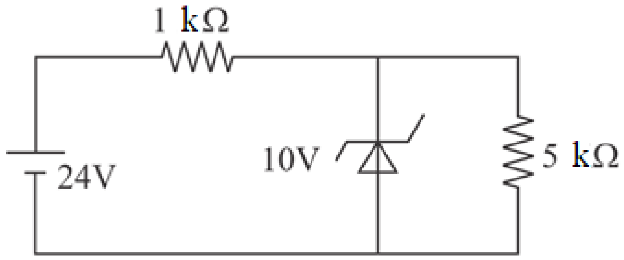
# JEE Main 2021 August 26, Shift 2 (Physics)

Q1. In the shown Zener diode, power consumed will be:




(A) 0.15 $W$

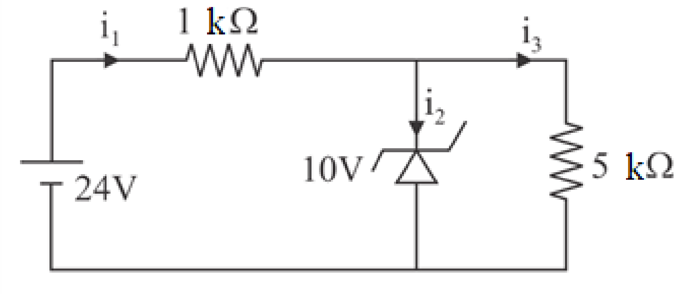
(B) 0.12 $W$

(C) 2 $W$

(D) 1 $W$

Correct option: (B)

Solution:




The Zener diode offers constant potential difference. So, potential difference across 5kΩ is 10V and across 1kΩ is 14V.

Current through $5k\Omega,\ i_3 = \frac{10}{5} = 2mA$

Current through $1k\Omega,\ i_1 = \frac{14}{1} = 14mA$

Current through Diode, $i_2 = i_1 - i_3 = 12mA$

Power consumed in Zener diode, $P = VI = 0.12W$

Q2. In a pendulum clock, the fractional error on the length of the string is 0.001. Calculate the error by the clock in a day.

(A) $15.6sec$

(B) $19.4sec$

(C) $43.2sec$

(D) $23.2 sec$

Correct option: (C)

Solution:

Time period of the simple pendulum is $T \propto \sqrt{l}$

Therefore, the fractional error in calculated time, $\frac{\Delta t}{t} = \frac{1}{2}\frac{\Delta l}{l}$

For one day, $\Delta t = \frac{1}{2} \times 0.001 \times (24 \times 3600)$

$$=> \ \Delta t = 43.2 sec$$

Q3. The initial temperatures of liquids $A, B$ and $C$are $10ºC, 20ºC$ and $30ºC$ respectively. When $A$ & $B$ are mixed, the temperature of the mixture is $16ºC$. When $B$ & $C$ are mixed, the temperature of mixture is $26ºC$. Find the temperature of the mixture, when $A$ & $C$ are mixed.

(A) $\frac{160}{13} ºC$

(B) $\frac{310}{13} ºC$

(C) $\frac{180}{13} ºC$

(D) $\frac{190}{13} ºC$

Correct option: (B)

Solution:

Let the heat capacities of liquids A, B and C are $H_1, H_2$ and $H_3$ respectively.

When $A$ & $B$ are mixed,

$$H_1(16 - 10) = H_2(20 - 16)$$

$$=> \ 6H_1 = 4H_2 \dots (1)$$

When $B$ & $C$ are mixed

$$H_2(26 - 20) = H_3(30 - 26)$$

$$=> \ 6H_2 = 4H_3 \dots (2)$$

From equation (1) and (2)

$$4H_3 = 9H_1$$

When $A$ & $C$ are mixed, let the temperature of the mixture be T,

$$H_1(T - 10) = H_3(30 - T)$$

$$T = \frac{30H_3 + 10H_1}{H_1 + H_3}$$

$$T = \frac{10(3H_3 + H_1)}{H_3 + H_1}$$

$$T = \frac{310}{13}\,ºC$$

Q4. If $\lambda$ is the wavelength for which energy is $E$. If $\lambda$ decreases to $75\%$ of initial value, then find the energy gain.

