

PHYSICS
JEE-MAIN (February-Attempt) 25
February (Shift-2) Paper

SECTION - A

1. Match List I with List II.

- List I**
- (a) Rectifier
 (b) Stabilizer
 (c) Transformer
 (d) Filter

- List II**
- (i) Used either for stepping up or stepping down the a.c. Voltage
 (ii) Used to convert a.c. voltage into d.c. voltage
 (iii) Used to remove any ripple in the rectified output voltage
 (iv) Used for constant output voltage even when the input voltage or load current change

Choose the correct answer form the options given below:

- (1) (a)-(ii), (b)- (i), (c)-(iv), (d)-(iii)
 (2) (a)-(ii), (b)- (iv), (c)-(i), (d)-(iii)
 (3) (a)-(ii), (b)- (i), (c)-(iii), (d)-(iv)
 (4) (a)-(iii), (b)- (iv), (c)-(i), (d)-(ii)

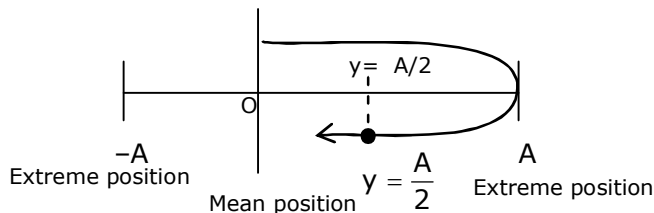
Sol. 2

- (a) Rectifier:- used to convert a.c voltage into d.c. Voltage.
 (b) Stabilizer:- used for constant output voltage even when the input voltage or load current change
 (c) Transformer:- used either for stepping up or stepping down the a.c. voltage.
 (d) Filter:- used to remove any ripple in the rectified output voltage.

2. $Y = A \sin(\omega t + \phi_0)$ is the time - displacement equation of a SHM, At $t = 0$ the displacement of the particle is $Y = \frac{A}{2}$ and it is moving along negative x-direction. Then the initial phase angle ϕ_0 will be.

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

Sol. 4

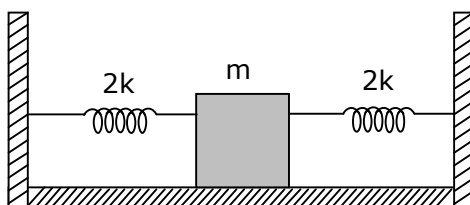


The initial phase angle $\phi_0 = \pi - \frac{\pi}{6}$
 $= \frac{5\pi}{6}$

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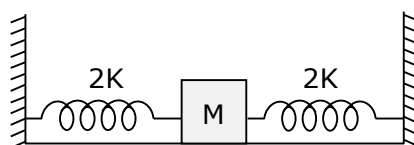
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3. Two identical spring of spring constant '2K' are attached to a block of mass m and to fixed support (see figure). When the mass is displaced from equilibrium position on either side, it executes simple harmonic motion. Then time period of oscillations of this system is:



- (1) $\pi\sqrt{\frac{m}{k}}$ (2) $\pi\sqrt{\frac{m}{2k}}$ (3) $2\pi\sqrt{\frac{m}{k}}$ (4) $2\pi\sqrt{\frac{m}{2k}}$

Sol. 1



Due to parallel combination $K_{\text{eff}} = 2k + 2k$
 $= 4k$

$$\begin{aligned} \therefore T &= 2\pi\sqrt{\frac{m}{K_{\text{eff}}}} \\ &= 2\pi\sqrt{\frac{m}{4k}} \\ T &= \pi\sqrt{\frac{m}{k}} \end{aligned}$$

4. The wavelength of the photon emitted by a hydrogen atom when an electron makes a transition from $n = 2$ to $n = 1$ state is:

