Head Office: 2nd Floor, Grand Plaza, Fraser Road, Dak Bunglow, Patna - 01

JEE Main 2023 (Memory based)

29 January 2023 - Shift 2

Answer & Solutions

PHYSICS

1. A force $F = -40x$ acts on a mass of $1\ kg$. x is the position of the mass. If maximum speed of the mass is $4\ m/s$, find the amplitude. All parameters are in SI units.

A. $\frac{1}{\sqrt{10}}m$
B. $\frac{2}{\sqrt{10}}m$
C. $\frac{3}{\sqrt{10}}m$
D. $\frac{4}{\sqrt{10}}m$

Answer (B)

Solution:

For SHM:

$$F = -kx \Rightarrow k = 40$$

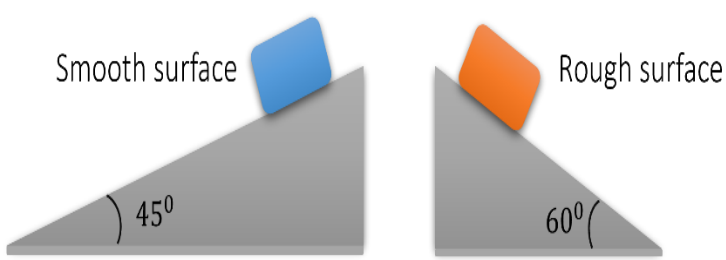
$$v_{max} = A\omega = A\sqrt{\frac{k}{m}}$$

$$4 = A\sqrt{\frac{40}{1}}$$

$$A = \frac{2}{\sqrt{10}}\ m$$

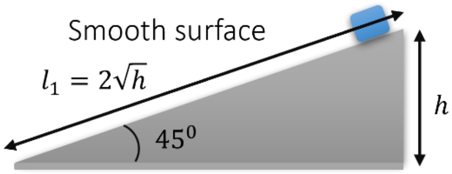
2. Consider 2 inclined plane of same height. 1^{st} has a smooth surface & angle of inclination is 45^0. Other has a rough surface & angle of inclination is 60^0. If the ratio of time taken to slide on them is $'n'$. Find coefficient of friction of rough inclined plane.

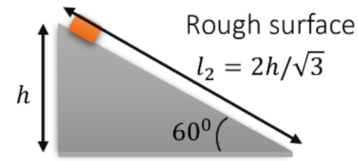
A. $3n^2$
B. $\mu = \frac{3-2n^2}{\sqrt{3}}$
C. $\mu = \frac{3-\sqrt{3}n^2}{2}$
D. $\mu = \frac{2n^2}{\sqrt{3}}$



Answer (B)

Solution:





$$a = g\sin\theta = \frac{g}{\sqrt{2}}$$

$$t = \sqrt{\frac{2l_1}{a}}$$

$$t = \sqrt{\frac{2\sqrt{2}h}{\frac{g}{\sqrt{2}}}}$$

$$t = \sqrt{\frac{4h}{g}}$$

$$a = g\sin\theta - \mu g\sin\theta$$

$$a = \left(\frac{g\sqrt{3}}{2} - \frac{\mu g}{2}\right) = g\left(\frac{\sqrt{3}}{2} - \frac{\mu}{2}\right)$$

$$t = \sqrt{\frac{l_2}{a}}$$

$$t = \sqrt{\frac{8h}{g(3 - \sqrt{3}\mu)}}$$

So,

$$\frac{t_1}{t_2} = \sqrt{\frac{3 - \sqrt{3}\mu}{2}} = n$$

$$3 - \sqrt{3}\mu = 2n^2$$

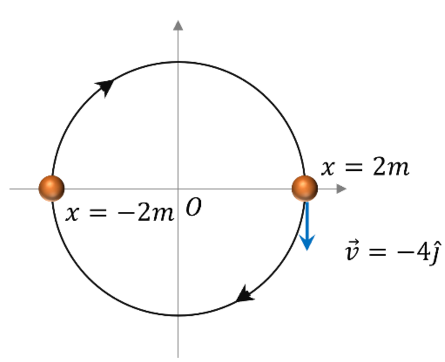
$$\mu = \frac{3 - 2n^2}{\sqrt{3}}$$

3. A particle undergoing uniform circular motion about origin. At certain instant $x = 2\ m$ and $\vec{v} = -4\hat{j}\ m/s$, find velocity and acceleration of particle when at $x = -2\ m$.

