1. Find $I_{\text{rms}}$ in the following circuit

![Circuit diagram](image)

(1) 3.5 mA
(2) 35 mA
(3) 350 mA
(4) 3500 mA

Sol. Answer (1)

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{z}$$

$$z = x_L = wL = 2\pi \times 50 \times 200$$

$$= 100 \times 200 \times \pi$$

$$x_L = 20000 \times \pi$$

$$V_{\text{rms}} = 220 \text{ V}$$

$$I_{\text{rms}} = \frac{220}{20000\pi} = 0.0035 A = 3.5 mA$$

2. A ball is thrown vertically upwards from a tower and reaches ground in 6 seconds. Another ball is thrown downwards with same position and with same speed reaches ground in 1.5 s. Time taken by the ball to reaches ground if dropped from same height is

(1) 3 s
(2) 4 s
(3) 5 s
(4) 2 s

Sol. Answer (1)

$$h = -ut_t + \frac{1}{2}gt_t^2 \quad (1)$$

and $h = ut_s + \frac{1}{2}gt_s^2 \quad (2)$

and $h = \frac{1}{2}gt_s^2 \quad (3)$

From (1), (2) & (3) we get

$$t_3 = \sqrt{t_1 t_2} = \sqrt{6 \times 1.5} = 3 \text{ s}$$

3. For the circuit shown in figure, if voltmeter reads 1.2 V, then find the value of $r$

![Circuit diagram](image)

(1) 4 Ω
(2) 5 Ω
(3) 6 Ω
(4) 8 Ω
1. \( i = \frac{1.5}{10 + \frac{r}{2}} = \frac{3}{r + 20} \)

But \( v = 10i \)

\[ 1.2 = 10 \left( \frac{3}{r + 20} \right) \]

\[ r + 20 = \frac{300}{12} = 25 \]

\[ r = 5 \Omega \]

4. At height \( h \) above the earth surface, mass of the person becomes 1/3. Find height

(1) \( 4.68 \times 10^6 \) m

(2) \( 2.68 \times 10^6 \) m

(3) \( 3.50 \times 10^6 \) m

(4) \( 4.20 \times 10^6 \) m

Sol. Answer (1)

We have, \( w = w \left( \frac{R}{h + R} \right)^2 \)

given \( w = \frac{w}{3} \)

\[ \frac{1}{3} = w \left( \frac{R}{h + R} \right)^2 \]

\[ \sqrt{3}R = h + R \]

\[ h = (\sqrt{3} - 1)R = 0.732 \times 6400 \]

\[ = 4684.8 \text{ km} \]

\[ = 4.68 \times 10^6 \text{ m} \]

5. A projectile is projected with horizontal velocity 25 m/s. If the range of projectile is 75 m, then find the angle of projection of projectile

(1) \( \theta = \tan^{-1} \left( \frac{4}{5} \right) \)

(2) \( \theta = \tan^{-1} \left( \frac{1}{2} \right) \)

(3) \( \theta = \tan^{-1} \left( \frac{3}{5} \right) \)

(4) \( \theta = \tan^{-1} \left( \frac{2}{5} \right) \)

6. Find the effective focal length in the given combination. Two biconvex lens of focal length 10 cm and refractive index 1.5 are kept in contact with space between the index filled with a medium of refractive index 1.25

(1) \( + 10 \) cm

(2) \( + \frac{20}{3} \) cm

(3) \( + 10 \) cm

(4) \( + 20 \) cm

Sol. Answer (2)

Given \( \mu = 1.5, f = 10 \) cm, \( \mu_f = 1.25 \)

\[ \frac{1}{f} = (\mu - 1) \frac{2}{R} \]

\[ \frac{1}{10} = (1.5 - 1) \frac{2}{R} \]

\[ \Rightarrow R = 10 \text{ cm} \]

\[ \Rightarrow \frac{1}{f} = (\mu_f - 1) \frac{2}{R} = 0.25 \times \frac{2}{10} \]

\[ = -\frac{1}{20} \Rightarrow f' = -20 \text{ cm} \]

We have, \( \frac{1}{f_e} = \frac{1}{f} + \frac{1}{f'} + \frac{1}{f} \)
7. Find the depth below the surface of the earth where weight of an object is \( \frac{1}{3} \)rd of its original weight. (R - Radius of the earth)

(1) \( \frac{R}{3} \)  
(2) \( \frac{2R}{3} \)  
(3) \( \frac{R}{2} \)  
(4) \( \frac{R}{6} \)