- (1) 194.8 nm (2) 490.7 nm (3) 913.3 nm (4) 121.8 nm

Sol. 4

$$\Delta E = 10.2 \text{ eV}$$

$$\frac{hc}{\lambda} = 10.2 \text{ eV}$$

$$\lambda = \frac{hc}{(10.2)e}$$

$$= \frac{12400}{10.2} \text{ \AA}$$

$$= 121.56 \text{ nm}$$

$$\approx 121.8 \text{ nm}$$

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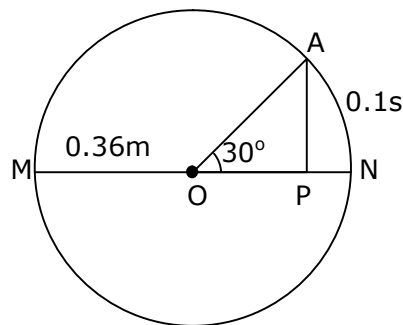
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5. In a ferromagnetic material, below the curie temperature, a domain is defined as:
- (1) a macroscopic region with consecutive magnetic dipoles oriented in opposite direction.
 - (2) a macroscopic region with zero magnetization.
 - (3) a macroscopic region with saturation magnetization.
 - (4) a macroscopic region with randomly oriented magnetic dipoles.

Sol. 3

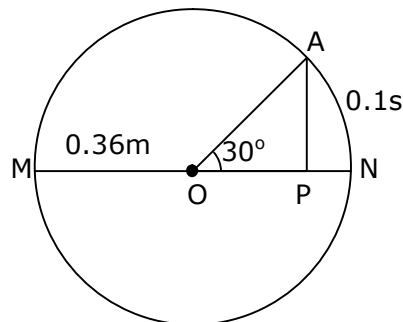
In a ferromagnetic material, below the curie temperature a domain is defined as a macroscopic region with saturation magnetization.

6. The point A moves with a uniform speed along the circumference of a circle of radius 0.36m and cover 30° in 0.1s. The perpendicular projection 'P' from 'A' on the diameter MN represents the simple harmonic motion of 'P'. The restoration force per unit mass when P touches M will be:



- (1) 100 N (2) 50 N (3) 9.87 N (4) 0.49 N

Sol. 3



The point a covers 30° in 0.1 sec.

$$\text{Means } \frac{\pi}{6} \longrightarrow 0.1 \text{ sec.}$$

$$1 \longrightarrow \frac{0.1}{\frac{\pi}{6}}$$

$$2\pi = \longrightarrow \frac{0.1 \times 6}{\pi} \times 2\pi$$

$$T = 1.2 \text{ sec.}$$

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We know that $\omega = \frac{2\pi}{T}$

$$\omega = \frac{2\pi}{1.2}$$

Restoration force (F) = $m\omega^2A$

Then Restoration force per unit mass $\left(\frac{F}{m}\right) = \omega^2A$

$$\begin{aligned}\left(\frac{F}{m}\right) &= \left(\frac{2\pi}{1.2}\right)^2 \times 0.36 \\ &\cong 9.87 \text{ N}\end{aligned}$$

7. The stopping potential for electrons emitted from a photosensitive surface illuminated by light of wavelength 491 nm is 0.710 V. When the incident wavelength is changed to a new value, the stopping potential is 1.43V. The new wavelength is:
(1) 400 NM (2) 382 nm (3) 309 nm (4) 329 nm

Sol. 2

From the photoelectric effect equation

$$\frac{hc}{\lambda} = \phi + ev_s$$

$$\text{so } ev_{s_1} = \frac{hc}{\lambda_1} - \phi \quad \dots(i)$$

$$ev_{s_2} = \frac{hc}{\lambda_2} - \phi \quad \dots(ii)$$

Subtract equation (i) from equation (ii)

$$ev_{s_1} - ev_{s_2} = \frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}$$

$$v_{s_1} - v_{s_2} = \frac{hc}{e} \left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2} \right)$$

