point charge Q is placed at the centre of conducing spherical shell of inner radius a and outer radius b. The electric field due to charge Q in three different regions I, II and III is given by (I : r < a, II : a < r, b, III : r > b)



(1) $E_I = 0, E_{II} = 0, E_{III} = 0$

(2) $E_I \neq 0, E_{II} = 0, E_{III} = 0$

(3) $E_I = 0, E_{II} = 0, E_{III} \neq 0$

(4) $E_I \neq 0, E_{II} = 0, E_{III} \neq 0$

Ans. **(4)**

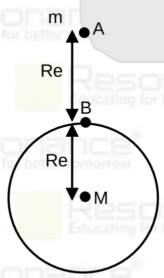
Sol. Electric field inside conducing material is zero.

5. An object is allowed to fall from a height R above the earth, where R is the radius of earth. Its velocity when it strikes the earth's surface, ignoring air resistance, will be

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

Ans. **(1)**

Sol.

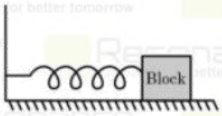


By energy conservation, $PE_A + KE_A = PE_B + KE_B$

$$\frac{-GMm}{2R} + 0 = \frac{-GMm}{R} + \frac{1}{2}mV^2 \Rightarrow \frac{GMm}{2R} = \frac{1}{2}mV^2$$

$$V = \sqrt{\frac{GM}{R}} \Rightarrow \text{We know } GM = gR^2 \Rightarrow V = \sqrt{\frac{gR^2}{R}} \Rightarrow V = \sqrt{gR}$$

6. For a simple harmonic motion in a mass spring system shown, the surface is frictionless. When the mass of the block is 1 kg, the angular frequency is ω_1. When the mass block is 2 kg the angular frequency is ω_2. The ratio ω_2/ω_1 is



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

Ans. **(4)**

Sol. For SHM

$\omega^2 = K/m$

$$\omega = \sqrt{\frac{K}{m}} \Rightarrow \omega \propto \sqrt{\frac{1}{m}}$$

$$\frac{\omega_2}{\omega_1} = \sqrt{\frac{m_1}{m_2}} = \frac{1}{\sqrt{2}}$$

7. A force is applied to a steel wire A, rigidly clamped at one end. As a result elongation in the wire is 0.2 mm. If same force is applied to another steel wire B of double the length and a diameter 2.4 times that of the wire A, the elongation in the wire B will be (wires having uniform circular cross sections)

(1) 2.77×10^{-2} mm (2) 6.9×10^{-2} mm (3) 6.06×10^{-2} mm (4) 3.0×10^{-2} mm

Ans. **(2)**

Sol. We know $\Delta L = \frac{FL}{AY}$

$$\Delta L_1 = \frac{FL_1}{A_1 Y} = 0.2 \text{ mm} \quad ....(1)$$

$$\Delta L_2 = \frac{FL_2}{A_2 Y} \quad .....(2)$$

Equation (2)/(1)

$$\frac{\Delta L_2}{\Delta L_1} = \frac{L_2}{A_2} \times \frac{A_1}{L_1}$$

$$\frac{\Delta L_2}{\Delta L_1} = \frac{2L}{\frac{\pi}{4}(2.4d)^2} \times \frac{\frac{\pi}{4}d^2}{L}$$

$\Delta L_2 = 0.06944$ mm $\Rightarrow 6.944 \times 10^{-2}$ mm

8. A machine gun of mass 10 kg fires 20 g bullets at the rate of 180 bullets per minute with a speed of 100 ms^{-1} each. The recoil velocity of the gun is :

(1) 0.6 m/s (2) 2.5 m/s (3) 1.5 m/s (4) 0.02 m/s

Ans. **(1)**

Sol. Number of bullets fired per second = 180/60 = 3

By momentum conservation

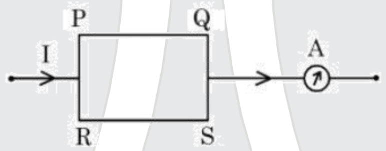
$M_GV_G = -M_BV_B$

$M_B = 3 \times 20 = 60$ gm

$10 \times V_G = 60 \times 10^{-3} \times 100$

$V_G = 0.6$ m/s

9. A current carrying rectangular loop PQRS is made of uniform wire. The length PR = Qs = 5 cm and PQ = RS = 100 cm. if ammeter current reading changes from I to 2I, the ratio of magnetic forces per unit length on the wire PQ due to wire RS in the two cases respectively $(f_{PQ}^{I} : f_{PQ}^{2I})$



