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JEE (Main)

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

2023

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 29 January, 2023 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

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PART : PHYSICS

1. Ratio of thermal energy released in two resistors R and 3R connected in parallel in an electric circuit is :

(1) 1 : 3 (2) 3 : 1 (3) 1 : 1 (4) 1 : 27

Ans. **(2)**

Sol. ∵ Resistance are in parallel.

Potential difference across the resistors are same

$$\frac{E_1}{E_2} = \frac{(V^2/R_1)t}{(V^2/R_2)t} = \frac{R_2}{R_1} = \frac{3R}{R} = \frac{3}{1}$$

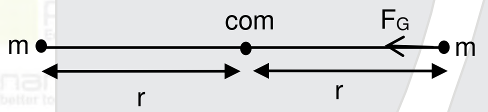
$E_1 : E_2 = 3 : 1$

2. Two particles of equal mass 'm' move in a circle of radius 'r' under the action of their mutual gravitational attraction. The speed of each particle will be :

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

Ans. **(2)**

Sol.



Gravitational force will provide centripetal force.

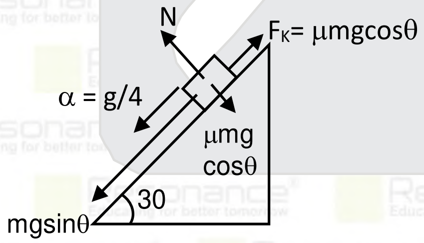
$$\frac{Gmm}{(2r)^2} = \frac{mv^2}{r} \Rightarrow \frac{Gm}{4r} = V^2 \Rightarrow V = \sqrt{\frac{Gm}{4r}}$$

3. A block of mass m slides down the plane inclined at angle 30º with an acceleration g/4. The value of coefficient of kinetic friction will be :

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

Ans. **(4)**

Sol.



$mg\sin\theta - \mu gm\cos\theta = ma$

$$\frac{g}{2} - \frac{\mu g\sqrt{3}}{2} = \frac{g}{4}$$

$$\frac{1}{2} - \frac{\sqrt{3}\mu}{2} = \frac{1}{4}$$

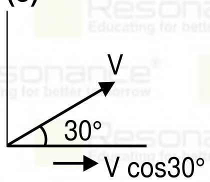
$$\frac{1}{2} - \frac{1}{4} = \frac{\sqrt{3}}{2}\mu, \quad \mu = \frac{1}{2\sqrt{3}}$$

4. A stone is projected at angle 30º to the horizontal. The ratio of kinetic energy of the stone at point of projection to its kinetic energy at the highest point of fight will be -

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

Ans. (3)

Sol.



Let initial velocity = v

Velocity at maximum height = Vcos30° = $\frac{\sqrt{3}v}{2}$

$KE_1 = KE_{initial} = \frac{1}{2}mv^2$

$KE_2 = KE \text{ at } h_{max} = \frac{1}{2}m\left(\frac{\sqrt{3}v}{2}\right)^2 = \frac{3mv^2}{8}$

So, $KE_1 : KE_2$

$\frac{1}{2}mv^2 : \frac{3}{8}mv^2$ 4 : 3 Ans.

5. If a radioactive element having half-life of 30 min is undergoing beta decay, the fraction of radioactive element remains undecayed after 90 min. will be

(1) $\frac{1}{8}$ (2) $\frac{1}{2}$ (3) $\frac{1}{4}$ (4) $\frac{1}{16}$

Ans. (1)

Sol. Half life of decay = 30 min.

Initial no. of nuclei = N_o

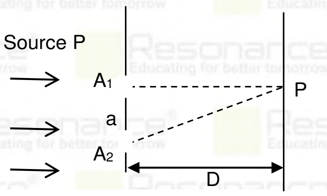
after 30 min. (1 half life) remaining nuclei = $\frac{N_o}{2}$

after 60 min. (2nd half life) remaining nuclei = $\frac{N_o}{4}$

after 90 min. (3rd half life) remaining nuclei = $\frac{N_o}{8}$

$\frac{N}{N_o} = \frac{N_o}{8N_o} = \frac{1}{8}$

6. In a young's double slit experiment, two slits are illuminated with a light of wavelength 800 nm. The line joining A_1 P is perpendicular to A_1 A_2 as shown in the figure. If the first minimum is detected at P, the value of slits separation 'a' will be