$$(0.710 - 1.43) = 1240 \left(\frac{1}{491} - \frac{1}{\lambda_2} \right)$$

$$\frac{-0.72}{1240} = \frac{1}{491} - \frac{1}{\lambda_2}$$

$$\frac{1}{\lambda_2} = \frac{1}{491} + \frac{0.72}{1240}$$

$$\frac{1}{\lambda_2} = 0.00203 + 0.00058$$

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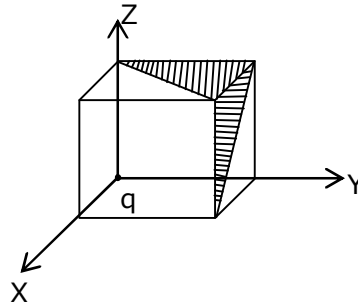
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$$\frac{1}{\lambda_2} = 0.00261$$

$$\lambda_2 = 383.14$$

$$\lambda_2 \approx 382\text{nm}$$

8. A charge 'q' is placed at one corner of a cube as shown in figure. The flux of electrostatic field \vec{E} through the shaded area is:



(1) $\frac{q}{48\epsilon_0}$

(2) $\frac{q}{8\epsilon_0}$

(3) $\frac{q}{24\epsilon_0}$

(4) $\frac{q}{4\epsilon_0}$

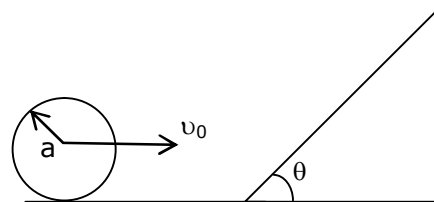
Sol. 3

$$\phi = \frac{q}{24\epsilon_0}$$

$$\phi_T = \left(\frac{q}{24\epsilon_0} + \frac{q}{24\epsilon_0} \right) \times \frac{1}{2}$$

$$\phi_T = \frac{q}{24\epsilon_0}$$

9. A sphere of radius 'a' and mass 'm' rolls along horizontal plane with constant speed v_0 . It encounters an inclined plane at angle θ and climbs upward. Assuming that it rolls without slipping how far up the sphere will travel ?



(1) $\frac{2}{5} \frac{v_0^2}{g \sin \theta}$

(2) $\frac{10v_0^2}{7g \sin \theta}$

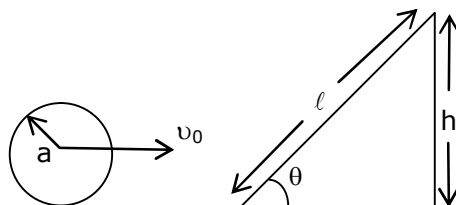
(3) $\frac{v_0^2}{5g \sin \theta}$

(4) $\frac{v_0^2}{2g \sin \theta}$

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Sol. Bonus, our answer $\left(\frac{7v_0^2}{10g \sin \theta}\right)$, **NTA answer (2)**



From energy conservation

$$mgh = \frac{1}{2}mv_0^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv_0^2 + \frac{1}{2} \times \frac{2}{5}ma^2 \times \frac{v_0^2}{a^2}$$

$$gh = \frac{1}{2}v_0^2 + \frac{1}{5}v_0^2$$

$$gh = \frac{7}{10}v_0^2$$

$$h = \frac{7}{10} \frac{v_0^2}{g}$$

from triangle, $\sin \theta = \frac{h}{l}$

then $h = l \sin \theta$

$$l \sin \theta = \frac{7}{10} \frac{v_0^2}{g}$$

$$l = \frac{7}{10} \frac{v_0^2}{g \sin \theta}$$

10. Consider the diffraction pattern obtained from the sunlight incident on a pinhole of diameter $0.1 \mu\text{m}$. If the diameter of the pinhole is slightly increased, it will affect the diffraction pattern such that:

- (1) its size decreases, but intensity increases
- (2) its size increases, but intensity decreases
- (3) its size increases, and intensity increases
- (4) its size decreases, and intensity decreases

Sol. 1

$$\sin \theta = \frac{1.22\lambda}{D}$$

If D is increased, then $\sin \theta$ will decreased

\therefore size of circular fringe will decrease but intensity increases

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11. An electron of mass m_e and a proton of mass $m_p = 1836 m_e$ are moving with the same speed.