(1) 1 : 5 (2) 1 : 3 (3) 1 : 2 (4) 1 : 4

Ans. **(4)**

Sol. Length of PQ ≫ Length of PR

$$f_{PQ}^{I} = \frac{\mu_0 \left(\frac{I}{2}\right)\left(\frac{I}{2}\right)}{2\pi d} \quad ....(1)$$

$$f_{PQ}^{2I} = \frac{\mu_0 I.I}{2\pi d} \quad ....(2)$$

From equation (1) & (2)

$f_{PQ}^{I} : f_{PR}^{2I} = 1 : 4$

10. A flask coins hydrogen and oxygen in the ratio of 2 : 1 by mass at temperature 27°C. The ratio of average kinetic energy per molecule of hydrogen and oxygen respectively is :

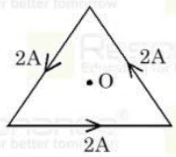
(1) 2 : 1 (2) 1 : 4 (3) 1 : 1 (4) 4 : 1

Ans. **(3)**

Sol. Average Kinetic Energy per molecule = $\frac{3}{2}k_BT$

As both gases are at same temperature Average Kinetic Energy per molecule will be same for both.

11. A shown in the figure, a current of 2A flowing in an equilateral triangle of side $4\sqrt{3}$ cm. The magnetic field at the centroid O of the triangle is :



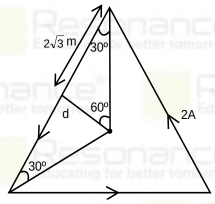
(Neglect the effect of earth's magnetic field)

(1) $4\sqrt{3} \times 10^{-4}$T (2) $\sqrt{3} \times 10^{-4}$T (3) $4\sqrt{3} \times 10^{-5}$T (4) $3\sqrt{3} \times 10^{-5}$T

Ans. (4)

Sol. $\tan 30^\circ = \frac{d}{2\sqrt{3}}$

$\frac{1}{\sqrt{3}} = \frac{d}{2\sqrt{3}}$ d = 2 cm = 2 × 10^{-2} m



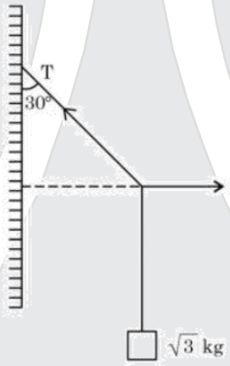
$B_{net} = B_1 + B_2 + B_2$ (•)

But $B_1 = B_2 = B_2 = B$

Between : $B = \frac{3 \times \mu_0 i}{4\pi d}$ [sin60º + sin60º]

$= \frac{3 \times 10^{-7} \times 2}{2 \times 10^{-2}}[\sin 60^\circ + \sin 60^\circ] = 3\sqrt{3} \times 10^{-5}$ T

12. A block of $\sqrt{3}$ kg is attached to a string whose other end is attached to the wall. An unknown force F is applied so that the string makes an angle of 30° with the wall. The tension T is :



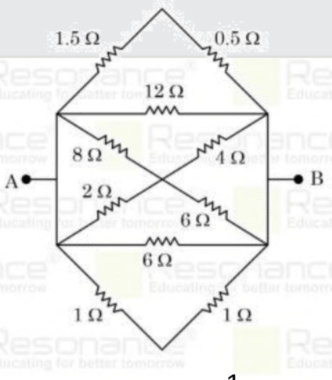
(1) 25 N (2) 15 N (3) 10 N (4) 20N

Ans. (4)