(A) $\frac{E}{3}$

(B) $\frac{E}{2}$

(C) $\frac{4E}{3}$

(D) $\frac{3E}{4}$

Correct option: (A)

Solution: $\lambda' = 75\%$ of $\lambda$

$= \left(\frac{75}{100} \times \lambda\right)$

$= \frac{3\lambda}{4}$

$E = \frac{hc}{\lambda}$

$\therefore E_1 = \frac{hc}{\lambda}$

$\therefore E_2 = \frac{hc}{\lambda'} = \frac{hc}{\left(\frac{3\lambda}{4}\right)} = \frac{4hc}{3\lambda}$

$\therefore E_2 = \frac{4E}{3}$

Therefore,

Energy gain = find energy – initial energy

$= \frac{4hc}{3\lambda} - \frac{hc}{\lambda}$

$= \frac{4E}{3} - E = \frac{E}{3}$



Q5. Angle between two vector $\vec{A}$ and $\vec{B}$ is 60º, then find angle between $\vec{A} - \vec{B}$ & $\vec{A}$

(A) $tan^{-1}\left(\frac{Asin\ 60^\circ}{B-Acos\ 60^\circ}\right)$

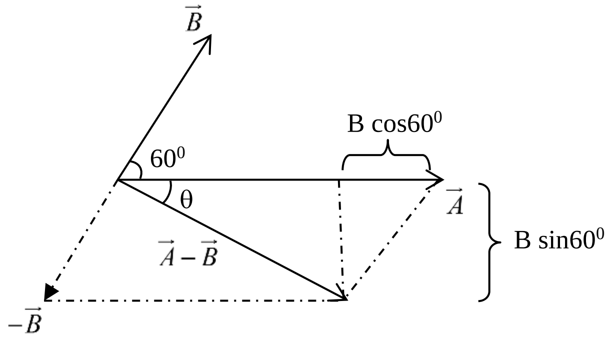
(B) $tan^{-1}\left(\frac{Bsin\ 60^\circ}{A+Bcos\ 60^\circ}\right)$

(C) $tan^{-1}\left(\frac{Bcos\ 60^\circ}{A-Bsin\ 60^\circ}\right)$

(D) $tan^{-1}\left(\frac{Bsin\ 60^\circ}{A-Bcos\ 60^\circ}\right)$

Correct option: (D)

Solution:




$$\therefore \tan\theta = \frac{B\sin60°}{A - B\cos60°}$$

$$\therefore \theta = \tan^{-1}\left(\frac{B\sin60°}{A - B\cos60°}\right)$$



Q6. A conical pendulum of length $l$ moving in a circle of radius $\frac{l}{\sqrt{2}}$ Find the velocity of Pendulum:

(A) $\frac{l}{\sqrt{2}}g$

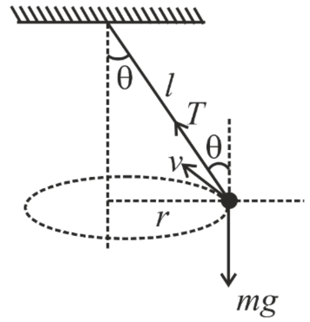
(B) $\sqrt{\frac{l}{2\sqrt{2}}g}$

(C) $\sqrt{\frac{l}{\sqrt{2}}g}$

(D) $\sqrt{\frac{l}{2}g}$

Correct option: (C)

Given,




$$r = \frac{l}{\sqrt{2}}$$

$\sin\theta = \frac{r}{l} = \frac{1}{\sqrt{2}}$

Therefore, $\theta = 45°$

$T\cos\theta = mg \quad \ldots.(1)$

$T\sin\theta = \frac{mv^2}{r} \quad \ldots.(2)$

From equation (1) and (2),

We can write

$\frac{T\sin\theta}{T\cos\theta} = \frac{\frac{mv^2}{r}}{mg} = \frac{v^2}{rg}$

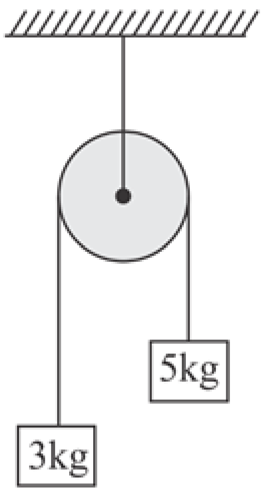
$\therefore \tan\theta = \frac{\frac{mv^2}{r}}{\frac{l}{\sqrt{2}}g}$

$\therefore \tan 45° = \frac{v^2\sqrt{2}}{lg}$

$\therefore lg = \sqrt{2}v^2$

$\therefore \text{v} = \sqrt{\frac{lg}{\sqrt{2}}}$

Q7. In an Atwood machine the maximum stress that a string can tolerate without break is $\frac{24}{\pi} \times 10^{-2}$. Find the radius of string:




(A) 12.5

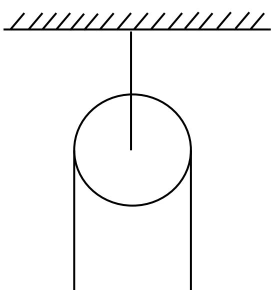
(B) 16.5

(C) 20.5

(D) 24.5

Correct option: (A)

Solution:



$m_1 = 5$ kg

$m_2 = 3$ kg

$$T = \frac{2m_1 m_2 g}{m_1 + m_2}$$

$$= \frac{2 \times 5 \times 3 \times 10}{5 + 3} = \frac{300}{8} = \frac{75}{2}$$

Stress developed in rope $= \frac{T}{A}$

$$\frac{24}{\pi} \times 10^2 = \frac{75/2}{2}$$

$$r^2 = \frac{75}{48} \times 100 = 156.25$$

$\therefore r = 12.5$

Q8. Electric field of an electromagnetic wave is $E = 200 sin\left(\omega\left(t - \frac{x}{c}\right)\right)\frac{v}{m}$. An electron is moving with speed $3 \times 10^7 m/s$. Find magnitude of magnetic force on electron.

(A) $2.2 \times 10^{-18}$ $Newton$

(B) $3.2 \times 10^{-18}$ $Newton$

(C) $1.2 \times 10^{-18}$ $Newton$

(D) $4.2 \times 10^{-18}$ $Newton$

Correct option: (B)

Solution:

General equation of wave.

$E = E_o \sin\left[w\left(t - \frac{x}{c}\right)\right]$

$\therefore E_o = 200$

Now velocity of light is given by

$$C = \frac{E_o}{B_o}$$

Or

$3 \times 10^8 = \frac{200}{B_o}$

$\therefore B_o = \frac{200}{3 \times 10^8}$

Force experienced by electron

$= qvB_o$

$= (1.6 \times 10^{-19}) \times (3 \times 10^7) \times \left(\frac{200}{3 \times 10^8}\right)$

$= 3.2 \times 10^{-18}$ N

Q9 Equation of SHM for two particles is $x_1 = 5sin\left(\omega t + \frac{\pi}{4}\right)$ and $x_2 = 5\sqrt{2}[sin2\pi t + cos2\pi t]$ Then how many times amplitude of second particle is greater than first.

Correct option: (2)

Solution:

Standard equation of SHM

$x = A\sin(\omega t + \phi)$

where, $A =$ amplitude

Now,

$x_1 = 5\sin\left(\omega t + \frac{\pi}{4}\right)$

$\therefore \quad A_1 = 5$

And $x_2 = 5\sqrt{2}[\sin 2\pi t + \cos 2\pi t]$

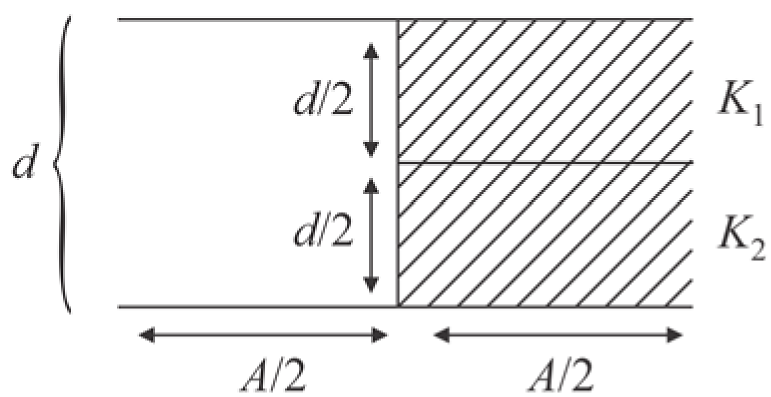
$= 5\sqrt{2} \times \sqrt{2}\ \left[(\sin 2\pi t) \times \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\cos(2\pi t)\right]$

$= 10\ \left[\sin\left(2\pi t + \frac{\pi}{4}\right)\right]$

$\therefore \quad A_2 = 10$

Clearly, $A_2 = 2A_1$

Q10. Find equivalent capacitance.



(A) $\frac{A\varepsilon_0}{d}\left(\frac{1}{3}+\frac{K_1K_2}{K_1+K_2}\right)$

(B) $\frac{A\varepsilon_0}{d}\left(\frac{1}{2}-\frac{K_1K_2}{K_1+K_2}\right)$

(C) $\frac{A\varepsilon_0}{d}\left(\frac{1}{2}+\frac{K_1K_2}{K_1+K_2}\right)$

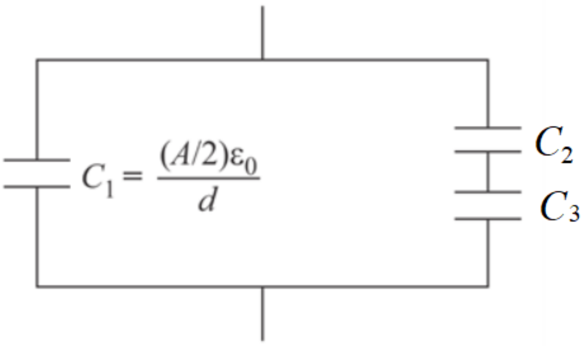
(D) $\frac{A\varepsilon_0}{d}\left(\frac{1}{2}+\frac{2K_1K_2}{K_1+K_2}\right)$

Correct option: (C)

Solution:

The given configuration can be treated as series and parallel combination of the capacitors.