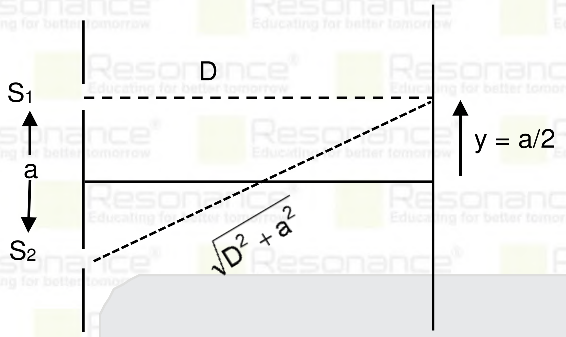


The distance of screen from slits D = 5 cm

(1) 0.4mm (2) 0.2 mm (3) 0.5 mm (4) 0.1 mm

Ans. (2)

Sol.



Path difference, $\Delta x = \sqrt{D^2+a^2} - D$

$$\frac{\lambda}{2} = \sqrt{D^2+a^2} - D$$

$$\frac{\lambda}{2} = D\left[1+\frac{a^2}{2D^2}-1\right] \quad \therefore \quad \text{(Binomial expansion)}$$

$$\frac{\lambda}{2} = \frac{a^2}{2D}$$

$$a = \sqrt{D_0\lambda}$$

$$a = \sqrt{5\times10^{-2}\times800\times10^{-9}}$$

$a = 2 \times 10^{-4}$ m = 0.2 mm

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

Assertion A : If dQ and dW represent the heat supplied to the system and the work done on the system respectively. Then according to the first law of thermodynamics dQ = dU – dW.

Reason R : First law of thermodynamics is based on law of conservation of energy.

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

(1) Both A and R are correct but R is not the correct explanation of A
(2) A is correct but R is not correct
(3) A is not correct but R is correct
(4) Both A and R are correct and R is the correct explanation of A

Ans. **(4)**

Sol. Both A and R are correct and R is the correct explanation of A

8. Which of the following are true ?

(1) Speed of light in vacuum is dependent on the direction of propagation.
(2) Speed of light in a madium is independent of the wavelength of light.
(3) The speed of light is independent of the motion of the source.
(4) The speed of light in a medium is independent of intensity.

Choose the correct answer from the options given below :

(1) B and D only (2) C and D only (3) A and C only (4) B and C only

Ans. **(2)**

Sol. $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

9. If the height of transmitting and receiving antennas are 80 m each, the maximum line of sight distance will be : Given : earth's radius = 6.4×10^6m

(1) 36 km (2) 32 km (3) 28 km (4) 64 km

Ans. **(4)**

Sol. $d_{max} = \sqrt{2Rh_t} + \sqrt{2Rh_r}$

$d_{max} = \sqrt{2\times6400\times10^3\times80} + \sqrt{2\times6400\times10^3\times80}$

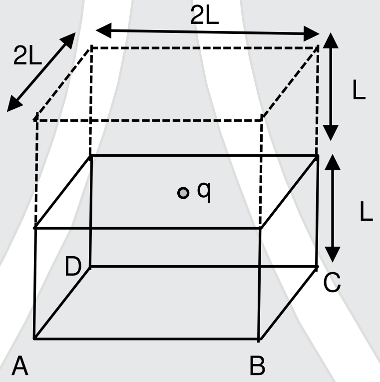
d_{max} = 64 Km.

10. In a cuboid of dimension 2 L × 2L × L, a charge q is placed at the centre of the surface 'S' having area of 4 L^2. The flux through the opposite surface to 'S' is given by

(1) $\frac{q}{12\varepsilon_0}$ (2) $\frac{q}{2\varepsilon_0}$ (3) $\frac{q}{3\varepsilon_0}$ (4) $\frac{q}{6\varepsilon_0}$

Ans. **(4)**

Sol. We can put similar cuboid on above this cupboard to make symmetry about charge



Flux through this whole cube = $\frac{q}{\varepsilon_0}$

As total faces are 6, so flux through ABCD is $\frac{q}{6\varepsilon_0}$

11. Which one of the following statement is not correct in the case of light emitting diodes ?

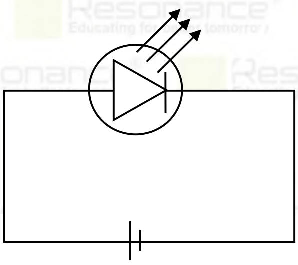
A. It is a heavily doped p-n junction.
B. It emits light only when it is forward biased.
C. It emits light only when it is reverse biased.
D. The energy of the light emitted is equal to or slightly less than the energy gap of the semiconductor used.

