A Voltmeter of resistance 10 kΩ is connected across a resistor of resistance 400 Ω as shown in figure. Find reading of volt meter.

\[ 6 \text{ V} \]

\[ \text{VMM} \quad \text{VMM} \]

\[ 400 \quad 400 \]

\[ \text{SoL:} \]

Current in circuit \[ I = \frac{G}{\text{Req}} \]

\[ I = \frac{6}{\frac{400 + 400 \times 10,000}{10,400}} = \frac{6}{11,841.02} = 5 \times 10^{-3} \text{ Amp} \]

Now reading of Voltmeter will be equal to PD across combination of Voltmeter and 400Ω.

Thus \[ V = I \times R \]

\[ V = 5 \times 10^{-3} \times \frac{4 \times 10^3 \times 10,000}{10,400} = 1.95 \text{ Volt} \]
9.1 A block has been thrown along a rough inclined surface at an initial velocity of \( v_0 \) as shown in figure. If it reaches again at starting point with a speed of \( v_0/2 \) then coefficient of friction \( \mu \) block and inclined surface is:

- a) 0.05
- b) 0.75
- c) 0.35
- d) 0.50

Solution:
If block is moving up, its acceleration is

\[
\begin{align*}
\text{mg} \sin 30^\circ + \mu \text{mg} \cos 30^\circ &= ma \\
a &= \frac{g}{2} \left( 1 + \sqrt{3} \mu \right)
\end{align*}
\]

Now block will reach a maximum distance of \( L \) along surface, then

\[
\begin{align*}
\dot{v}^2 &= \dot{u}^2 - 2as \\
v_0^2 &= \frac{g}{2} \left( 1 + \sqrt{3} \mu \right) L
\end{align*}
\]

Now apply work-energy theorem for complete motion.

\[
\begin{align*}
-f \times 2L &= \frac{1}{2} m v_0^2 - \frac{1}{2} m v_L^2 \\
\mu \theta \frac{\sqrt{3}}{2} L \times 2 \cdot \frac{v_0^2}{g(1+\sqrt{3}\mu)} &= \frac{3}{8} \dot{\theta} v_0^2
\end{align*}
\]
Q.3 Two concentric shells of radius $R$ and $4R$ having charges of $Q_1$ and $Q_2$ respectively as placed as shown in figure, potential difference between shell will be.

\[ a) \frac{3}{4\pi\varepsilon_0} \frac{Q_2}{R} \]
\[ b) \frac{3}{4\pi\varepsilon_0} \frac{Q_1}{R} \]
\[ c) \frac{3}{4\pi\varepsilon_0} \frac{Q_1}{R} \]

Solf \[ = \text{for shell of radius } R, \text{ potential is} \]
\[ V_1 = \frac{1}{4\pi\varepsilon_0} \frac{Q_1}{R} + \frac{1}{4\pi\varepsilon_0} \frac{Q_2}{4R} \]

for outer shell of radius $4R$, potential is
\[ V_2 = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 + Q_2}{4R} \]

\[ DV = V_2 - V_1 \]
\[ = \frac{1}{4\pi\varepsilon_0} \frac{Q_1}{R} - \frac{1}{4\pi\varepsilon_0} \frac{Q_1}{4R} \]
\[ DV = \frac{3}{16\pi\varepsilon_0} \frac{Q_1}{R} \]
Three point masses of \( m \) mass each are placed at the corners of an equilateral triangle as shown in figure. Find moment of inertia of given mass system about \( y \)-axis. \( I_y = \frac{N}{20} m a^2 \) then find \( N \).

\[
\begin{align*}
\text{a)} & \ 5 \\
\text{b)} & \ 15 \\
\text{c)} & \ 25 \\
\text{d)} & \ 50
\end{align*}
\]

So:\[ I_y = m(0)^2 + m(a)^2 + m\left(\frac{a}{2}\right)^2 \]

\[
I_y = ma^2 + ma^2 = 5ma^2 \quad \therefore \quad \frac{s}{5} = \frac{25ma^2}{20} \]

\[ N = 25 \]
A body cools from 50°C to 40°C in 5 min. Surrounding temperature for the process is given as 20°C. Find temperature of body in next 5 min.