A. $\vec{v} = -4\hat{j},\ \vec{a} = 8\hat{i}$
B. $\vec{v} = 4\hat{j},\ \vec{a} = 8\hat{i}$
C. $\vec{v} = -4\hat{j},\ \vec{a} = -8\hat{i}$
D. $\vec{v} = 4\hat{j},\ \vec{a} = -8\hat{i}$

Answer (B)

Solution:



For uniform circular motion:

At $x = -2\ m, v = 4\hat{j}$

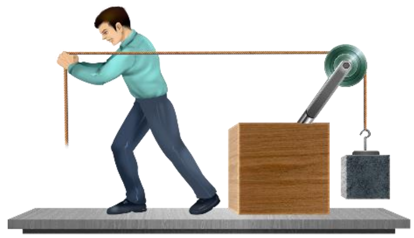
Acceleration towards the center is:

$$a = \frac{v^2}{r}$$

$$a = \frac{4^2}{2} = 8\ m/s^2$$

$$\vec{a} = 8\ m/s^2\hat{i}$$

4. A man pulls a block as shown:
Consider the following statements:
1: Work done by the gravity on block is positive.
2: Work done by the gravity on block is negative.
3: If man pulls block with constant speed, then tension in the string equals to weight of the block.
4: None of the above.



A. 2 and 3 only
B. 4 only
C. 4 only
D. 1 only

Answer (A)

Solution:

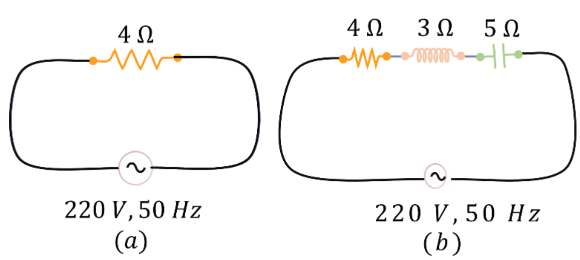
Weight acts down and displacement is up, so work done by gravity is negative.

If speed is constant, acceleration is zero, hence tension is equal to weight.

⇒Statement 3 is correct.

$T - mg = ma$
If $a = 0$, $T = mg$

5. RMS current in circuit (a) is I_a while RMS current in circuit (b) is I_b then:



A. $I_a > I_b$
B. $I_a < I_b$
C. $I_a = I_b$
D. $none\ of\ the\ above$

Answer (A)

Solution:

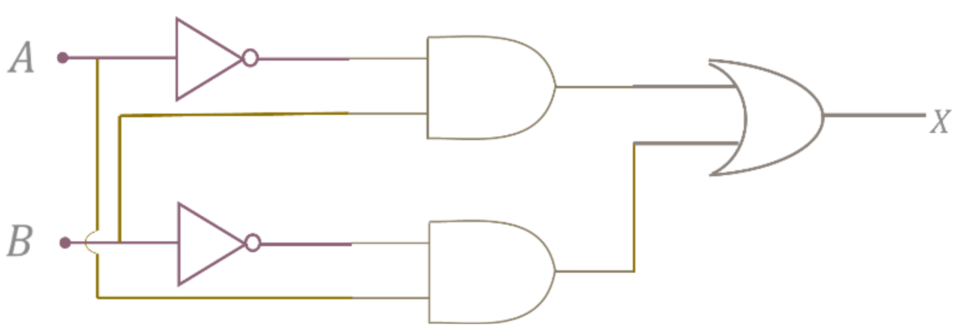
Impedance for circuit (a) and (b):

$Z_a = 4\ \Omega$ and $Z_b = \sqrt{(4^2 + (5-3)^2}\ \Omega = \sqrt{20}\ \Omega$

$I_a = \frac{220}{4} \quad and \quad I_b = \frac{220}{\sqrt{5}}$

$I_a > I_b$

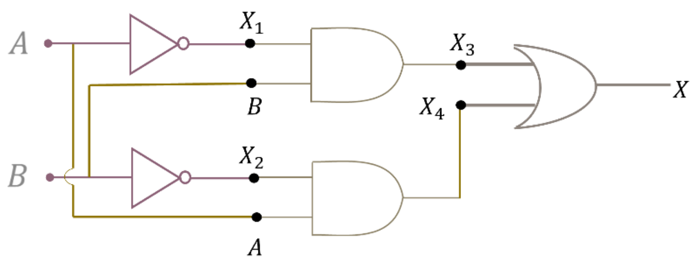
6. Find truth table:



A.	B.	C.	D.
A B X 0 0 1 0 1 1 1 0 1 1 1 1	A B X 0 0 1 0 1 0 1 0 0 1 1 1	A B X 0 0 0 0 1 0 1 0 0 1 1 1	A B X 0 0 0 0 1 1 1 0 1 1 1 0