The ratio of their de Broglie wavelength $\frac{\lambda_{\text{electron}}}{\lambda_{\text{proton}}}$ will be:

- (1) 918 (2) 1836 (3) $\frac{1}{1836}$ (4) 1

Sol. 2

Given mass of electron = m_e

Mass of proton = m_p

\therefore given $m_p = 1836 m_e$

From de-Broglie wavelength

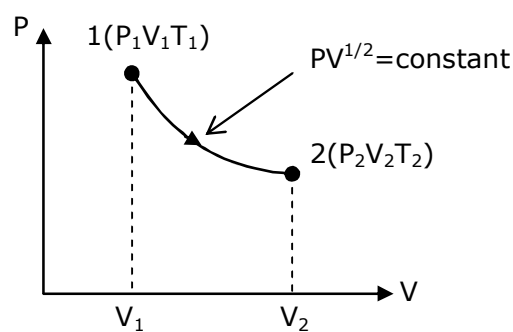
$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

$$\frac{\lambda_e}{\lambda_p} = \frac{m_p}{m_e}$$

$$= \frac{1836m_e}{m_e}$$

$$\frac{\lambda_e}{\lambda_p} = 1836$$

12. thermodynamic process is shown below on a P-V diagram for one mole of an ideal gas. If $V_2 = 2V_1$ then the ratio of temperature T_2/T_1 is:

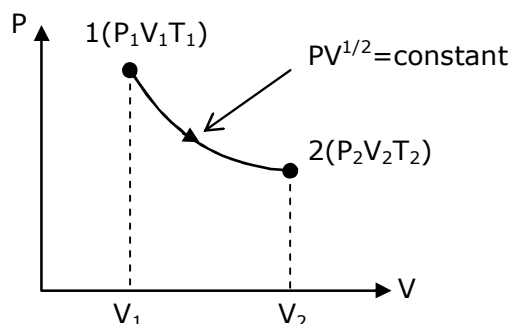


- (1) $\frac{1}{\sqrt{2}}$ (2) $\frac{1}{2}$ (3) 2 (4) $\sqrt{2}$

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Sol. 4



From p-v diagram,
Given $Pv^{1/2} = \text{constant}$

.....(i)

We know that

$$Pv = nRT$$

$$P \propto \left(\frac{T}{v}\right)$$

Put in equation (i)

$$\left(\frac{T}{v}\right)(v)^{1/2} = \text{constant}$$

$$T \propto v^{1/2}$$

$$\frac{T_2}{T_1} = \sqrt{\frac{v_2}{v_1}}$$

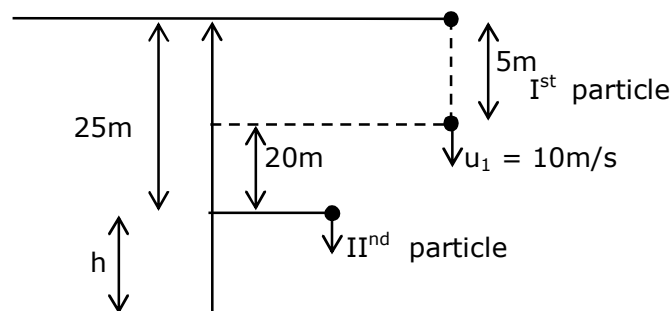
$$\frac{T_2}{T_1} = \sqrt{\frac{2v_1}{v_1}}$$

$$\frac{T_2}{T_1} = \sqrt{2}$$

13. A stone is dropped from the top of a building. When it crosses a point 5m below the top, another stone starts to fall from a point 25m below the top, Both stones reach the bottom of building simultaneously. The height of the building is:

(1) 45 m (2) 35 m (3) 25 m (4) 50 m

Sol. 1



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For particle (1)

$$20+h = 10t + \frac{1}{2}gt^2 \quad \dots(i)$$

For particle (2)

$$h = \frac{1}{2}gt^2 \quad \dots(ii)$$

put equation (ii) in equation (i)

$$20 + \frac{1}{2}gt^2 = 10t + \frac{1}{2}gt^2$$

$$t = 2\text{sec.}$$

Put in equation (ii)

$$h = \frac{1}{2}gt^2$$

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

$$h = 20\text{m}$$

the height of the building = 25 + 20 = 45m

- 14.** if a message signal of frequency ' f_m ' is amplitude modulated with a carrier signal of frequency ' f_c ' and radiated through an antenna, the wavelength of the corresponding signal in air is:

(1) $\frac{c}{f_c + f_m}$ (2) $\frac{c}{f_c - f_m}$ (3) $\frac{c}{f_m}$ (4) $\frac{c}{f_c}$

Sol. 4

Given frequency of message signal = f_m

frequency of carrier signal = f_c

the wavelength of the corresponding signal in air is $\Rightarrow \lambda = \frac{c}{f_c}$

- 15.** Given below are two statements:
Statement I: In a diatomic molecule, the rotational energy at a given temperature obeys Maxwell's distribution.
Statement II: in a diatomic molecule, the rotational energy at a given temperature equals the translational kinetic energy for each molecule.
In the light of the above statements, choose the correct answer from the options given below:
(1) Both statement I and statement II are false.
(2) Both statement I and statement II are true.
(3) Statement I is false but statement II is true
(4) Statement I is true but statement II is false.

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Sol. 4

The translational kinetic energy & rotational kinetic energy both obey Maxwell's distribution independent of each other.

$$\text{T.K.E of diatomic molecules} = \frac{3}{2}kT$$

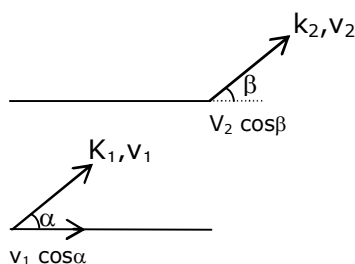
$$\text{R.K.E. of diatomic molecules} = \frac{2}{2}kT$$

So statement I is true but statement II is false.

16. An electron with kinetic energy K_1 enters between parallel plates of a capacitor at an angle ' α ' with the plates. It leaves the plates at angle ' β ' with kinetic energy K_2 . Then the ratio of kinetic energies $K_1 : K_2$ will be:

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

Sol. 2



$$\therefore v_1 \cos \alpha = v_2 \cos \beta$$

$$\frac{v_1}{v_2} = \frac{\cos \beta}{\cos \alpha}$$

Then the ratio of kinetic energies

$$\frac{k_1}{k_2} = \frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2} = \left(\frac{v_1}{v_2}\right)^2 = \left(\frac{\cos \beta}{\cos \alpha}\right)^2$$

$$\frac{k_1}{k_2} = \frac{\cos^2 \beta}{\cos^2 \alpha}$$

17. An LCR circuit contains resistance of 110Ω and a supply of 220 V at 300 rad/s angular frequency. If only capacitance is removed from the circuit, current lags behind the voltage by 45° . If on the other hand, only inductor is removed the current leads by 45° with the applied voltage. The rms current flowing in the circuit will be:

- (1) 2.5A (2) 2A (3) 1A (4) 1.5 A

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Sol. 2

Since ϕ remain same, circuit is in resonance

$$\therefore I_{\text{rms}} = \frac{V_{\text{rms}}}{Z}$$

$$= \frac{220}{110}$$

$$I_{\text{rms}} = 2A$$

18. For extrinsic semiconductors: when doping level is increased;

(1) Fermi-level of p and n-type semiconductors will not be affected.

(2) Fermi-level of p-type semiconductors will go downward and Fermi-level of n-type semiconductor will go upward.

(3) Fermi-level of both p-type and n-type semiconductors will go upward for $T > T_F$ K and downward for $T < T_F$ K, where T_F is Fermi temperature.

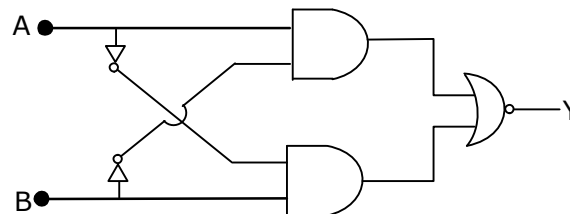
(4) Fermi-level of p-type semiconductor will go upward and Fermi-level of n-type semiconductors will go downward.