Choose the correct answer from the options given below :

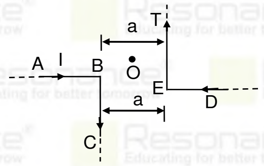
(1) B (2) C (3) A (4) C and D

Ans. **(2)**

Sol.



12. The magnitude of magnetic induction at mid point O due to current arrangement as shown in Fig will be



(1) 0 (2) $\frac{\mu_0 I}{\pi a}$ (3) $\frac{\mu_0 I}{2\pi a}$ (4) $\frac{\mu_0 I}{4\pi a}$

Ans. **(2)**

Sol. $B_0 = B_{AB} + B_{BC} + B_{ED} + B_{ET}$

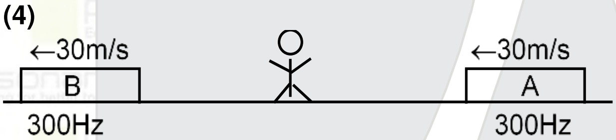
$= 0 + \frac{\mu_0 I}{4\pi \frac{a}{2}} + 0 + \frac{\mu_0 I}{4\pi \frac{a}{2}} = \frac{\mu_0 I}{\pi a}$

13. A person observes two moving trains. 'A' reaching the station and 'B' leaving the station with equal speed of 30 m/s. If both trains emit sounds with frequency 300 Hz, (Speed of sound : 330 m/s) approximate difference of frequencies heard by the person will be :

(1) 33 Hz (2) 80 Hz (3) 10 Hz (4) 55 Hz

Ans. **(4)**

Sol.



Apparent frequency $f = \left(\frac{V \pm V_0}{V \pm V_s}\right) f_0$

(for leaving train) $f_B = \left(\frac{V}{V + V_s}\right) f_0$ $[V_0 = 0]$

$f_B = \left(\frac{330}{330 + 30}\right) \times 330 = 275\text{Hz}$

(for reaching train) $f_A = \left(\frac{V}{V - V_s}\right) \times f_0 = \left(\frac{330}{330 - 30}\right) \times 300 = 330\text{Hz}$

Beat frequency $= f_A - f_B$

$= 330 - 275 = 55$ Hz

14. Surface tension of a soap bubble is 2.0×10^{-2} Nm^{-1}. Work done to increase the radius of soap bubble from 3.5 cm to 7 cm will be : Take $\left[\pi = \frac{22}{7}\right]$

(1) 9.24×10^{-4} J (2) 18.48×10^{-4} J (3) 0.72×10^{-4} J (4) 5.76×10^{-4} J

Ans. **(2)**

Sol. The energy for soap bubble is given by $U = S \times 2 \times 4\pi R^2$

When 'S' is surface tension R is radius

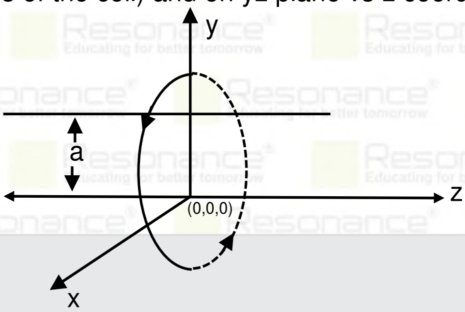
$\Delta U = S \times 8\pi \left(R_2^2 - R_1^2\right)$

