Regd. Office: Aakash Tower, 8, Pusa Road, New Delhi-110005, Ph.011-47623456

JEE Main 2023 (Memory based)

24 January 2023 - Shift 1

Answer & Solutions

PHYSICS

1. The equation of wave is given as $y = 0.05\sin(2x - 4t)$, where x in meters and t is time in seconds. The velocity of the wave is equal to

A. 2
B. 4
C. 0.5
D. 0.25

Answer (A)

Sol. Comparing it with the general equation of wave; $y = A\sin(kx - \omega t + \phi)$

$k = 2, \omega = 4$

$V = \frac{\omega}{k} = \frac{4}{2} = 2\ m/s$

2. Two charges q_1 and q_2 separated by a distance d are placed in a medium of dielectric constant k, if they are placed in the air then find equivalent distance at which they experience same force.

A. $d\sqrt{k}$
B. $k\sqrt{d}$
C. $2d\sqrt{k}$
D. $1.5d\sqrt{k}$

Answer (A)

Sol.

Without dielectric placed in between, $F = \frac{q_1q_2}{4\pi\epsilon_0 r^2}$

With dielectric placed in between, $F' = \frac{q_1q_2}{4\pi k\epsilon_0 d^2}$

At equivalent distance (r_{eq})

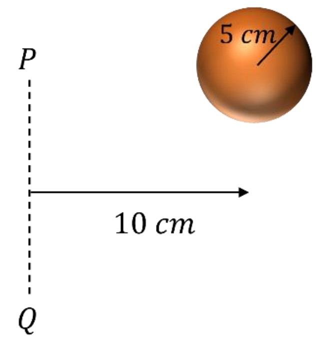
$$\frac{q_1q_2}{4\pi\epsilon_0 r_{eq}^2} = \frac{q_1q_2}{4\pi k\epsilon_0 d^2}$$

$$r_{eq}^2 = kd^2$$

$$r_{eq} = d\sqrt{k}$$

3. Find the radius of gyration for the uniform solid sphere of radius $5\ cm$ about the axis PQ, as shown in the figure.

A. $5\ cm$
B. $10\ cm$
C. $\sqrt{110}\ cm$
D. $\sqrt{90}\ cm$



Answer (C)

Sol.

Applying parallel axis - theorem

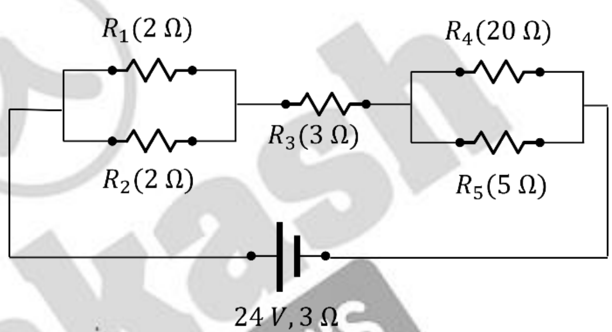
$$MK^2 = M\left(\frac{2}{5}R^2 + d^2\right)$$

$$K^2 = \frac{2}{5} \times 25 + 100$$

$$K = \sqrt{110}\ cm$$

4. In the circuit shown, Find the current through $R_4(I_4)$ and $R_5(I_5)$

A. $I_4 = \frac{24}{55}$ A , $I_5 = \frac{96}{55}$ A
B. $I_4 = \frac{96}{55}$ A , $I_5 = \frac{24}{55}$ A
C. $I_4 = \frac{24}{37}$ A , $I_5 = \frac{96}{37}$ A
D. $I_4 = \frac{96}{37}$ A , $I_5 = \frac{24}{37}$ A



Answer (A)

Sol.