Sol. Answer (2)

\[
\begin{align*}
g_d & = g_s \left(1 - \frac{d}{R}\right) \\
\text{So,} \ rac{1}{3} g_s & = g_s \left(1 - \frac{d}{R}\right) \\
\Rightarrow \frac{1}{3} & = 1 - \frac{d}{R} \\
\Rightarrow d & = R - \frac{3}{2} \\
\Rightarrow d & = \frac{2R}{3}
\end{align*}
\]

8. Two soap bubbles of radii 4 cm & 5 cm are placed in contact with each other. Radii of curvature of interface is

(1) 10  
(2) 16  
(3) 15  
(4) 20

Sol. Answer (4)

Pressure difference at their common interface is,

\[
\frac{4T}{R_i} = \frac{4T}{R_2}
\]

So,

\[
\frac{4T}{R_{\text{common}}} = \frac{4T}{R_i} - \frac{4T}{R_2}
\]

9. A ball dropped from height \( h \) falls on spring of spring constant, \( k \). Ball sticks to the spring and came to rest when spring compressed by \( \frac{h}{2} \), value of spring constant is

(1) \( \frac{8mg}{h} \)  
(2) \( \frac{6mg}{h} \)  
(3) \( \frac{4mg}{h} \)  
(4) \( \frac{12mg}{h} \)

Sol. Answer (4)

Using work energy theorem between initial and final condition;

\[
\frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2 = w_{\text{gravity}} + w_{\text{spring}}
\]

\[
\Rightarrow 0 - 0 = mg\left(h + \frac{h}{2}\right) + \left(-\frac{1}{2}k\left(\frac{h}{2}\right)^2\right)
\]

\[
\Rightarrow \frac{1}{2}k\frac{h^2}{4} = \frac{3mgh}{2}
\]

\[
\Rightarrow h = \frac{12mg}{k}
\]

\[
\Rightarrow k = \frac{12mg}{h}
\]

10. If a charged ball of mass \( m = 0.1 \) g is held stationary by an electric field \( E = 2 \times 10^9 \) V/m. The charge on the ball is

(1) \( 5 \times 10^{-9} \) C  
(2) \( 5 \times 10^{-11} \) C  
(3) \( 5 \times 10^{-12} \) C  
(4) \( 5 \times 10^{-13} \) C

Sol. Answer (4)
The normal reaction $N$ for a vehicle of 800 kg negotiating a turn on a 30° banked road at maximum possible speed is $\text{____} \times 10^3 \text{ kg m/s}^2$

- **Given** $\cos 30^\circ = \frac{\sqrt{3}}{2}$
- $\mu_s = 0.2$
- **(1) 9.0**
- **(2) 10.44**
- **(3) 9.6**
- **(4) 9.8**

**Sol. Answer (2)**

As $v$ is wax, friction is acting inwards

$f = \mu_s N$, for limiting case in vertical dissection

$N \cos \theta = mg + f \cos 60^\circ$

$\Rightarrow N \cos 30^\circ = mg + \mu_s N \cos 60^\circ$

$\Rightarrow N = \frac{\frac{\sqrt{3}}{2} - 0.2 \times \frac{1}{2}}{0.77} = 10.4 \times 10^3 \text{ N}$

12. Stopping potential for wavelength $\lambda = 491 \text{ nm}$ is 0.41 V. If wavelength is changed so that stopping potential becomes 1.02 V then wavelength of new wave is

- **(1) 4500 Å**
- **(2) 3955 Å**
- **(3) 6000 Å**
- **(4) 4276 Å**

**Sol. Answer (2)**

Using photoelectric equation:

$\frac{hc}{\lambda} - \phi = eV_s$

$hc = 12400 \text{ evÅ}$

(i) $\frac{12400}{4910} ev - \phi = e(0.41) v$

$\Rightarrow \phi = (2.52 - 0.41) ev = 2.11 ev$

(ii) $\frac{12400}{\lambda} = 2.11 = 1.02$

$\Rightarrow \lambda = \frac{12400}{3.13} = 3961 \text{ Å}$

$\lambda = 3961 \text{ Å}$

13. Efficiency of caron engine was 25% at 27°C. so what will be the increase in temperature required to increase its efficiency by 100%