$\Delta U = 2 \times 10^{-2}$ N/m $\times 8\pi(7^2 - (3.5)^2) \times 10^{-4}$

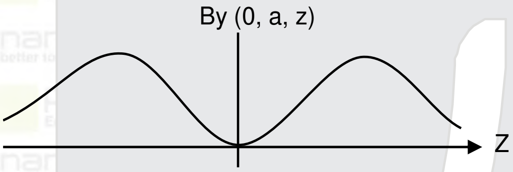
$= \frac{16\pi \times 10^{-2}(49 - 12.25)}{10^4} = 558\pi \times 10^{-6} = 588 \times \frac{22}{7} \times 10^{-6}$

$\Delta U = 1848 \times 10^{-6}$J $= 18.48 \times 10^{-4}$J

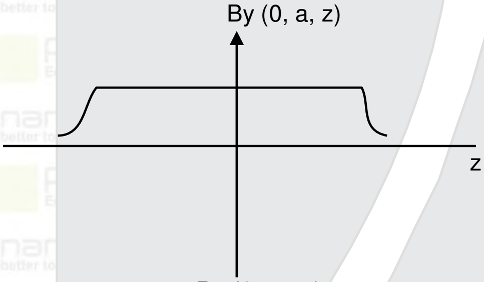
15. A single current carrying loop of wire carrying current I flowing in anticlockwise direction seen from +ve z direction and lying in xy plane is shown in figure. The plot of $\hat{j}$ component of magnetic field (By) at a distance 'a' (less than radius of the coil) and on yz plane vs z coordinate looks like



(1)



(2)



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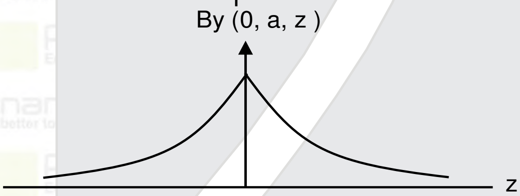

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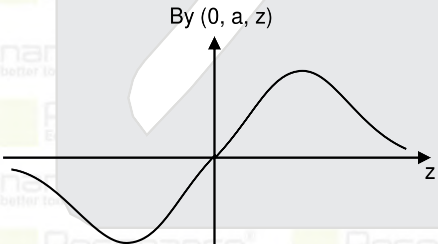
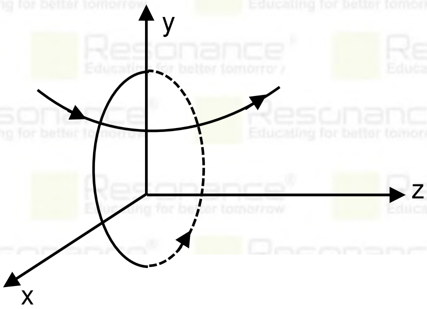
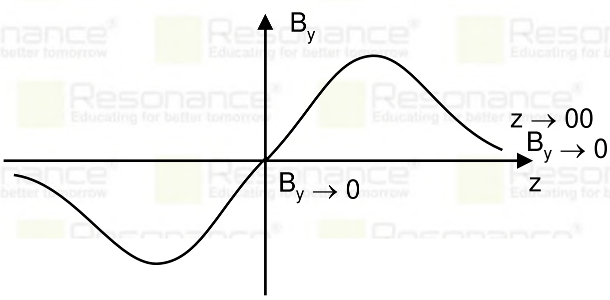


Ans. (4)

Sol.



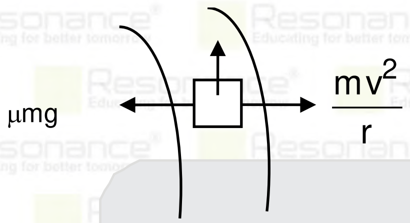


16. A car is moving on a horizontal curved road with radius 50 m. The approzimate maximum speed of car will be, if friction between tyres and road is 0.34 [take $g = 10\ ms^{-2}$]

(1) $3.4\ ms^{-1}$ (2) $13\ ms^{-1}$ (3) $14\ ms^{-1}$ (4) $22.4\ ms^{-1}$

Ans. (2)

Sol.