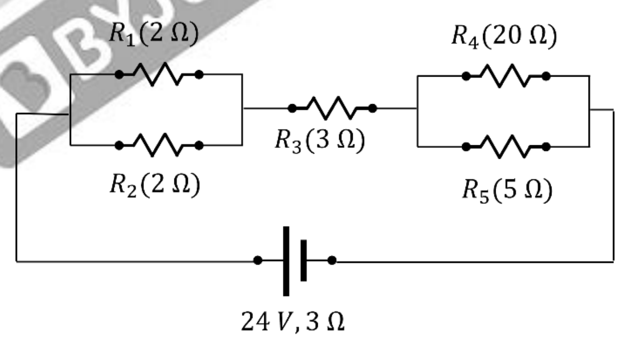
$$R_{eq} = 2 \times \frac{2}{4} + 20 \times \frac{5}{25} + 3 + 3$$

$$R_{eq} = 11\ \Omega$$

$$Current, I_T = \frac{24}{11}\ A$$

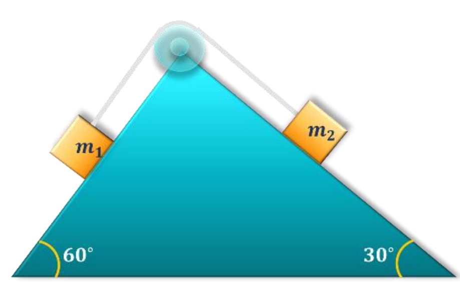
$$I_4 = \frac{5}{25} \times \frac{24}{11}\ A = \frac{24}{55}\ A$$

$$I_5 = \frac{20}{25} \times \frac{24}{11}\ A = \frac{96}{55}$$



5. In the figure shown two blocks of masses $m_1 = 4\ kg$ and $m_2 = 1\ kg$ are placed over a smooth fixed wedge, connected by an ideal string over a smooth pulley. As the system is released the tension in the string is

A. $4(\sqrt{3}+1)\ N$
B. $10\left(1-\frac{1}{\sqrt{3}}\right)\ N$
C. $10(\sqrt{3}-1)\ N$
D. $\frac{10}{3}(\sqrt{3}-1)\ N$



Answer (A)

Sol.

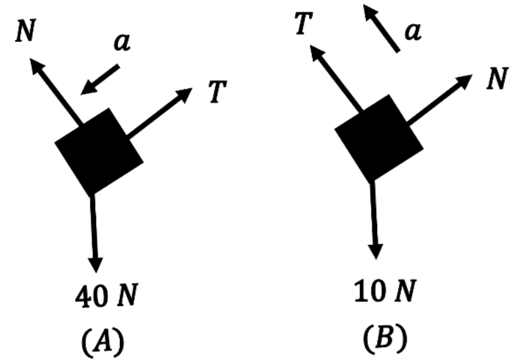
Equation for A parallel to the surface

$$40\sin 60^0 - T = 4a$$

Equation for B parallel to the surface

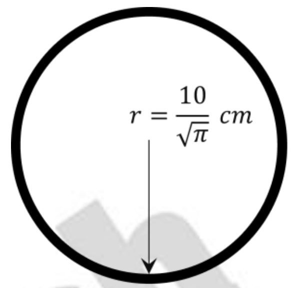
$$T - 10\sin 30^0 = a$$

On solving: $4(\sqrt{3}+1)\ N$



6. A circular loop of radius $\frac{10}{\sqrt{\pi}}\ cm$ is placed in a linearly varying perpendicular magnetic field which has magnitude $0.5\ T$ at time $t = 0$. The magnetic field reduces to zero at $t = 0.5\ sec$. Find the emf induced in the loop at $t = 0.25\ sec$.

A. $0.01\ V$
B. $0.005\ V$
C. $0.02\ V$
D. $0.03\ V$



Answer: (A)

Sol.