Capacitance, $C \quad = \frac{KA\varepsilon_0}{d}$

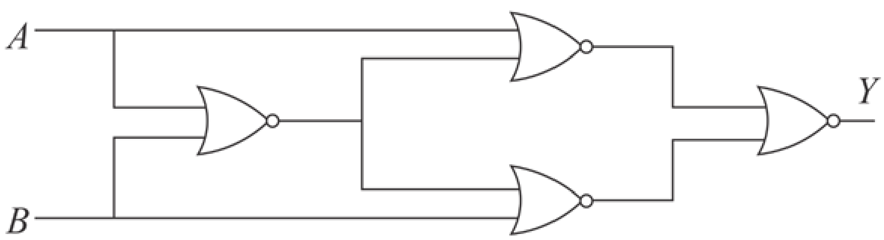



$$C_{eq} = C_1 + \frac{C_2C_3}{C_2+C_3}$$

$$C_{eq} = \frac{A\varepsilon_0}{2d} + \frac{\frac{K_1A\varepsilon_0}{d}\times\frac{K_2A\varepsilon_0}{d}}{\frac{K_1A\varepsilon_0}{d}+\frac{K_2A\varepsilon_0}{d}}$$

$$C_{eq} = \frac{A\varepsilon_0}{2d} + \frac{A\varepsilon_0}{d}\left(\frac{K_1K_2}{K_1+K_2}\right) = \frac{A\varepsilon_0}{d}\left(\frac{1}{2}+\frac{K_1K_2}{K_1+K_2}\right)$$

Q11. Find truth table for given logic gates




(A)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 1 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 1 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |

(B)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 1 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |

(C)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 1 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |

(D)

Correct option: (B)



$y=\overline{\overline{A+(\overline{A+B})}+\overline{B+(\overline{A+B})}}$

$=\left(A+(\overline{A+B})\right)\cdot(B+\overline{A+B})$

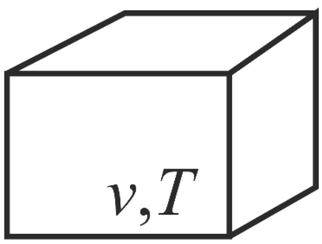
| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 1 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |

Q12. A container has 1 mole of gas 'A' and 2 mole of gas 'B' confined in a space of volume 1 $m^3$ at $127°C$ temperature. Find the pressure exerted on the wall of container in $kPa$.

Correct Answer: $(10)$

Solution:

Ideal gas equation



$PV = nRT$

Net pressure $= P_A + P_B$

$P_A$ = pressure due to gas $A$

$P_B$ = pressure due to gas $B$

$V = 1\text{m}^3, T = 127\ °\text{C} = 127 + 273$

$= 400\ \text{K}$

$P_A V = n_A RT$

$\therefore P_A = \frac{n_A RT}{V} = \frac{1 \times R \times 400}{1}$

$= 8.314 \times 400$

$= 3325.6\ Pa$

$P_B V = n_B RT$

$P_B = \frac{n_B RT}{V} = \frac{2 \times 8.314 \times 400}{1}$

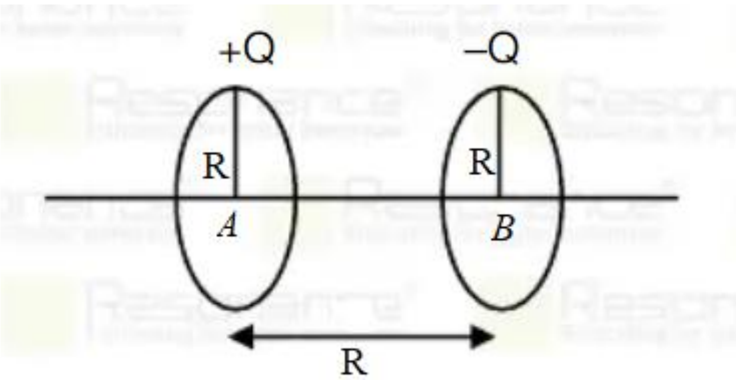
$= 6651.2\ \text{Pa}$

$\therefore P = P_A + P_B = 9976.8$

$Pa = 9.976\ \text{kPa}$

$= 10\ \text{kPa}$

Q13. Two identical circular rings of radius R are placed at R distance apart as shown with charges +Q and -Q. Calculate potential difference between their centres.