Sol. 2

In n-type semiconductor pentavalent impurity is added. Each pentavalent impurity donates a free electron. So the Fermi-level of n-type semiconductor will go upward.

& In p-type semiconductor trivalent impurity is added. Each trivalent impurity creates a hole in the valence band. So the Fermi-level of p-type semiconductor will go downward.

19. The truth table for the following logic circuit is:



(1)

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

(2)

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

(3)

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

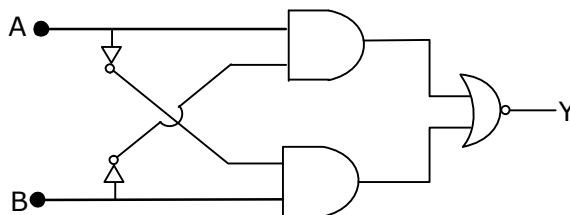
(4)

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

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Sol. 4



If $A = B = 0$ then output $y = 1$
If $A = B = 1$ then output $y = 1$

20. If e is the electronic charged, c is the speed of light in free space and h is planck's constant, the quantity $\frac{1}{4\pi\epsilon_0} \frac{|e|^2}{hc}$ has dimensions of :

- (1) $[LC^{-1}]$ (2) $[M^0 L^0 T^0]$ (3) $[MLT^0]$ (4) $[MLT^{-1}]$

Sol. 2

Given

e = electronic charge

c = speed of light in free space

h = planck's constant

$$\frac{1}{4\pi\epsilon_0} \frac{e^2}{hc} = \frac{ke^2}{hc} \times \frac{\lambda^2}{\lambda^2}$$

$$= \frac{F \times \lambda}{E}$$

$$= \frac{E}{E}$$

= dimensionless

$$= [M^0 L^0 T^0]$$

SECTION – B

1. The percentage increase in the speed of transverse waves produced in a stretched string if the tension is increased by 4% will be _____%.

Sol. 2

Speed of transverse wave is

$$v = \sqrt{\frac{T}{\mu}}$$

$$\ln v = \frac{1}{2} \ln T - \frac{1}{2} \ln \mu$$

$$\frac{\Delta v}{v} = \frac{1}{2} \frac{\Delta T}{T}$$

$$= \frac{1}{2} \times 4$$

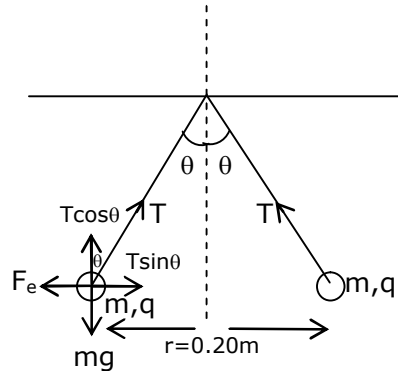
$$\frac{\Delta v}{v} = 2\%$$

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2. Two small spheres each of mass 10 mg are suspended from a point by threads 0.5 m long. They are equally charged and repel each other to a distance of 0.20 m . Then charge on each of the sphere is $\frac{a}{21} \times 10^{-8} \text{C}$. The value of 'a' will be_____.

Sol. 20



$$T \sin \theta = \frac{kq^2}{r^2}$$

$$T \cos \theta = mg$$

$$\tan \theta = \frac{kq^2}{mgr^2}$$

$$q^2 = \frac{\tan \theta mgr^2}{k}$$

$$\therefore \tan \theta = \frac{0.1}{0.5} = \frac{1}{5}$$

$$q^2 = \frac{1}{5} \times \frac{10 \times 10^{-6} \times 10 \times 0.2 \times 0.2}{9 \times 10^9}$$

$$q = \frac{2\sqrt{2}}{3} \times 10^{-8}$$

after comparison from the given equation

$$a = 20$$

3. The peak electric field produced by the radiation coming from the 8 W bulb at a distance of 10 m is $\frac{x}{10} \sqrt{\frac{\mu_0 c}{\pi}} \frac{\text{V}}{\text{m}}$. The efficiency of the bulb is 10% and it is a point source. The value of x is ____.