Sol. T cos30º = $\sqrt{3}$ g

$T \times \frac{\sqrt{3}}{2} = \sqrt{3}g$; T = 20 N

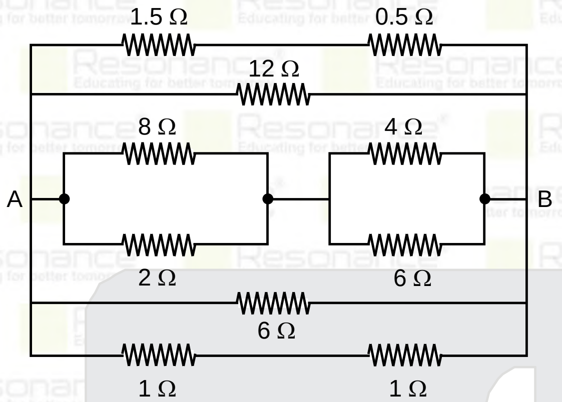
13. The equivalent resistance between A and B is _______________



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

Ans. (1)

Sol.



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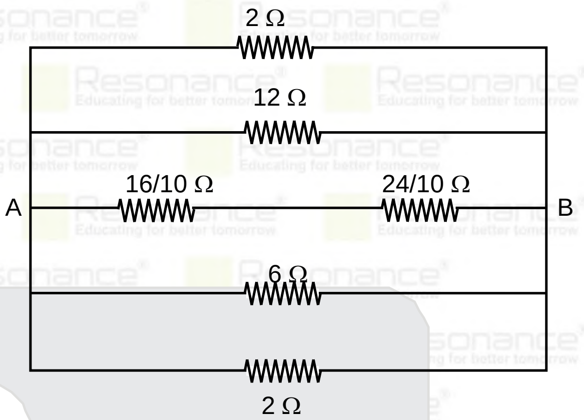
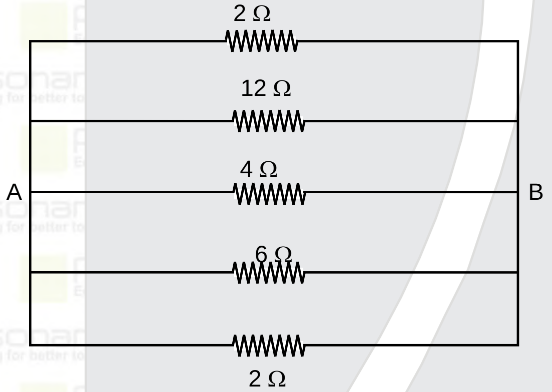




$$\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{12} + \frac{1}{4} + \frac{1}{6} + \frac{1}{2} \quad ; \quad R_{eq} = 2/3\ \Omega$$

14. Other is labelled as Reason R

Assertion A : Efficiency of a reversible heat engine will be highest at –273°C temperature of cold reservoir.

Reason R : The efficiency of Carnot's engine depends not only on temperature of cold reservoir but it depends on the temperature of hot reservoir too and is given as $\eta = \left(1 - \frac{T_2}{T_1}\right)$

In the light of the above statements, choose the correct answer from the options given below :

(1) A is true but R is false

(2) Both A and R are true and R is the correct explanation

(3) Both A and R are true but R is NOT the correct explanation of A

(4) A is false but R is true

Ans. **(2)**

Sol. $\eta = 1 - \frac{T_{sink}}{T_{source}}$

Given that T_{sink} = –273°C = 0K

$\eta = 1 - \frac{0}{T}$; $\eta = 1$

So, efficiency is maximum at T_{sink} = –273°C

15. An electron accelerated through a potential difference V_1 has a de-Broglie wavelength of λ. When the potential is changed to V_2, its de-Broglie wavelength increases by 50%. The value of (V_1/V_2) is equal to

(1) 4 (2) 9/4 (3) 3 (4) 3/2

Ans. (2)

Sol. $\lambda_1 = \lambda,\ \lambda_2 = \lambda + \lambda \times \frac{50}{100} = 1.5\ \lambda$

$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2meV}}$ .....(1)

$\lambda \propto \frac{1}{\sqrt{V}} \Rightarrow \frac{\lambda}{1.5\lambda} = \sqrt{\frac{V_2}{V_1}} \Rightarrow \frac{2}{3} = \sqrt{\frac{V_2}{V_1}} \Rightarrow \frac{V_1}{V_2} = \frac{9}{4}$