- **(1) 150° C**
- **(2) 300° C**
- **(3) 200° C**
- **(4) 400° C**

**Sol. Answer (3)**

Given $x_1 = 25% = 0.25$, $T_2 = 300K$

$x_2 = 2x_1 = 0.5$

We have, $x = 1 - \frac{T_2}{T_1} \Rightarrow 1 = 1 - \frac{300}{T_1}$

$\Rightarrow \frac{3}{4} = \frac{300}{T_1} \Rightarrow T_1 = 400K$

And in 2nd case, $x_2 = 1 - \frac{T_2}{T_1}$

$\Rightarrow \frac{1}{2} = 1 - \frac{300}{T_1} \Rightarrow T_1 = 600K$

$\therefore$ increase of temperature $= T_1 - T_i = 200K$

14. A projectile is projected with speed 10 m/s for maximum range on incline plane of angle of inclination 30°. The maximum range of projectile is

- **(1) \frac{40}{3} m**
- **(2) \frac{10}{3} m**

- **(4)**
(3) \( \frac{20}{3} \) m  \hspace{1cm} (4) 5 m

Sol. Answer (3)

Maximum range of projectile on an incline

\[ 10 \text{ m/s} \]

\[ \alpha = \frac{\pi}{4} - \frac{\theta}{2} \]

\[ R_{\text{max}} = \frac{u^2}{g(1+\sin\theta)} \]

\[ = \frac{10^2}{10 \left(1 + \frac{1}{2}\right)} = \frac{10 \times 2}{3} = \frac{20}{3} \text{ m} \]

15. If a block is displaced from (1, 2) to (2, 3) on applying a force \( \vec{F} = 4x^2\hat{i} + 3y^2\hat{j} \), find the change in kinetic energy

\( \Delta \text{K.E.} = \text{Work done} \)

So, \( w = \int \vec{F}.d\vec{r} \)

\[ = \int 4x^2\,dx + 3y^2\,dy \]

\[ = \int_{1}^{2} 4x^2\,dx + \int_{2}^{3} 3y^2\,dy \]

\[ = \frac{4}{3}(x^3)_{1} - 3(\frac{y^3}{3})_{2} \]

\[ = \frac{4}{3}(8-1) + 1(27-8) \]

\[ W = \frac{28}{3} + 19 = 28.33 \text{ joule} \]

16. If \( B = 10^9 \) Nm\(^{-2}\) fractional charge in volume is 2\%. Find volumetric stress required

(1) 1\times10^7 \text{ Pa}

(2) 2\times10^7 \text{ Pa}

(3) 3\times10^7 \text{ Pa}

(4) 4\times10^7 \text{ Pa}

Sol. Answer (2)

Given, \( \frac{\Delta v}{v} = \frac{2}{100} \) and \( B = 10^9 \) Pa

We have, \( B = \frac{\text{stress}}{\text{strain}} \Rightarrow \text{stress} = B \times \text{strain} \)

\[ = 10^9 \times \frac{2}{100} = 2 \times 10^7 \text{ Pascal} \]

17. If at the centre of circular current carrying wire magnetic field is \( B_0 \), then magnetic field at distance \( \frac{r}{2} \) from the axis of coil from centre is

(1) \( \frac{2B_0}{\sqrt{5}} \)

(2) \( \frac{4B_0}{5\sqrt{2}} \)

(3) \( \frac{8B_0}{5\sqrt{5}} \)

(4) \( \frac{4B_0}{5\sqrt{5}} \)

Sol. Answer (3)

\[ B_{\text{centre}} = \frac{\mu_0}{2R}i \]

\[ B_{\text{axis}} = \frac{\mu_0}{4\pi} \left( \frac{2(\pi R^2)}{R^2 + (\frac{R}{2})^{3/2}} \right) \]

\[ = \frac{\mu_0}{2\pi} \left( \frac{i\pi R^2}{\left(\frac{5R^2}{4}\right)^{3/2}} \right) \]

\[ = \frac{\mu_0}{2R} \left( \frac{2R}{\sqrt{5}} \right) \]

\[ = \frac{\mu_0}{2R} \left( \frac{8}{\frac{5\sqrt{5}}{8}} \right) \]

18. In the given figure, if the temperature of interface is 80ºC, then value of \( K' \) is

\( \begin{array}{ccc}
100^\circ \text{C} & \text{K'} & 80^\circ \text{C} & \text{K} & 0^\circ \text{C}
\end{array} \)

\( \begin{array}{ccc}
\text{16 cm} & \text{8 cm}
\end{array} \)

(1) 16 \text{K}

(2) 4 \text{K}
19. A liquid drop having mass \( m \) is in equilibrium in air. Electric field \( E \) is present in vertically upward direction. Find charge on drop.