(A) $\frac{\sqrt{3}kQ}{a}$

(B) $\frac{kQ}{a}(2 - \sqrt{2})$

(C) $\frac{\sqrt{2}kQ}{a}$

(D) $\frac{2kQ}{a}$

Correct option: (B)

Solution: Potential at A due to both rings, $V_A=\frac{kQ}{R}-\frac{kQ}{\sqrt{2}R}$

Potential at B due to both rings,$V_B=\frac{kQ}{\sqrt{2}R}-\frac{kQ}{R}$

$$V_A-V_B=\frac{kQ}{R}(2-\sqrt{2})$$

Q14. Height of transmission and receiver tower are $80m$ and $50m$ respectively. If radius of earth is $6400km$. Then find the range of LOS communication.

(A) $60km$

(B) $116km$

(C) $200km$

(D) $245km$

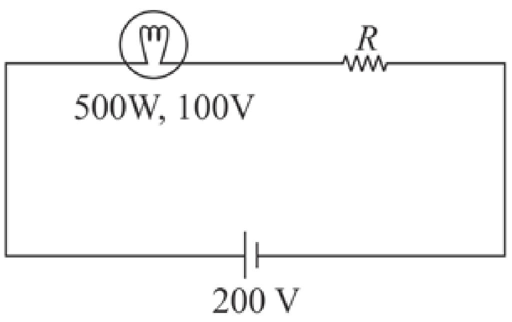
Correct option: $(A)$

Solution: Range of transmission $=\sqrt{2Rh_1}+\sqrt{2Rh_2}=\sqrt{2\times 6400\times 0.08}+\sqrt{2\times 6400\times 0.05}$

Putting values range $=60km$



Q15. In given circuit, find the value for resistance ' R ' So that bulb operate at the rated power of 500 $Watt$.




(A) $20\Omega$

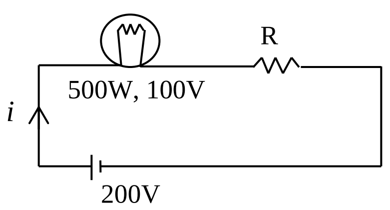
(B) $30\Omega$

(C) $40\Omega$

(D) $50\Omega$

Correct option: (A)

Solution:



For given rated power of bulb,

$$P_b = \frac{V^2}{P_b}$$

$$\therefore\ R_b = \frac{V^2}{P_b} = \frac{(100)^2}{500} = 20\ \Omega$$

Current through bulb for rated power,

$$i = \frac{P_b}{V} = \frac{500}{100} = 5\ \text{A}$$

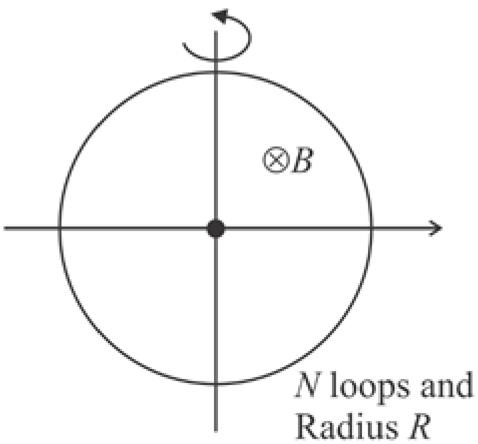
∴ potential different across

Bulb = $100\ \text{V}$

Then, $100 = i \times R$

$$\therefore\ R = \frac{100}{5} = 20\ \Omega$$

Q16. A circular coil is rotating in uniform magnetic field shown in figure. Find the maximum induced emf?




(A) $2B\omega N(\pi R^2)$

(B) $B\omega(\pi R^2)$

(C) $B\omega N(\pi R^2)$

(D) $\sqrt{2}B\omega N(\pi R^2)$

Correct option: (3)

Solution:

$\varepsilon = NAB\ \omega \sin \omega t$

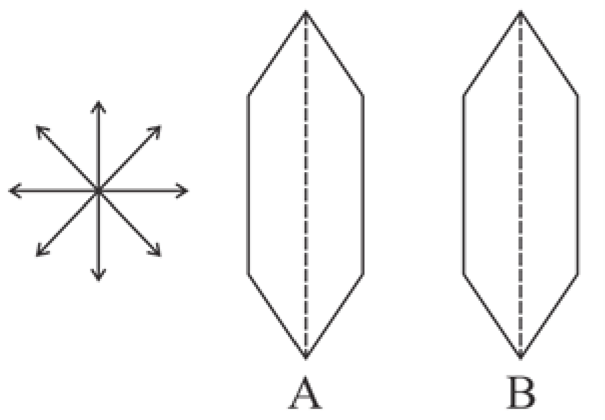
$= [N(\pi R^2)\ B]\ \omega \sin cot$

Hence, max value of emf

$= [N(\pi R^2)\ B]\ \omega$

$= B\omega N(\pi R^2)$

Q17. Unpolarized light passes through polarizer $A$ and $B$, intensity of unpolarized light is $I$, then find out angle of rotation of polarizer $B$, so final intensity becomes $3I/8$.