Sol. 2

$$I = \frac{1}{2} c \epsilon_0 E_0^2$$

$$\frac{8}{4\pi \times 10^2} = \frac{1}{2} \times c \times \frac{1}{\mu_0 c^2} \times E_0^2$$

$$E_0 = \frac{2}{10} \sqrt{\frac{\mu_0 c}{\pi}}$$

$$\Rightarrow x = 2$$

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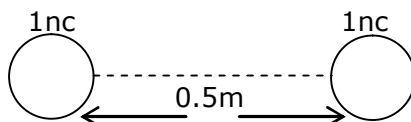
4. Two identical conducting spheres with negligible volume have 2.1nC and -0.1nC charges, respectively. They are brought into contact and then separated by a distance of 0.5 m . The electrostatic force acting between the spheres is _____ $\times 10^{-9}\text{ N}$.

[Given : $4\pi\epsilon_0 = \frac{1}{9 \times 10^9}$ SI unit]

Sol. 36



When they are brought into contact & then separated by a distance = 0.5 m
Then charge distribution will be



The electrostatic force acting b/w the sphere is

$$F_e = \frac{kq_1q_2}{r^2}$$

$$= \frac{9 \times 10^9 \times 1 \times 10^{-9} \times 1 \times 10^{-9}}{(0.5)^2}$$

$$= \frac{900}{25} \times 10^{-9}$$

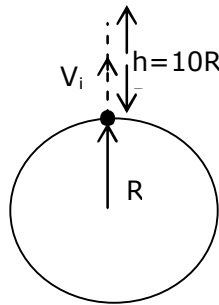
$$F_e = 36 \times 10^{-9}\text{ N}$$

5. The initial velocity v_i required to project a body vertically upward from the surface of the earth to reach a height of $10R$, where R is the radius of the earth, may be described in terms of escape velocity v_e such that $v_i = \sqrt{\frac{x}{y}} \times v_e$. The value of x will be_____.

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Sol. 10



Here R = radius of the earth

From energy conservation

$$\frac{-Gm_e m}{R} + \frac{1}{2} m v_i^2 = \frac{-Gm_e m}{11R} + 0$$

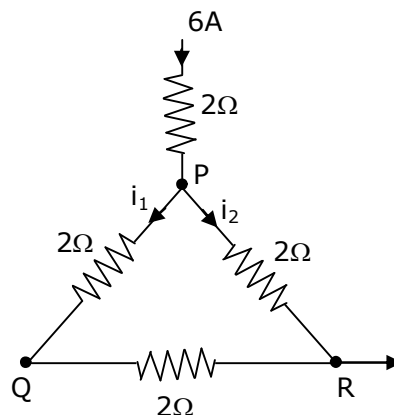
$$\frac{1}{2} m v_i^2 = \frac{10}{11} \frac{Gm_e m}{R}$$

$$v_i = \sqrt{\frac{20}{11} \frac{Gm_e}{R}}$$

$$v_i = \sqrt{\frac{10}{11}} v_e \quad \left\{ \because \text{escape velocity } v_e = \sqrt{\frac{2Gm_e}{R}} \right\}$$