<table>
<thead>
<tr>
<th>Option</th>
<th>Charge Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>( mg/E )</td>
</tr>
<tr>
<td>(2)</td>
<td>( 2 mg/E )</td>
</tr>
<tr>
<td>(3)</td>
<td>( 2 mg/4E )</td>
</tr>
<tr>
<td>(4)</td>
<td>Zero</td>
</tr>
</tbody>
</table>

**Sol.** Answer (1)

For equilibrium

\[ qE = mg \]

\[ q = \frac{mg}{E} \]

20. Equation two waves are given by

\[ y = 5 \sin{(wt - kx)} \]

\[ y = 3 \sin{(wt - kx + 1.57)} \]

Find resultant amplitude

<table>
<thead>
<tr>
<th>Option</th>
<th>Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>8</td>
</tr>
<tr>
<td>(2)</td>
<td>2</td>
</tr>
<tr>
<td>(3)</td>
<td>4</td>
</tr>
<tr>
<td>(4)</td>
<td>( \sqrt{34} )</td>
</tr>
</tbody>
</table>

**Sol.** Answer (4)

\[ y_1 = 5 \sin{(wt - kx)} \]

\[ y_2 = 3 \sin{(wt - kx + 1.57)} = 3 \sin{(wt - kx + \frac{\pi}{2})} \]

Phase difference \( (\Delta \phi) \) = \( \frac{\pi}{2} \)

So, Area = \( \sqrt{A_1^2 + A_2^2 + 2A_1 A_2 \cos(\Delta \phi)} \)

21. If frequency of light is double of its threshold frequency its velocity is \( v_1 \) and if frequency is five time the threshold frequency its velocity is \( v_2 \), \( v_2 = xv_1 \). Find the value of \( x \)

<table>
<thead>
<tr>
<th>Option</th>
<th>Value of ( x )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>1</td>
</tr>
<tr>
<td>(2)</td>
<td>2</td>
</tr>
<tr>
<td>(3)</td>
<td>3</td>
</tr>
<tr>
<td>(4)</td>
<td>4</td>
</tr>
</tbody>
</table>

**Sol.** Answer (2)

Using photoelectric equation;

\[ hf - \phi = \frac{1}{2}mv_{\text{max}}^2 \]

(I) \( h(2\lambda) - h\lambda = \frac{1}{2}mv_1^2 \) .......(1)

(II) \( h(5\lambda) - h\lambda = \frac{1}{2}mv_2^2 \) .......(2)

Dividing (1)/(2)

\[ \frac{h\lambda}{4\lambda} = \frac{v_2^2}{v_1^2} \]

\[ \Rightarrow v_2 = 2v_1 \]

So, \( x = 2 \)

22. In a given AC circuit which has maximum voltage \( V \), and frequency 50 Hz . Find the time instant where the current in the circuit will be equal to its rms value

<table>
<thead>
<tr>
<th>Option</th>
<th>Time Instant</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>2 ms</td>
</tr>
<tr>
<td>(2)</td>
<td>2.5 ms</td>
</tr>
<tr>
<td>(3)</td>
<td>3 ms</td>
</tr>
<tr>
<td>(4)</td>
<td>3.5 ms</td>
</tr>
</tbody>
</table>

**Sol.** Answer (2)

Let \( I = I_0 \sin \omega t \)

\[ I = \frac{I_0}{\sqrt{2}} \]

\[ I_0 = I_0 \sin \omega t \]

\[ \sin \omega t = \frac{1}{\sqrt{2}} \]

\[ \omega t = \frac{\pi}{4} \]

\[ 100\pi t = \frac{\pi}{4} \]
23. Electric field strength = \( E \), Max charge = \( q \), find the \( K \)?

\[
\begin{align*}
(1) & \quad K = \frac{q}{\varepsilon_0 EA} \\
(2) & \quad K = \frac{qd}{\varepsilon_0 EA} \\
(3) & \quad K = \frac{qA}{\varepsilon_0 E} \\
(4) & \quad \text{None of these}
\end{align*}
\]

Sol. Answer (1)

\[
E = \frac{q}{KA\varepsilon_0} \\
K = \frac{q}{\varepsilon_0 EA}
\]

24. Find effective focal length

\[
\begin{align*}
\text{Sol. Answer (1)} & \\
& \quad f = 15 \text{ cm}, \mu = 1.5, \mu' = 3
\end{align*}
\]