a) 13.3°C  
**Let** 83.3°C  

b) 23.3°C  
**N** 43.3°C

**Sol.**- According to Newton's Cooling Law

\[
\frac{dT}{dt} = k \left( T_{\text{body}} - T_{\text{surrounding}} \right)
\]

for 1st 5 min =

\[
\frac{50 - T_0}{5} = k \left( \frac{50 + T_0}{2} - 20 \right) = k \times 25
\]

for next 5 min =

\[
\frac{40 - T}{5} = k \left( \frac{T + 40}{2} - 20 \right) = \frac{k \times 40}{2}
\]

**eq 0**

\[
\frac{10}{40 - T} = \frac{25 \times 2}{T} \quad \Rightarrow \quad T = 33.33°C
\]
A particle of mass \( m \) which is placed at rest, has been given constant power \( P \). Choose correct graph:

a)

\[
\text{distance } (s) \quad \text{time } (t)
\]

b)

\[
\text{distance } (s) \quad \text{time } (t)
\]

d)  

\[
\text{distance } (s) \quad \text{time } (t)
\]

d)

\[
\text{distance } (s) \quad \text{time } (t)
\]

**Solution:**

\[
P = F \cdot v = m \cdot a \cdot v
\]

\[
P = m \frac{dv}{dt} \cdot v
\]

\[
\int v \, dv = \int \frac{P}{m} \, dt
\]

\[
v^2 = \frac{P}{m} t + C
\]

\[
\frac{v^2}{2} = \frac{P}{m} t
\]

\[
v = \sqrt{\frac{2P}{m} t + 112}
\]

\[
\int ds = \sqrt{\frac{2P}{m}} \int \frac{112}{t} \, dt
\]

\[
s = \frac{2}{3} \sqrt{\frac{2P}{m}} t^{3} + 12
\]
Two point sources of powers 200 W emit photons and x-rays at wavelengths 500 nm and 1 nm respectively, then what will be the ratio of photon density for both the sources.

\[ \frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{500}{1} = 500 \]

For any point charge powers emitted is

\[ p = n \ h \ \nu = n \ \frac{h \ c}{\ \lambda} \]

then for same powers, \( n \ \propto \ \lambda \)
Mass density of a solid sphere of radius $R$ varies as 
\[ \rho = \rho_0 \left( 1 - \frac{r^2}{R^2} \right) \]
where $r$ is distance from centre of sphere. Find maximum gravitational field.

a) \( \frac{\sqrt{5}}{5} \pi \rho_0 R \)
b) \( \frac{\sqrt{3}}{3} \pi \rho_0 R \)
c) \( \frac{\sqrt{5}}{8} \pi \rho_0 R \)

The gravitational field at a distance $r$ from centre is

\[ E_g = \frac{\mu_0 M_{\text{inside}}}{r^2} \]

Now 
\[ M_{\text{inside}} = \int_0^R \int_0^{2\pi} \int_0^1 \rho_0 \left( 1 - \frac{r^2}{R^2} \right) r \, dr \, d\theta \, dz \]

\[ M_{\text{inside}} = \frac{4}{3} \pi \rho_0 \left( \frac{R^3}{3} - \frac{R^5}{5R^2} \right) \]

Then 
\[ E_g = \frac{\mu_0 M_{\text{inside}}}{r^2} = \frac{\mu_0 \frac{4}{3} \pi \rho_0 \left( \frac{R^3}{3} - \frac{R^5}{5R^2} \right)}{r^2} = \mu_0 \frac{4}{3} \pi \rho_0 \left( \frac{9}{3} - \frac{8}{3} \right) \]

For maximum $E_g = \frac{dE_g}{dr}$

\[ \frac{dE_g}{dr} = 0 \Rightarrow \frac{1}{3} - \frac{3r^2}{5R^2} = 0 \]

\[ r = \sqrt{5} R \]

Then 
\[ (E_g)_{\text{max}} = \frac{\sqrt{5}}{27} \pi \rho_0 R \]
A spherical mirror forms an image of an object placed at a distance of 30 cm at 100 cm distance. Now if object start moving with a speed of 3 cm/sec towards mirror then what will be speed of image.