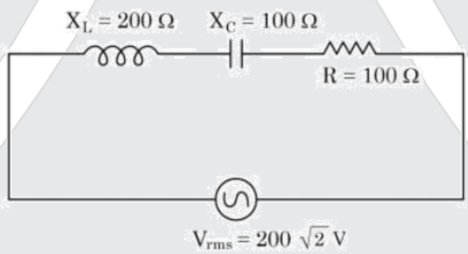
16. Match List I with List II :

List-I		List-II	
(A)	Attenuation	I	Combination of a receiver and transmitter.
(B)	Transducer	II.	Process of retrieval of information from the carrier wave at receiver
(C)	Demodulation	III.	Convert one form of energy into another
(D)	Repeater	IV.	Loss of strength of a signal while propagating through a medium.

(1) A-II, B-III, C-IV, D-I (2) A-IV, B-III, C-II, D-I (3) A-I, B-II, C-III, D-IV (4) A-IV, B-III, C-I, D-II

Ans. (2)

17. In the given circuit, rms value of current (I_{rms}) through the resistor R is



(1) $\frac{1}{2}$A (2) 20A (3) 2A (4) $2\sqrt{2}$A

Ans. (3)

Sol. $I_{RMS} = \frac{V_{RMS}}{Z}$

$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{100^2 + (200-100)^2} = 100\sqrt{2}$

$I_{RMS} = \frac{200\sqrt{2}}{100\sqrt{2}} = 2A$

18. A vehicle travels 4 km with speed of 3 km/h and another 4 km with speed of 5 km/h, then its average speed is

(1) 3.75 km/h (2) 4.25 km/h (3) 3.50 km/h (4) 4.00 km/h

Ans. (1)

Sol. Average speed = $\frac{2V_1V_2}{V_1+V_2} = \frac{2\times3\times5}{3+5} = \frac{15}{4}$ km/hr = 3.75 km/h

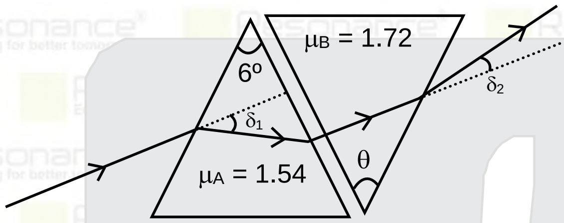
19. A thin prism P_1 with an angle 6° and made of glass of refractive index 1.54 is combined with another prims P_2 made from glass of refractive index 1.72 to produce dispersion without average deviation. The angle of prism P_2 is

(1) 7.8° (2) 4.5° (3) 6° (4) 1.3°

Ans. **(2)**

Sol. As we know

$S_1 + S_2 = 0$



$A(\mu_A - 1) - B(\mu_B - 1) = 0$

$6(1.54 - 1) - \theta(1.72 - 1) = 0$

$6 \times 0.54 - \theta \times 0.72 = 0$

$\Rightarrow = \dfrac{6 \times 3}{4} = 4.5^o$

20. A point source of 100W emits light with 5% efficiency. At a distance of 5 m from the source, the intensity produced by the electric field component is :

(1) $\dfrac{1}{40\pi}\dfrac{W}{m^2}$ (2) $\dfrac{1}{10\pi}\dfrac{W}{m^2}$ (3) $\dfrac{1}{20\pi}\dfrac{W}{m^2}$ (4) $\dfrac{1}{2\pi}\dfrac{W}{m^2}$

Ans. **(1)**

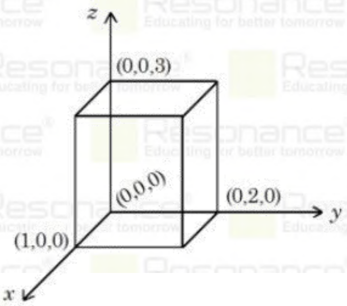
Sol. Total power emitted = $100 \times \dfrac{5}{100} = 5W$