Answer (D)

Solution:



$X_1 = \bar{A}$

$X_3 = B.\bar{A}$

$X_2 = \bar{B}$

$X_4 = (\overline{AB})$

$X = X_3 + X_4$

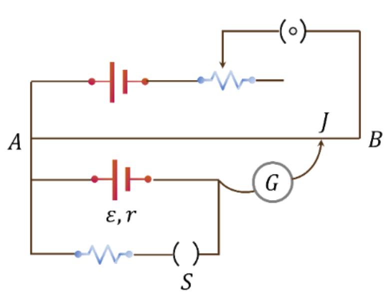
$X = A\bar{B} + B\bar{A}$

Y=output=XOR Gate

So, the correct answer is:

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

7. Consider the following potentiometer circuit. When switch S is open, length AJ is $300\ cm$. When switch S is closed, length AJ is $200\ cm$. If $R = 5\Omega$, then find internal resistance r of the cell.



A. $4\ \Omega$

B. $2\ \Omega$

C. $5\ \Omega$

D. $2.5\ \Omega$

Answer (D)

Solution:

For both the cases:

$C \times 300 = \epsilon \ldots \ldots (1)$

$C \times 200 = \frac{\epsilon}{R+r} \times R \ldots \ldots (2)$

$\frac{300}{200} = \frac{R+r}{R}$

$r = \frac{R}{2} = 2.5\ \Omega$

8. In a communication system, maximum voltage is $14\ mV$ and minimum voltage is $6\ mV$. Find out the modulation index.

A. 0.2
B. 0.6
C. 0.4
D. 0.3

Answer (C)

Solution:

$$Index = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

$$= \frac{14-6}{14+6}$$

$$= 0.4$$

9. The gravitational potential due to a solid uniform sphere of mass M and radius R at a point at radial distance $r\ (r > R)$ from its centre is equal to

A. $-\frac{GM}{r}$
B. $-\frac{GM}{2r}$
C. $-\frac{GMR}{r^2}$
D. $-\frac{GM(R+r)}{r^2}$

Answer (A)

Solution:

For outside point of solid sphere, $V = -\frac{GM}{r}$

10. Resolving power of compound microscope will increase with

A. Decrease in wavelength of light and increase in numerical aperture.
B. Increase in wavelength of light and decrease in numerical aperture.
C. Increase in both wavelength numerical aperture.
D. Decrease in both wavelength numerical aperture.

Answer (A)

Solution:

Resolving power of compound microscope $\propto \left(\frac{2n \sin\theta}{\lambda}\right)$

$\lambda =$ Wavelength of used light
$n \sin\theta =$ Numerical aperture
$n =$ Refractive index of medium separating object and aperture

11. It is given that $x^2 + y^2 = a^2$ where, a: radius.
Also, it is given that $(x - \alpha t)^2 + \left(y - \frac{t}{\beta}\right)^2 = a^2$, where, t: time
Then dimensions of α and β are

A. $[M^0LT^{-1}]$ & $[M^0L^{-1}T]$
B. $[M^0LT]$ & $[M^0L^{-1}T^{-1}]$
C. $[M^0LT]$ & $[M^0LT^{-1}]$
D. $[M^0L^{-1}T]$ & $[M^0LT]$

Answer (A)

Solution:

$$x = \alpha t = \frac{t}{\beta}$$
$$\Rightarrow L' = \alpha T' = \frac{T'}{\beta}$$
$$\Rightarrow \alpha = [LT^{-1}] \,\&\, \beta = [L^{-1}T]$$

12. Assertion (A): EM waves are not deflected by electric field and magnetic field.
Reason (R): EM waves don't carry any charge, so they are not deflected by electric field and magnetic field.

A. $Both\ (A)\ and\ (R) are\ true\ and\ (R)\ is\ the\ correct\ explanation\ of\ (A)$
B. $Both\ (A)\ and\ (R) are\ true\ and\ (R)\ is\ not\ the\ correct\ explanation\ of\ (A)$
C. $(A)\ is\ true\ but\ (R)\ is\ false.$
D. $(A)\ is\ false\ but\ (R)\ is\ true.$

Answer (A)

Solution:

EM wave does not have charge therefore they are not deflected by electric or magnetic field.