a) - 90 cm/sec
b) - 30 cm/sec
c) + 90 cm/sec

\[ \frac{1}{v} + \frac{1}{u} = \frac{1}{f} \] then \[ -\frac{1}{v} \frac{dv}{dt} - \frac{1}{u} \frac{du}{dt} = 0 \]

\[ v_1 = -\frac{u^2}{v} \cdot v_0 \]

\[ v_1 = -\frac{100}{800} \times 9 = -1 \text{ cm/sec} \]
An ideal gas has given a heat of 160 J at constant pressure and when 240 J heat has been given at constant volume then its temperature rises by 100°C. What is degree of freedom of gas?

a) 3
b) 5
d) 7

\[ \text{at } P = c \Rightarrow \Delta H = n C_p \Delta T \]
\[ 160 = n C_p \times 50^\circ C \quad -1 \]

\[ \text{at } V = c \Rightarrow \Delta H = n C_V \Delta T \]
\[ 240 = n C_V \times 100^\circ C \quad -2 \]

\[ \frac{1}{2} = \frac{C_p}{C_V} = \frac{4}{3} = 1 + \frac{2}{f} \]

Then \( f = 6 \)
8.11 A block of mass \( m \) is performing SHM on a line with amplitude \( A \) and frequency \( f \). Now suddenly it half of the mass comes to rest when block is at mean position then amplitude of remaining mass is \( \frac{A}{2} \). Find \( \lambda \).

(a) 2  
(b) \( \frac{1}{2} \)  
(c) \( \frac{1}{\sqrt{2}} \)

SOL:- At mean position, apply conservation of linear momentum.

\[
M \times v_{\text{max}} = \frac{M}{2} \times v'_{\text{max}}
\]

\[
M \times \frac{\pi f}{2} \times A = \frac{M}{2} \times \frac{\pi f}{2} \times A'
\]

\[
A \times \sqrt{\frac{k}{m}} = \frac{A'}{2} \sqrt{\frac{k}{m''}}
\]

\[
A' = \sqrt{2} A
\]
Q. 12 which is correct option for dimension of Solar constant:

a) \( M^0 L^0 T^3 \)

b) \( M^1 L^1 T^{-2} \)

c) \( M^0 L^0 T^{-3} \)

d) \( M^1 L^1 T^{-3} \)

\[ \text{Solar constant} = \frac{\text{Radiation energy}}{\text{Radiant area \times time}} \]

\[ \text{Solar constant} (\sigma) = \frac{M^1 L^2 T^{-2}}{T L^2} = M^1 L^0 T^{-3} \]
A block of mass 1.9 kg is placed on another fixed block of height 1 m as shown in figure. A bullet of mass 0.1 kg hit the block of mass 1.9 kg and get embedded into it. Find kinetic energy of block when it hit ground.

\[ \begin{align*}
&20 \text{ms} \\
\rightarrow \quad &1.9 \\
\uparrow &1 \text{m} \\
\downarrow 
\end{align*} \]

\begin{align*}
\text{Sol.} & \quad \text{Apply conservation of momentum for block and bullet.} \\
0.1 \times 20 & = (1.9 + 0.1) V \\
\Rightarrow \quad & V = 1 \text{ms} \\
\text{now apply work-energy theorem from top of the block to ground.} \\
+ 20 \times 1 & = \frac{1}{2} x 2 x V^2 - \frac{1}{2} x 2 x 1^2 \\
\Rightarrow \quad & V^2 = 21 \\
\Rightarrow \quad & KE = \frac{1}{2} x 2 x V^2 \\
\Rightarrow \quad & KE = 21 J
\end{align*}
A current carrying loop is placed in uniform magnetic field \( B \) such that the magnetic field lies in the plane of loop. Area of loop is \( S \) and carry a current \( I \). If \( \tau \) is the torque experienced by loop then find \( |\tau| \).

\[
\text{a) } \frac{2S}{Ni} \quad \text{c) } \frac{2N}{iS} \\
\text{b) } \frac{2}{NSi} \quad \text{d) } \frac{2i}{NS} \]

(where \( N \) = number of turn of coil)

Solution:

\[
|\tau| = |\vec{M} \times \vec{B}| = MB \sin \theta
\]

\[
\tau = NI \times B \sin \theta
\]

\[
\frac{\tau}{B} = \frac{2}{NSi}
\]
Electric field of an electromagnetic wave is given as \( \vec{E} = E_0 \cos(\omega t - kx) \hat{j} \). Then which equation gives corresponding magnetic field at \( t = 0 \)?