Intensity = $\dfrac{\text{Power}}{\text{Area}}$

$\dfrac{5}{4\pi \times 5^2} = I$; $\dfrac{1}{20\pi}\dfrac{W}{m^2} = I$

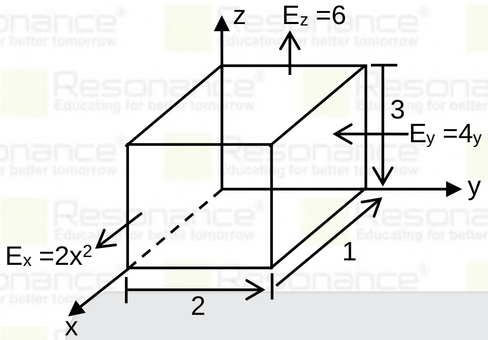
This intensity is due to both electric & magnetic field so, due electric field = 1/2 × $\dfrac{1}{20\pi}\dfrac{W}{m^2} = \dfrac{1}{40\pi}\dfrac{W}{m^2}$

21. As shown in figure, a cuboid lies in a region with electric field E = $2x^2\hat{i} - 4y\hat{j} + 6\hat{k}\,N/C$. The magnitude of charge within the cuboid is $n\epsilon_0$C. The value of n is __________ (if dimension of cuboid is 1 × 2 × 3 m^3)



Ans. 12

Sol.



As $\phi = \vec{E}.\vec{A}$

then are 6 surface so will find it for every surface.

(i) face at x =0

$\phi_{ox} = E_{x=0}.A \Rightarrow \phi_0 = 2(0)^2 \times 2 \times 3 = 0$

(ii) face at x = 1

$\phi_{zx} = 2(1)^2 \times (3 \times 2) = 2 \times 6 = 12$

(iii) face at y = 0

$\phi_{oy} = 0\ [\therefore\ E_{y=0} = 4 \times 0 = 0]$

(iv) face at y = 2

$\phi_{2y} = -4 \times 2 \times 3 \times 1 = -24$

(negative sign: area vector & $\vec{E}$ are opposite)

(v) face at z = 0, $\phi = 6 \times 1 \times 2 = 12$

(vi) face at z = 3, $\phi_{3z} = (6) \times 1 \times 2 = 12$

$\phi_{net} = \phi_{ox} + \phi_{ix} + \phi_{oy} + \phi_{2y} + \phi_{oz} + \phi_{3z} = 0 + 12 - 24 + 0 + 12 + 12$

$\phi_{net} = 12$

as $\phi_{net} = q/\varepsilon_0 \Rightarrow q = 12\varepsilon_0$

22. A uniform disc of mass 0.5 kg and radius r is projected with velocity 18 m/s at t = 0s on a rough horizontal surface. It starts off with a purely sliding motion at t = 0s. After 2s it acquires a purely rolling motion (see figure). The total kinetic energy of the disc after 2s will be ____ J (given, coefficient of friction is 0.3 and g = 10 m/s²)

Ans. 54

Sol. $-\mu N = ma$

$0.3 \times 0.5 \times 10 = 0.5a$

$a = 3\ m/s^2$

Velocity after 2 sec V' = 18 – 3 × 2 = 12 m/s

Kinetic energy after 2 sec K.E. = $1/2\ mV^2 + 1/2\ I\omega^2$

$$K.E. = \frac{1}{2}mV'^2 + \frac{1}{2}\frac{mR^2}{2}\left(\frac{V'}{R}\right)^2$$

$$K.E. = \frac{1}{2}mV'^2 + \frac{1}{4}mV'^2$$

$$K.E. = \frac{1}{2}\times 0.5\times(12)^2 + \frac{1}{4}\times 0.5\times(12)^2 = 54J$$

23. A faulty thermometer reads 5°C in melting ice and 95°C in steam. The correct temperature on absolute scale will be_________ K when the faulty thermometer reads 41°C.

Ans. **313**

Sol. $\frac{X-LFP}{UFP-LFP}$ = constant

$\frac{41-5}{95-5}=\frac{t-0}{100-0}$

$\frac{36}{90}=\frac{t}{100}$

t = 40°C

in k $t \to 40+273$

t = 313K

24. A body of mass 2 kg is initially at rest. It starts moving unidirectionally under the influence of a source of constant power P. Its displacement in 4s is $\frac{1}{3}\alpha^2\sqrt{P}m$. The value of α will be_________

Ans. **4**

Sol. Relation between displacement & time

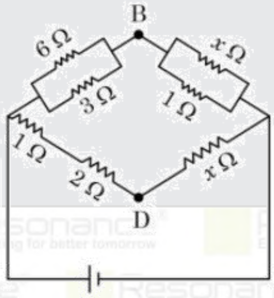
$x = \frac{2}{3}\sqrt{\frac{2P}{m}}t^{3/2}$