(A) 30°

(B) 40°

(C) 50°

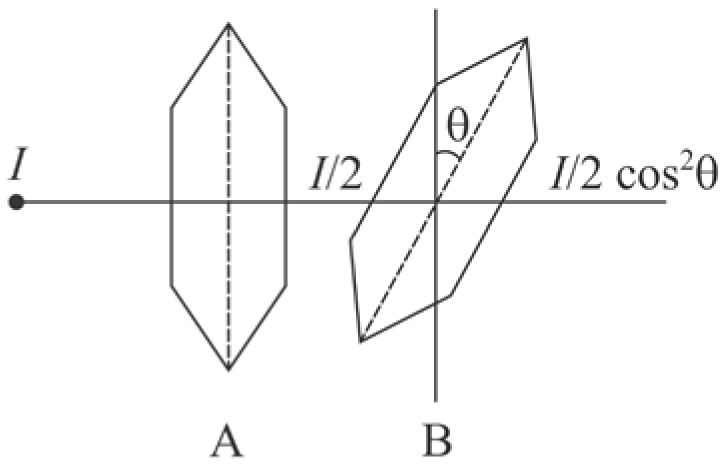
(D) 60°

Correct option: (A)

Solution:

When unpolarized light passes through a polarizer, its intensity becomes half and the light becomes polarized with a plane of polarization as along the axis of polarizer.

So, after passing through polarizer A, intensity will be $\frac{I}{2}$.




From Malus law,
Intensity after passing through polarizer B will be,

$$I' = \frac{I}{2}cos^2\theta = \frac{3I}{8}$$

On solving, $\theta = 30°$

Q18. A Carnot engine working between $-10°C$ and $25°C$ temperature limit. It produces a power of $35W$ then what is the heat input rate in the engine.

(A) $190J$

(B) $290J$

(C) $298J$

(D) $250J$

Correct option: (C)

Efficiency of car not engine is given by

$\eta = 1 - \frac{T_L}{T_H}$

$T_L$ = temperature of sink

$= (-10°\text{C})$

$= (-10 + 273)\text{K} = 263\text{ K}$

$T_H$ = temperature of source

$= 25°\text{C}$

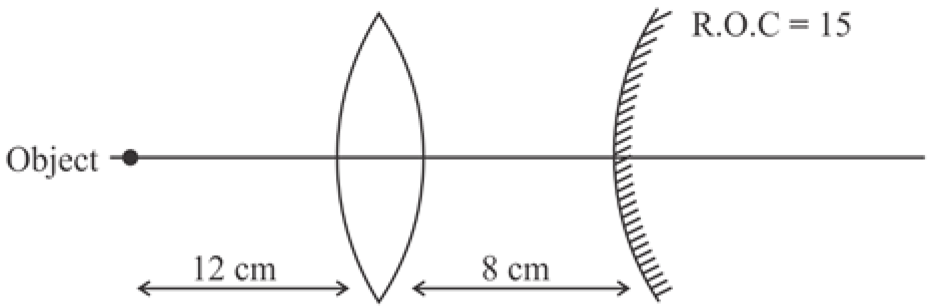
$= 25 + 273 = 298\text{ K}$

$\therefore\ \eta = 1 - \frac{263}{298} = \frac{35}{298}$

$\therefore Q_{\text{input}} = \frac{Q_{\text{ouput}}}{\eta} = \left(\frac{298}{35} \times 35\right)$

$= 298\text{ J}$

Q19. A convex lens is placed in front of a concave mirror as shown. The radius of curvature of the mirror is 15 cm. If location of image of the object is same as location of object, then calculate separation between object and new image when mirror is removed.