a) \( \vec{B} = \frac{E_0}{\mu_0 \epsilon_0} \cos kx \hat{k} \)  
\( \Rightarrow \vec{B} = E_0 \sqrt{\frac{\mu_0}{\epsilon_0}} \cos kx \hat{k} \)

b) \( \vec{B} = \frac{E_0}{\sqrt{\mu_0 \epsilon_0}} \cos kx (-\hat{k}) \)  
\( \Rightarrow \vec{B} = E_0 \sqrt{\frac{\mu_0}{\epsilon_0}} \cos kx (-\hat{k}) \)

so \( \vec{B} \) for amplitude of magnetic field
\( B_0 = \frac{E_0}{c} = E_0 \sqrt{\frac{\mu_0}{\epsilon_0}} \)

now to satisfy \( \vec{E} \times \vec{B} \parallel \hat{z} \)
and \( \hat{z} \) is in a direction.
then \( \vec{B} \) is in \( +z \)-direction.

\[ \vec{B} = E_0 \sqrt{\frac{\mu_0}{\epsilon_0}} \cos kx \hat{k} \]
A P-N Junction becomes active when photons of wavelength 1.0um falls on it. Find energy band gap for junction.

\[ \text{Let } E = 8.09 \text{ ev} \quad c) \quad 3.45 \text{ ev} \]
\[ b) \quad 2.45 \text{ ev} \quad d) \quad 2.09 \text{ ev} \]

**Solution for energy band gap**

\[ E = h\nu = \frac{hc}{\lambda} = \frac{1237.5}{400} = 3.09 \text{ ev} \]
An uniform rod of length $l$ is rotating about vertical axis $AB$ from one end with angular velocity $\omega$ rad/sec as shown in figure. Find $\cos \theta$.

\[ a) \quad \frac{g}{2 \omega^2} \]
\[ b) \quad \frac{g}{\omega^2} \]
\[ c) \quad \frac{2g}{l \omega^2} \]
\[ d) \quad \frac{3g}{l \omega^2} \]

Solve for $\theta$ from rotating frame.

\[ \rightarrow \quad \tau_{centrifugal} = \tau_{mg} \]
\[ \tau_{centrifugal} = \int (dm \sin \theta \omega^2) \times (r \cos \theta) \]
\[ = M \int_a^b \omega^2 \sin \theta \cos \theta \, du = \frac{Md \omega^2 \sin \theta \cos \theta}{3} \]
\[ \tau_{centrifugal} = \tau_{mg} \]
\[ \rightarrow \quad \tau = \tau_{mg} \]
\[ \frac{Md \omega^2 \sin \theta \cos \theta}{3} = mg \times \frac{4}{3} \sin \theta \]

\[ \cos \theta = \frac{3}{2} \frac{8}{l \omega^2} \]
Two light rays of wavelength $\lambda$ are in phase initially. Now 1st ray travels from a medium of refractive index $n_1$ upto a length $L_1$, and second ray travels from a medium of refractive index $n_2$ upto a length $L_2$. Find phase difference between rays now.

a) \( \frac{2\pi c}{\lambda} (L_2 - L_1) \) \hspace{1cm} \text{let} \hspace{1cm} \frac{2\pi c}{\lambda} (n_1 L_1 - n_2 L_2)

b) \( \frac{2\pi c}{\lambda} \left( \frac{L_2}{n_2} - \frac{L_1}{n_1} \right) \) \hspace{1cm} \text{or} \hspace{1cm} \frac{2\pi c}{\lambda} \left( \frac{L_1}{n_1} - \frac{L_2}{n_2} \right)

Solution:

According to optical path concept:

\[ L_1' = L_1 n_1 \quad L_2' = L_2 n_2 \]

Then path difference

\[ DL = L_1' - L_2' \]

\[ DL = L_1 n_1 - L_2 n_2 \]

Now

\[ \Delta \phi = \frac{2\pi c}{\lambda} DL = \frac{2\pi c}{\lambda} (L_1 n_1 - L_2 n_2) \]