25. A particle of mass 100g is in horizontal circular motion with the help of 2m string fixed at one end over a smooth table. Maximum tension possible in string is 80 N. If maximum revolution per minute for the particle is given by \( k / \pi \) then find the value of \( k \).

\[
\begin{align*}
& \quad f_e = -7.5 \text{ cm} \\
& \quad f_e = \frac{400}{20} \text{ rad/sec} = 20 \text{ rev/s} \\
& \quad \omega = \frac{20}{2\pi} \text{rev/s} \\
& \quad \omega = \frac{10}{\pi} \text{rev/s} \\
& \quad \omega = 600 \frac{\text{rad}}{\text{m}}
\end{align*}
\]

26. Statement 1: Magnetic field can’t change K.E. and speed of body.

Statement 2: Force due to magnetic field always acts perpendicular to the velocity.

\[
\begin{align*}
(1) & \quad \text{Statement 1 is true, Statement 2 is true, Statement 2 is a correct explanation for Statement 1.} \\
(2) & \quad \text{Statement 1 is true, Statement 2 is true, Statement 2 is not a correct explanation for Statement 1.} \\
(3) & \quad \text{Statement 1 is true, Statement 2 is false.} \\
(4) & \quad \text{Statement 1 is false, Statement 2 is true.}
\end{align*}
\]

Sol. Answer (1)
In magnetic field force is perpendicular to velocity
So, \( w = 0 \)
\[ \Delta K.E = 0 \]
Both statement 1 and 2 is correct and 2 is correct explanation for statement 1.

27. A nucleus of atomic number 220 decays into atomic number 105 and 115. If binding energy per nucleon of reactants is 5.6 MeV each and product is 6.4 MeV. Find out energy released in this reaction.

(1) 176 MeV  (2) 189 MeV  (3) 200 MeV  (4) 160 MeV

Sol. Answer (1)
\[ Q = 6.4 \times 105 + 6.4 \times 115 - 5.6 \times 220 = 176 \text{ MeV} \]

28. In a potentiometer, balance length for a cell of emf \( \varepsilon_1 \) is 75 cm. If the cell is replaced by another cell of emf \( \varepsilon_2 \) and \( \varepsilon_1 = \frac{3}{2} \varepsilon_2 \), then find the difference between initial length and final balance length.

(1) 15 cm  (2) 20 cm  (3) 25 cm  (4) 30 cm

Sol. Answer (3)

Given \( l_1 = 75 \text{ cm} \)

We have, \( \frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2} \)

\[ \Rightarrow \frac{3}{2} = \frac{75}{l_2} \Rightarrow l_2 = 50 \text{ cm} \]

\[ \therefore l_1 - l_2 = 25 \text{ cm} \]

29. In a medium electric field of any E.M. wave is \( 7 \times 10^{-3} \) V/m. If relative permittivity & relative permeability of medium is 4 & 9 respectively, find magnetic field in the medium :

(1) \( 1.4 \times 10^{-5} \)  (2) \( 1.4 \times 10^{-2} \)  (3) \( 1.4 \times 10^5 \)  (4) \( 1.4 \times 10^{-10} \)

Sol. Answer (4)
\[ \frac{c}{v} = \mu \]
\[ v = \frac{c}{\sqrt{\mu \varepsilon}} = \frac{c}{\sqrt{4 \times 9}} = \frac{c}{6} \]
\[ E_0 = v \Rightarrow B_0 = \frac{E_0}{v} \]
\[ B_0 = \frac{E_0}{c} \]
\[ B_0 = \frac{7 \times 10^{-3} \times 6}{3 \times 10^8} = 14 \times 10^{-11} \]
\[ B_0 = 1.4 \times 10^{-10} T \]

30. A particle of mass 200g moving in circular motion which is tied by a massless string of length 2m that can bear a maximum 80 N tension. What is the maximum possible speed with which particle can move on circular path.

(1) \( 10\sqrt{2} \text{ m/s} \)  (2) \( 20\sqrt{2} \text{ m/s} \)  (3) \( 20 \text{ m/s} \)  (4) \( 30\sqrt{2} \text{ m/s} \)

Sol. Answer (2)
\[ T = \frac{mv^2}{\ell} \]
\[ 80 \times 2 = \frac{1}{5} \times v^2 \]
\[ v = \sqrt{800} = 10\sqrt{8} = 20\sqrt{2} \]