$B = 0.5\ T$

$B = 0,\ at\ t = 0.5\ sec$

Assuming linear graph between B & t

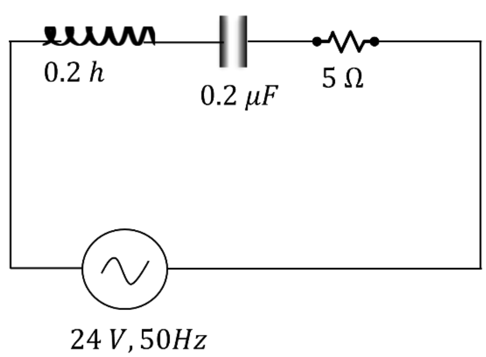
$$\varepsilon_{ind} = \frac{\Delta\phi}{\Delta t} = \frac{\Delta(BA)}{\Delta t} = A\frac{\Delta(B)}{\Delta t}$$

$$= \pi \times \left(\frac{10}{\sqrt{\pi}}\right)^2 \times 10^{-4} \times \left(\frac{0.25}{0.25}\right)$$

$$= 10^{-2} \times 1\ = 0.01\ V$$

7. Calculate the ratio between bandwidth and quality factor for the following circuit

A. 1/3
B. 1/8
C. 1/16
D. 1/4



Answer (B)

Sol.

For an RLC circuit

Band width $= R/L$

$$= \frac{5}{0.2}\ Hz$$

$$= 25\ Hz$$

For an RLC circuit quality factor

$$= \frac{\sqrt{L}}{R\sqrt{C}}$$

$$= \frac{\sqrt{0.2}}{5 \times \sqrt{(0.2 \times 10^{-6})}}$$

$$= 200$$

$$\frac{BW}{Q} = \frac{25}{200} = 1/8$$

8. If a ball is thrown from ground in vertical plane, it attains maximum height of $360\ m$. Find the maximum distance, the ball can cover on ground keeping the projection speed constant.

A. $360\ m$
B. $720\ m$
C. $1440\ m$
D. $180\ m$

Answer (B)

Sol.

For ground projectile, Range = $2\ \times$ Maximum height $= 2 \times 360 = 720\ m$

9. Which statement is correct about photoelectric effect?

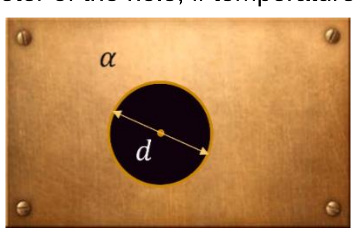
A. Maximum kinetic energy depends upon intensity of light.
B. Stopping potential is dependant only on work function of metal.
C. Photoelectric effect can be explained by wave nature of light.
D. Photoelectric effect can be explained by particle nature of light.

Answer (D)

Sol.

We know that photoelectric effect is supported by particle nature of light, so option D is correct.

10. A uniform rectangular plate has a circular hole of diameter 'd' as shown. The coefficient of linear expansion of the plate is α. Find the change in diameter of the hole, if temperature of the plate is increased by ΔT.



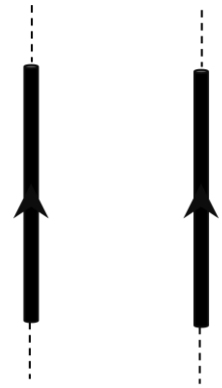
A. $2d\alpha\Delta T$
B. $d\alpha\Delta T$
C. $\frac{d}{2}\alpha\Delta T$
D. $3d\alpha\Delta T$

Answer (B)

Sol.

As we know that $\frac{\Delta d}{d} = \alpha\Delta T \implies \Delta d = d\alpha\Delta T$

11. Two parallel infinite wires carry equal currents as shown. If both the currents are doubled and separation is halved, the force on a $10\ cm$ section of one of the wires becomes:



A. 4 times
B. $1/4$ times
C. 8 times
D. $1/8$ times

Answer: (C)

Sol.