For max speed,

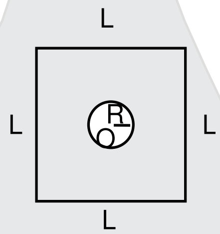
$\mu mg = \dfrac{mv^2}{r}$

$V = \sqrt{\mu gr}$

$V = \sqrt{0.34 \times 10 \times 50}$

V = 13 m/s

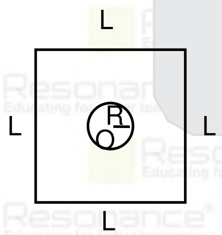
17. Find the mutual inductance in the arrangement, when a small circular loop of wire of radius 'R' is placed inside a large square loop of wire of side L (L >>R). The loops are coplanar and their centres coincide :



(1) $M = \dfrac{2\sqrt{2}\mu_0 R^2}{L}$ (2) $M = \dfrac{\sqrt{2}\mu_0 R^2}{L}$ (3) $M = \dfrac{2\sqrt{2}\mu_0 R}{L^2}$ (4) $M = \dfrac{2\sqrt{2}\mu_0 R}{L^2}$

Ans. (1)

Sol.



$B_1 = \dfrac{\mu_o i_1}{4\pi\left(\dfrac{L}{2}\right)}(\text{Sin}45^\circ + \text{Sin}45^\circ) \times 4$

$B_1 = \dfrac{2\sqrt{2}\mu_o i_1}{\pi L}$; $\phi_{21} = \left(\dfrac{2\sqrt{2}\mu_o i_1}{\pi L}\right)(\pi R^2)$; $\phi_{21} = \left(\dfrac{2\sqrt{2}\mu_o \pi R^2}{\pi L}\right) i_1$

$M_{21} = \dfrac{2\sqrt{2}\mu_o R^2}{L}$

18. The threshold wavelength for photoelectric emission from a material is 5500 Å. Photoelectrons will be emitted, when this material is illuminated with monochromatic radiation from a

(A) 75 W infra-red lamp (B) 10 W infra-red lamp
(C) 75 W ultra-violet lamp (D) 10W ultra-violet lamp
(1) C only (2) B and C only (3) C and D only (4) A and D only

Ans. **(3)**

Sol. λ_{th} = 550nm, So to eject electrons, the wavelength of light should be $\lambda < \lambda_{th}$

λ < 550 nm. So ultra-violet light will be able to eject the electrons.

19. Match List I with List -II

List-I (Physical Quantity)	List-II (Dimensional Formula)
A. Pressure gradient	I. $[M^0L^2T^{-2}]$
B. Energy density	II. $[M^1L^{-1}T^{-2}]$
C. Electric Field	III. $[M^1L^{-2}T^{-2}]$
D. Latent heat	I. $[M^1L^1T^{-2}A^{-1}]$

Choose the correct answer from the options given below :

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

Ans. **(2)**

Sol. A-III $\frac{dP}{dx} = \frac{f}{A.L}$

$= \frac{MLT^{-2}}{L^3} = M^1L^{-2}T^{-2}$

B–II $U_d = \frac{\text{Energy}}{\text{volume}} = \frac{ML^2T^{-2}}{L^3} = ML^{-1}T^{-2}$

C–IV $E = \frac{F}{q} = \frac{MLT^{-2}}{AT} = M^1L^1T^{-3}A^{-1}$

D–I $L = \frac{\text{Heat}}{\text{mass}} = \frac{\text{energy}}{\text{mass}} = \frac{ML^2T^{-2}}{M} = L^2T^{-2}$

20. A bicycle tyre is filled with air having pressure of 270 kPa at 27ºC. The approximate pressure of the air in the tyre when the temperature increases

(1) 262 kPa (2) 270 kPa (3) 360 kPa (4) 278 kPa

Ans. **(4)**

Sol. PV = nRT (ideal gas equation)

For constant volume

$P \propto T$

$\frac{P_1}{P_2} = \frac{T_1}{T_2}$

$\frac{270\text{KPa}}{P_2} = \frac{(273+27)K}{(273+36)K}$

$P_2 = (270\text{KPa})\left(\frac{309}{300}\right) \approx 278$ KPa

21. A body cools from 60ºC to 40ºC in 6 minutes. If, temperature of surroundings is 10ºC. Then, after the next 6 minutes, its temperature will be ——— ºC.