13. De-Broglie wavelength of a body of mass m and kinetic energy E is given by:

A. $\lambda = h/mE$
B. $\lambda = \sqrt{2mE}/h$
C. $\lambda = h/\sqrt{2mE}$
D. $\lambda = \sqrt{h/2mE}$

Answer (C)

Solution:

$$\lambda_d = \frac{h}{p} \ \ and \ \ p = \sqrt{2mE}$$
$$\lambda_d = \frac{h}{\sqrt{2mE}}$$

14. In a region with electric field $30\,\hat{\imath}\,V/m$ a charge particle of charge $q = 2 \times 10^{-4}\,C$ is displaced slowly from $(1,2)$ to origin. The work done by external agent is equal to

A. $1\,mJ$
B. $6\,mJ$
C. $2\,mJ$
D. $3\,mJ$

Answer (B)

Solution:

$F = qE$

$= 2 \times 10^{-4} \times 30\ N$

Work Done $= 6 \times 10^{-3} \times 1\ J$

Work Done $= 6\ mJ$

15. At $300\ K$, RMS speed of an ideal gas molecules is $\sqrt{\frac{\alpha+5}{\alpha}}$ times the average speed of gas molecules, then value of α is equal to (take $\pi = 22/7$)

Answer (28)

Solution:

$$v_{rms} = \sqrt{\frac{3RT}{M_0}}$$

$$v_{avg} = \sqrt{\frac{8RT}{\pi M_0}}$$

$$\frac{v_{rms}}{v_{avg}} = \sqrt{\frac{3\pi}{8}} = \sqrt{\frac{33}{28}} = \sqrt{\frac{28+5}{28}}$$

So, $\alpha = 28$

16. An α particle and a proton are accelerated through same potential difference. The ratio of $de - Broglie$ wavelength of α particle to proton is equal to $1/\sqrt{x}$. Value of x is
Take $m_\alpha = 4m_{proton}$

Answer (8)

Solution:

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

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mqV}}$$

$$\frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{m_p q_p}{m_\alpha q_\alpha}} = \sqrt{\frac{1}{4} \times \frac{1}{2}} = \frac{1}{\sqrt{8}}$$

$x = 8$

17. Time period of rotation of a planet is $24\ hours$. If the radius decreases to $\frac{1}{4}th$ of the original value, then the new time period is x hours. Find $2x$.

Answer (3)

Solution:

We know, $I\omega = constant$

$$\Rightarrow I_1\omega_1 = \frac{I_1}{16}\omega_2$$

$$\Rightarrow \omega_2 = 16\omega_1$$

$$\Rightarrow T_2 = \frac{T_1}{16} = 1.5\ hours$$

$$\Rightarrow 2x = 3\ hours$$

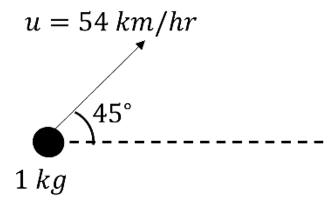
18. A projectile is fire with velocity $54\ km/hr$ making an angle $45°$ with horizontal. Angular momentum of this particle of mass $1\ kg$ about the point of projection one second into the motion will be $\frac{5N}{\sqrt{2}}$ in SI units ($g = 10\ m/s^2$). Find the value of N.

Answer (3)

Solution:

$u = 54\ km/hr = 15\ m/s$

Torque at time t is $\tau = mgu\cos\theta\, t$



$$\frac{dL}{dt} = \tau$$

$$\int_O^L dL = \int_0^1 mgu\cos\theta\, tdt$$

$$L = \frac{mgu\cos\theta}{2} = \frac{10 \times 15}{2\sqrt{2}} = \frac{75}{\sqrt{2}}\ kg\ m^2/sec$$

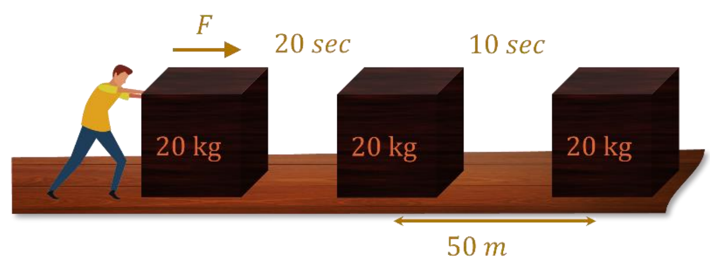
Comparing with $\frac{5N}{\sqrt{2}} \Rightarrow N = 15$

19. A block of mass $20\ kg$ is moved with a constant force 'F' for $20\ seconds$ starting from rest and then 'F' is removed. It is then observed that block moves $50\ m$ in next $10\ seconds$. Find $F\ (in\ N)$.

Answer (5)

Solution:

When Force is removed, let velocity of block is v.



$$v = \frac{50}{10} = 5m/s$$

For first $20\ seconds$,

Impulse, $Ft = mv$

$F \times 20 = 20 \times 5$

$F = 5\ N$