Magnetic force on length l of either wire

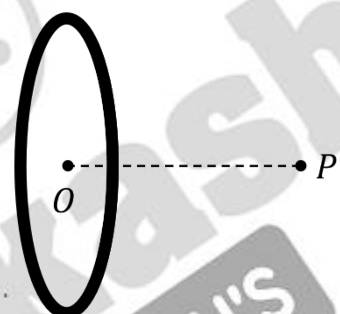
$$F = \frac{\mu_0 I_1 I_2 l}{2\pi d}$$

Original force, $F = \frac{\mu_0 I_0^2 l}{2\pi d}$

New force, $F' = \frac{\mu_0 \times 4 I_0^2 l}{2\pi\left(\frac{d}{2}\right)} = \frac{8\mu_0 I_0^2 l}{2\pi d}$

$F' = 8F$

12. A coil of radius R centred at O carries a current i. Point P is on the axis of coil at a distance R from the centre O as shown. Ratio of magnetic field at point O to magnetic field at point P is equal to



A. 2
B. $2\sqrt{2}$
C. $1/\sqrt{2}$
D. $1/2\sqrt{2}$

Answer (B)

Sol.

$$B_0 = \frac{\mu i}{2R}$$

$$B_p = \frac{\mu i R^2}{2(R^2+R^2)^{3/2}} = \frac{\mu i}{4\sqrt{2}R}$$

$$\frac{B_0}{B_p} = 2\sqrt{2}$$

13. Statement 1: Photodiodes are operated in reverse biased.

Statement 2 : Current in forward biased is more than current in reverse bias in $p-n$ diode.

A. Both the statements are true.
B. Statement 1 is true and statement 2 is false.
C. Statement 1 is true and statement 2 is false.
D. Both the statements are false.

Answer (A)

Sol.

Statement 1 is true as photodiode is used in reverse bias to increase the sensitivity of diode current.

Statement 2 is true as diode provides greater resistance in reverse bias.

14. Weight of an object at earth's surface is $18\ N$. If the object is taken $3200\ km$ above the surface, then the weight of the object (in N) is________

(Given; radius of Earth $=6400\ km$)

Answer (8)

Sol.

As we know that;

$g = \frac{GM}{r^2}$

$g_{new} = \frac{GM}{\left(R+\frac{R}{2}\right)^2} = \frac{4}{9} \times \frac{GM}{R^2} = \frac{4}{9} g_{surface}$

$New\ weight = \frac{4}{9} \times 18\ N = 8\ N$

15. A block of mass $2\ kg$ is attached with two identical spring of force constant $20\ N/m$ as shown in the figure. If the time period of the oscillation of the block is $2\pi\sqrt{\frac{1}{x}}\ sec$. Find x.

Answer (20)

Sol.

Equivalent spring constant

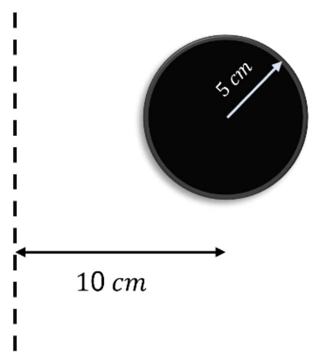
$k_{eq} = k_1 + k_2 = 40\ N/m$

Time period of system is:

$$T = 2\pi\sqrt{\frac{m}{k_{eq}}} = 2\pi\sqrt{\frac{2}{40}} = 2\pi\sqrt{\frac{1}{20}}$$

$x = 20$

16. A ring of uniform wire and radius $5\ cm$ is made to rotate about a coplanar axis which is at a distance of $10\ cm$ from the centre of the ring as shown. The radius of gyration of ring about the axis is equal to $\frac{15}{\sqrt{K}}\ cm$. The value of K is equal to



Answer : 2

Sol.

Moment of inertia is given as.

$$I_{axis} = \frac{m \times 5^2}{2} + m \times 10^2$$

$$= \frac{225}{2} m$$

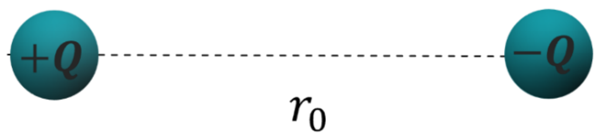
Let radius of gyration is K so,

$$mK^2 = \frac{225}{2} m$$

$K = \frac{15}{\sqrt{2}} cm$

So, the answer is **2**

17. Two charges (both at rest initially), having a charge Q and $-Q$ are released from the situation shown. If the kinetic energy of the system when the separation between them becomes half is $\frac{1}{4\pi\epsilon_0}\frac{Q^2}{nr_0}$, find n?