Ans. **28**

Sol. $\frac{T_i - T_f}{t} = k\left(\frac{T_i + T_f}{2} - T_s\right)$

$\Rightarrow \frac{60-40}{6} = k\left(\frac{100}{2} - 10\right)$

$\frac{20}{6} = k\,40$ ——(1)

$\frac{40-T}{6} = k\left(\frac{40+T}{2} - 10\right)$ ----(2)

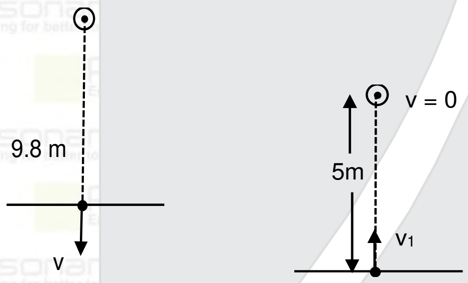
divide (1) & (2)

T = 28 ºC

22. A tennis ball is dropped on to the floor from a height of 9.8 m. It rebounds to a height 5.0 m. Ball comes in contact with the floor for 0.2s. The average acceleration during contact is —— ms^{-2} (Given $g = 10\ ms^{-2}$)

Ans. **120**

Sol.



$v = \sqrt{2gh} = \sqrt{2\times10\times9.8} = 14$ m/s

After collision ball rebound to height 5m

$0 = v_1^2 - 2 \times g \times 5$

$v_1 = \sqrt{2\times g\times5} = \sqrt{2\times10\times5} = 10$ m/s

Average acceleration = $\frac{v_1-(-v)}{t} = \frac{10+14}{0.2} = \frac{24}{0.2} = 120\ m/s^2$

23. A 0.4 kg mass takes 8s to reach ground when dropped from a certain height 'P' above surface of earth. The loss of potential energy in the last second of fall is ——— J. (Take $g = 10\ m/s^2$)

Ans. **300**

Sol. Loss in potential energy = gain in kinetic energy

Velocity after 8 sec $v_2 = 10 \times 8 = 80$m/s

Velocity after 7 sec $v_1 = 10 \times 7 = 70$ m/s

In last second gain in K.E.

$= \frac{1}{2}m\left(v_2^2 - v_1^2\right) = \frac{1}{2}\times0.4\ (6400 - 4900) = 300$ J

24. A certain elastic conducting material is stretched into a circular loop. It is placed with its plane perpendicular to a uniform magnetic field B = 0.8 T. When released the radius of the loop starts shrinking at a constant rate of 2 cms^{-1} . The induced emf in the loop at an instant when the radius of the loop is 10 cm will be ——mV.

Ans. 10

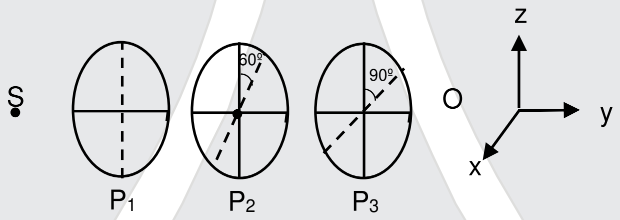
Sol. $e = \left|\frac{d\phi}{dt}\right| = \frac{d(BA)}{dt}$

$= B\frac{d(\pi r^2)}{dt}$

$= B\pi\, 2r\frac{dr}{dt}$

$= 0.8 \times \pi \times 2 \times 10 \times 2 \times 10^{-4} = 10$ mV.

25. As shown in the figure, three identical polaroids P_1, P_2 and P_3 are placed one after another. The pass axis of P_2 and P_3 are inclined at angle of 60º and 90º with respect to axis of P_1. The source S has an intensity of 256 $\frac{W}{m^2}$. The intensity of light at point O is ________ $\frac{W}{m^2}$



Ans. 24

Sol. **I =** $I_0\cos^2\phi$

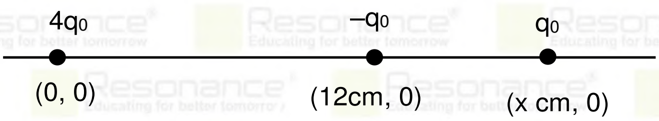
$I_1 = \frac{256}{2}\cos^2 60º = 32\ \frac{W}{m^2}$

$I_2 = 32\cos^2 30º = 24\ \frac{W}{m^2}$

26. A Point charge $q_1 = 4q_0$ is placed at origin. Another point charge $q_2 = -q_0$ is placed at x = 12 cm. Charge of proton is q_0. The proton is placed on x axis so that the electrostatic force on the proton is zero. In this situation, the position of the proton from the origin is ——— cm.