(A) 10

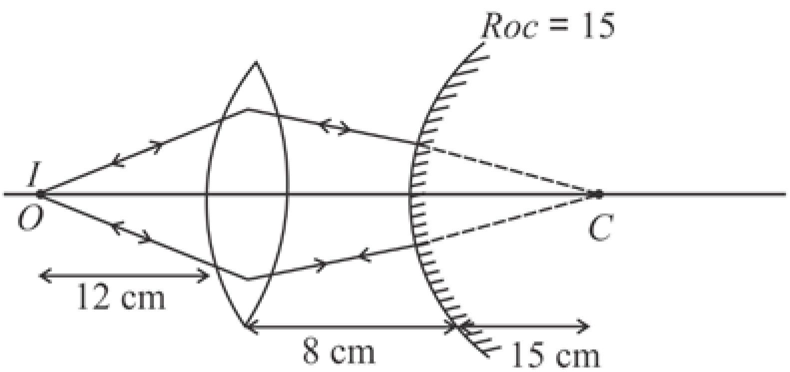
(B) 15

(C) 25

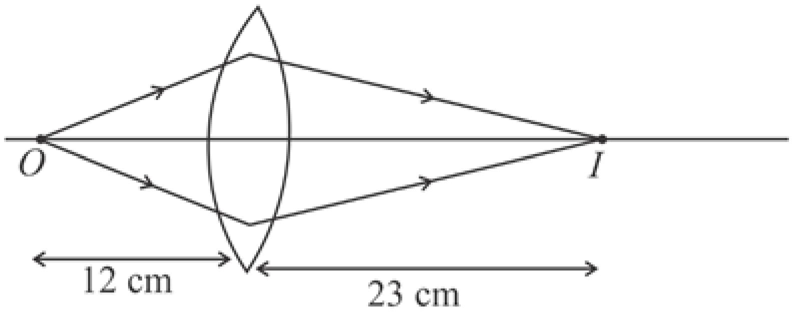
(D) 35

Correct option: (D)

Solution:



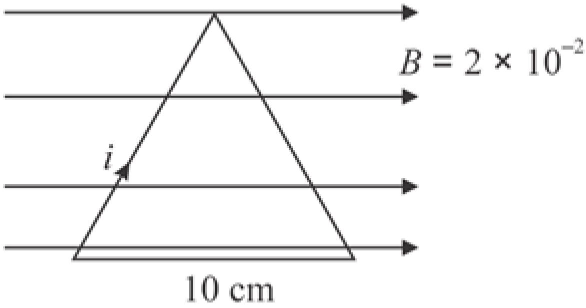

In case-1, the rays will retrace the path.



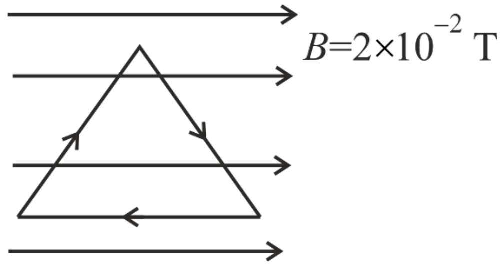



In case-2, the final Image coincide with the centre of curvature of the mirror. The distance between object and final image= $12 + 23 = 35\ cm$

Q20. An equilateral triangular coil placed in a uniform magnetic field $B = 2 \times 10^{-2} T$ exist in horizontal direction. A current of $0.2 A$ is flowing in the coil. If torque acting on coil is equal to $y \times 10^{-5} N \cdot m$ then find $y =$?




Solution:




$\left|\vec{M}\right| = I\left|\vec{A}\right|$

$= 0.2 \times \left[\frac{\sqrt{3}}{4}a^2\right]$

$= 0.2 \times \frac{\sqrt{3}}{4}(0.1)^2 = \frac{\sqrt{3}}{2} \times 10^3$

$\left|\vec{y}\right| = \left|\vec{M} \times \vec{B}\right|$

$= \left|\vec{M}\right|\left|\vec{B}\right| \sin 90$

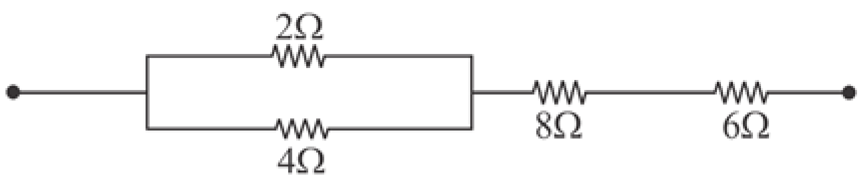
$= \left(\frac{\sqrt{3}}{2} \times 10^{-3}\right)(2 \times 10^{-3})$

$= \sqrt{3} \times 10^{-5} = 1.732 \times 10^{-5}$

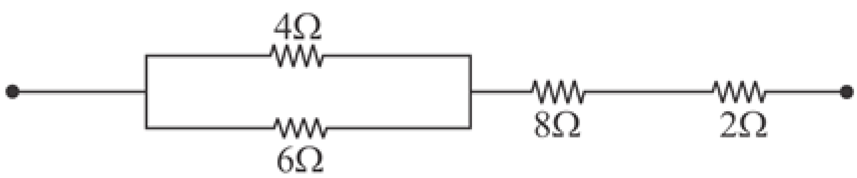
$\therefore y = 1.732$



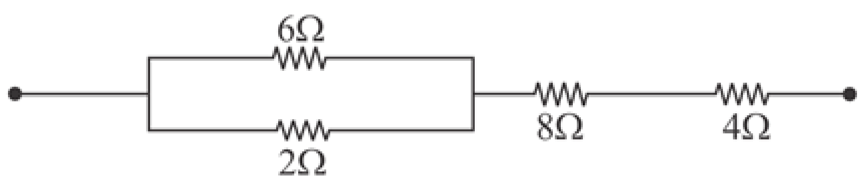
Q21. Four resistances $2\Omega, 6\Omega, 4\Omega, 8\Omega$ are arranged to find equivalent resistance of $\frac{46}{3}\Omega$. Then which arrangement is correct.