Answer: 1

Sol.

Initial potential energy $U_i = -\frac{1}{4\pi\epsilon_0} \times \frac{Q^2}{r_0}$

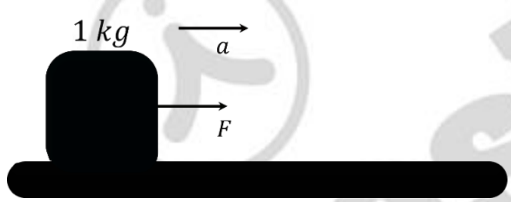
Final potential energy $U_f = -\frac{1}{4\pi\epsilon_0} \times \frac{Q^2}{r_0/2}$

Loss in potential energy ,$U_i - U_f = -\frac{1}{4\pi\epsilon_0} \times \frac{Q^2}{r_0} + \frac{1}{4\pi\epsilon_0} \times \frac{Q^2}{\frac{r_0}{2}} = \frac{1}{4\pi\epsilon_0} \times \frac{Q^2}{r_0}$

Kinetic energy$= \frac{1}{4\pi\epsilon_0} \times \frac{Q^2}{r_0}$

$n = 1$

18. A constant force acting on a body of mass $1\ kg$ provides it a kinetic energy of $1800\ J$ by the end of 5^{th} second. If the body was initially at rest at the beginning of action of force then magnitude of force is equal to _______ N.



Answer: 12 N

Sol.

$a = F/m$

As force is constant so block is moving with constant acceleration

$S = ½\ at^2 = Ft^2/2m$

From work energy theorem

$W = \Delta KE = \vec{F}.\vec{s}$

$$\frac{F^2t^2}{2m} = KE$$

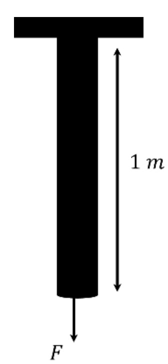
$$F = \sqrt{\frac{2mKE}{t^2}} = \sqrt{\frac{2 \times 1 \times 1800}{25}} = 12\ N$$

19. A light rod of cross-sectional area A and Young's Modulus Y is arranged as shown:

The applied force $F = 250\ N$. If length of rod is $1\ m$, the extension comes out to be $x \times 10^{-6}\ metres$. Find x.

Given that : $A = 6.25 \times 10^{-4}\ m^2$

$Y = 10^{10}\ N/m^2$



Answer: 40.00

Sol.

$$\Delta l = \frac{Fl}{AY}$$

$$\Delta l = \frac{250 \times 1}{6.25 \times 10^{-4} \times 10^{10}}$$

$$\Delta l = 40 \times 10^{-6}\, m$$

$$x = 40.00$$

20. Statement 1: If the weight of the lift is equal to the tension force of the cable wire, then it moves with uniform velocity.

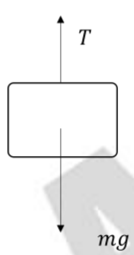
Statement 2: If the lift moves downward with an acceleration, then the contact force between the boy's feet and lift floor is more than the weight of boy.

A. Both the statements are true and (2) is the correct explanation of (1)
B. Both the statements are true and (2) is not the correct explanation of (1)
C. Statement 1 is true and statement 2 is false.
D. Statement 2 is true and statement 1 is false.

Answer (C)

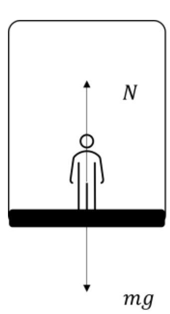
Sol.

Statement 1:



$a = 0,$ as lift is moving with constant velocity.
So, $T = mg$
Statement 1 is correct

Statement 2:



$mg - N = ma$
$N = m(g - a)$
So, $N < mg$
Statement 2 is incorrect.