Ans. 24

Sol. As all charges are in equilibrium $\therefore$ force on $q_0 = 0$



In equilibrium, $\frac{K(4q_0)(q_0)}{(x\times10^{-2})^2} = \frac{K(q_0)(q_0)}{[(x-12)\times10^{-2}]^2}$

$\frac{4}{x^2} = \frac{1}{(x-12)^2}$; $\frac{2}{x} = \frac{1}{x-12}$; $2x - 24 = x$

x = 24 cm

27. A Solid sphere of mass 2 kg is making pure rolling on a horizontal surface with kinetic energy 2240 J. The velocity of centre of mass of the sphere will be —— ms^{-1}

Ans. **40**

Sol. $KE = \frac{1}{2}I_{cm}\omega^2 + \frac{1}{2}mv^2$

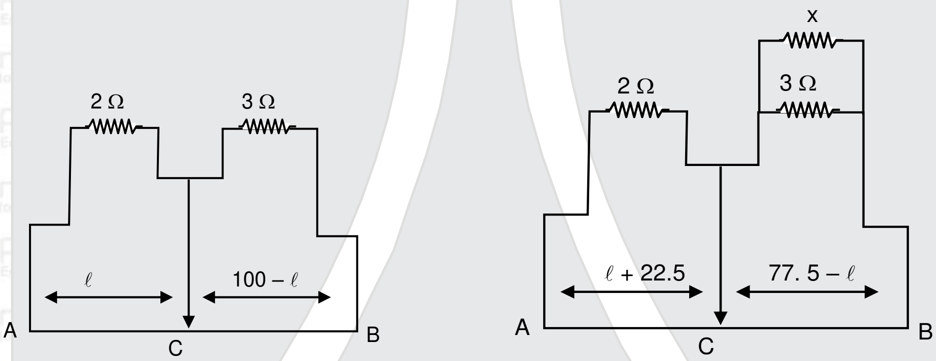
$= \frac{1}{2}\times\frac{2}{5}mR^2\times\frac{v^2}{R^2}+\frac{1}{2}mv^2 \Rightarrow \frac{mv^2}{5}+\frac{mv^2}{2} \Rightarrow \frac{7}{10}mv^2 = \frac{7}{10}\times 2\times v^2 = 2240$

$v^2 = \frac{22400}{14}$; $v = 40$ m/s

28. In a metre bridge experiment the balance point is obtained if the gaps are closed by 2Ω and 3Ω. A shunt of X Ω is added to 3Ω resistor to shift the balancing point by 22.5 cm. The value of X is______.

Ans. **2**

Sol.



$2(100-\ell) = 3\ell$; $\ell = 40$ cm

$\frac{2}{62.5} = \frac{3x}{(3+x)(37.5)}$; $75 + 25x = 62.5x$; $x = \frac{75}{37.5} = 2$

29. Two simple harmonic waves having equal amplitudes of 8 cm and equal frequency of 10 Hz are moving along the same direction. The resultant amplitude is also 8 cm. The phase difference between the individual waves is —— degree.

Ans. **120**

Sol. $A_1 = 8$ cm.

$A_2 = 8$ cm

$A = 8$ cm

$A^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$

$64 = 64 + 64 + 2 \times 64\cos\phi$.

$64 = 2 \times 64(2 + \cos\phi)$

$\cos\phi = -1/2$; $\phi = 120°$

30. A radioactive element ${}^{242}_{92}X$ emits two α-particles, one electron and two positrons. The product nucleus is represented by ${}^{234}_{P}Y$. The value of P is

Ans. **87**

Sol. ${}^{242}_{92}X \xrightarrow{2\alpha-\text{decay}} {}^{234}_{88}X_1 + 2\,{}^{4}_{2}He \xrightarrow{{}^{0}_{-1}e-\text{decay}} {}^{234}_{89}X_2 + {}^{0}_{-1}e \xrightarrow{2\,{}^{0}_{+1}e-\text{decay}} {}^{234}_{87}Y$

P = 87

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