Then the value of $x = 10$

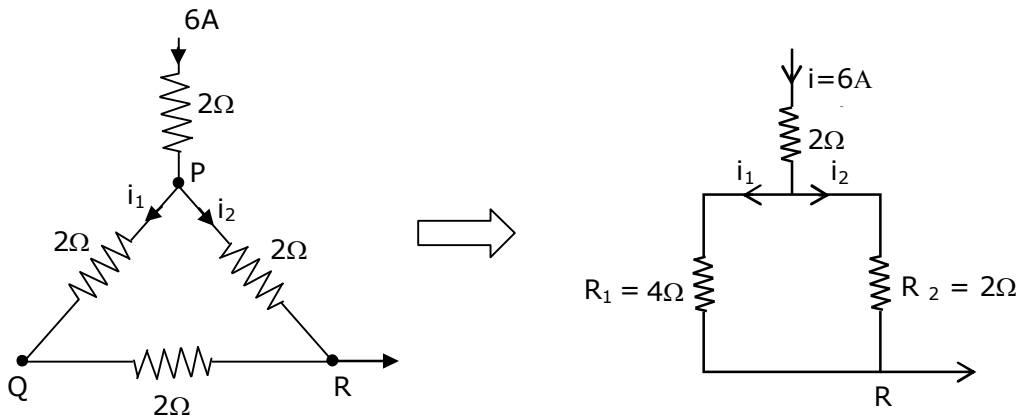
6. A current of 6A enters one corner P of an equilateral triangle PQR having 3 wires of resistance 2Ω each and leaves by the corner R. The currents i_1 in ampere is _____.



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Sol. 2



$$\text{The current } i_1 = \left(\frac{R_2}{R_1 + R_2} \right) i$$

$$= \left(\frac{2}{4 + 2} \right) \times 6$$

$$i_1 = 2\text{A}$$

7. The wavelength of an X-ray beam is 10 \AA . The mass of a fictitious particle having the same energy as that of the X-ray photons is $\frac{x}{3} h \text{ kg}$. The value of x is _____.

Sol. 10

Given wavelength of an x-ray beam = 10 \AA

$$\therefore E = \frac{hc}{\lambda} = mc^2$$

$$m = \frac{h}{c\lambda}$$

The mass of a fictitious particle having the same energy as that of the x-ray photons = $\frac{x}{3} h \text{ kg}$

$$\frac{x}{3} h = \frac{h}{c\lambda}$$

$$x = \frac{3}{c\lambda}$$

$$= \frac{3}{3 \times 10^8 \times 10 \times 10^{-10}}$$

$$x = 10$$

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8. A reversible heat engine converts one-fourth of the heat input into work. When the temperature of the sink is reduced by 52K, its efficiency is doubled. The temperature in Kelvin of the source will be_____.

Sol. 208

$$\therefore n = \frac{w}{Q_{in}} = \frac{1}{4}$$

$$\frac{1}{4} = 1 - \frac{T_1}{T_2}$$

$$\frac{T_1}{T_2} = \frac{3}{4}$$

When the temperature of the sink is reduced by 52k then its efficiency is doubled.

$$\frac{1}{2} = 1 - \frac{(T_1 - 52)}{T_2}$$

$$\frac{T_1 - 52}{T_2} = \frac{1}{2}$$

$$\frac{T_1 - 52}{T_2} = \frac{1}{2}$$

$$\frac{3}{4} - \frac{52}{T_2} = \frac{1}{2}$$

$$\frac{52}{T_2} = \frac{1}{4}$$

$$T_2 = 208 \text{ k}$$

9. Two particles having masses 4g and 16g respectively are moving with equal kinetic energies. The ratio of the magnitudes of their linear momentum is n:2. The value of n will be_____.

Sol. 1

\therefore relation b/w kinetic energy & momentum is

$$P = \sqrt{2mKE} \quad (\because KE = \text{same})$$

$$\frac{p_1}{p_2} = \sqrt{\frac{m_1}{m_2}}$$

$$\frac{n}{2} = \sqrt{\frac{4}{16}}$$

$$n = 1$$

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10. If $\vec{P} \times \vec{Q} = \vec{Q} \times \vec{P}$, the angle between \vec{P} and \vec{Q} is $\theta (0^\circ < \theta < 360^\circ)$. The value of ' θ ' will be_____.

Sol. 180

$$\text{If } \vec{P} \times \vec{Q} = \vec{Q} \times \vec{P}$$

$$\text{Only if } \vec{P} = 0$$

$$\text{Or } \vec{Q} = 0$$

The angle b/w \vec{P} & \vec{Q} is $\theta (0^\circ < \theta < 360^\circ)$

$$\text{So } \theta = 180^\circ$$

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