$x = \frac{2}{3}\sqrt{\frac{2P}{2}}.4^{3/2}$

$x = \frac{1}{3}\times 16\sqrt{P}$

$\alpha^2 = 16 \Rightarrow \alpha = 4$

25. If the potential difference between B and D is zero, the value of x is 1/n Ω. The value of n is _________



Ans. **2**

Sol. If potential difference between B & D is zero it will be work as wheat stone bridge

$2\times x = 3\left(\frac{x\times 1}{x+1}\right)$

$2x^2 + 2x = 3x$

$2x^2 + 2x - 3x = 0$

$2x^2 - x = 0$; $x(2x-1) = 0$; $x = 1/2$

$x=\frac{1}{n}=\frac{1}{2}$; n = 2

26. A stone tied to 180 cm long string at its end is making 28 revolutions in horizontal circle in every minute. The magnitude of acceleration of stone is $\frac{1936}{x}ms^{-2}$. The value of x ____. (Take $\pi = \frac{22}{7}$)

Ans. **125**

Sol. $V = R\omega = \frac{180}{100} \times \left(\frac{2\pi \times 28}{60}\right) = \left(\frac{132}{25}\right)$

$a = \frac{V^2}{R} = \left(\frac{132}{25}\right)^2 \times \frac{100}{180} = \frac{1936}{125} m/s^2$

$\therefore$ x = 125

27. In a Young's double slit experiment, the intensities at two points, for the path differences $\lambda/4$ and $\lambda/3$ (l being the wavelength of light used) are I_1 and I_2 respectively. If I_0 denotes the intensity produced by each of the individual slits, then $\frac{I_1 + I_2}{I_0} =$ _____.

Ans. **3**

Sol. $I_1 = I_0 + I_0 + 2I_0 \cos \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = 2I_0$

$I_2 = I_0 + I_0 + 2I_0 + \cos \frac{2\pi}{\lambda} \times \frac{\lambda}{3} = I_0$

$\frac{I_1 + I_2}{I_0} = 3$

28. In an ac generator, a rectangular coil of 100 turns each having area $14 \times 10^{-2} m^2$ is rotated at 360 rev./min. about an axis perpendicular to a uniform magnetic field of magnitude 3.0 T. The maximum value of the emf produced will be _____V.

Ans. **1584**

Sol. $\varepsilon = NAB\omega$

$= 100 \times 14 \times 10^{-2} \times 3 \times 2\pi \times 360/60$

= 1584 Volt

29. The velocity of a particle executing SHM varies with displacement (x) as $4v^2 = 50 - x^2$. The time period of oscillations is $\frac{x}{7}s$. The value of x is ____________ $\left(\text{Take } \pi = \frac{22}{7}\right)$

Ans. **88**

Sol. $4v^2 = 50 - x^2$

differentiate the equation w.r.t to time

$\Rightarrow$ 8v.dv/dt = –2x dx/dt

8v.dv/dt = –2x.v (∵ dx/dt = v)

$8\frac{dv}{dt} = -2x$ (∵ $dv/dt = dx^2/dt^2$)

$8\frac{d^2x}{dt^2} = -2x$

$$\frac{d^2x}{dt^2}+\frac{x}{4}=0$$

Comparing with standard equation $\omega = 1/2$

$\omega = 2\pi/T$

$$T=\frac{2\pi}{\omega}=\frac{2\pi}{\frac{1}{2}}$$

$$T=2\pi=4\times\frac{22}{7}$$

T = 88/7

x = 88

30. A radioactive nucleus decays by two different process. The half life of the first process is 5 minutes and that of the second process is 30 s. The effective half-life of the nucleus is calculated to be $\frac{\alpha}{11}$ s. The value of α is _____.

Ans. **300**

Sol. $t_1 = 300$ sec & $t_2 = 30$ sec

The effective half life

$$t_{1/2}=\frac{t_1\times t_2}{t_1+t_2}=\frac{300\times 30}{330}$$

$$=\frac{300}{11}$$

$\alpha = 300$

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