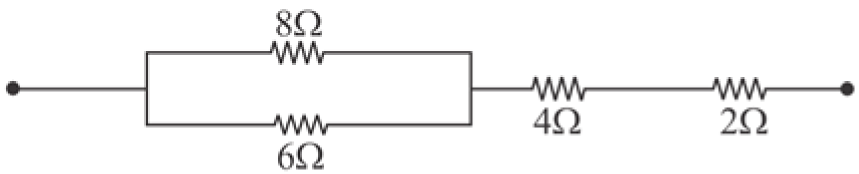

(A)




(B)




(C)




(D)

Correct option: (A)

**Solution:**

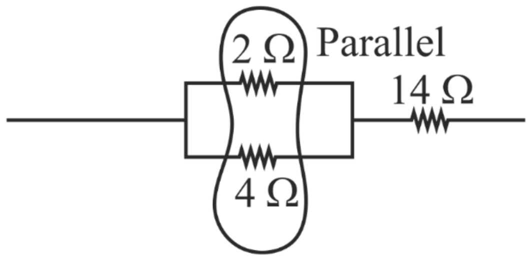
For parallel combination

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

For series combination

$$R_{eq} = R_1 + R_2$$

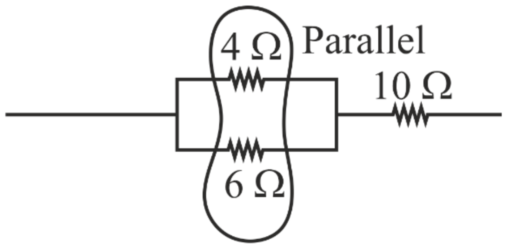
A)




$$R_{\text{parallel}} = \frac{2 \times 4}{4 + 2} = \frac{8}{6} = \frac{4}{3}$$

$$\therefore R_{eq} = \frac{4}{3} + 14 = \frac{46}{3}\ \Omega$$

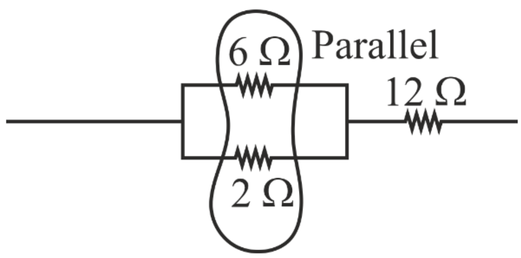
B)




$$R_{\text{parallel}} = \frac{4 \times 6}{4 + 6} = \frac{24}{10} = 2.4$$

$$R_{eq} = 2.4 + 10 = 12.4\ \Omega$$

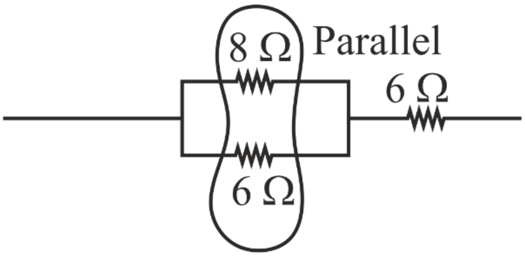
$C$)




$$R_{\text{parallel}} = \frac{6 \times 2}{6 + 2} = \frac{12}{8} = \frac{4}{3}$$

$$R_{\text{eq}} = \frac{4}{3} + 12 = \frac{40}{3}$$

D)




$$R_{\text{parallel}} = \frac{8 \times 6}{8+6} = \frac{48}{14} = \frac{24}{7}$$

$$R_{\text{eq}} = \frac{24}{7} + 6 = \frac{66}{7}\ \ \Omega$$

Q22. A fighter jet plane is flying horizontally drops a bomb, find the nature of the path of the bomb as seen by the pilot?

(A) hyperbola

(B) straight line

(C) parabola

(D) None of these

Correct option: (B)

Solution: Initially the bomb and fighter plane both are moving horizontally. After the bomb detaches from the plane, its horizontal velocity will be the same as the plane. Due to gravity, the bomb falls vertically downward also.

Since they have identical horizontal velocities, hence the bomb will appear below the plane as seen from the plane.

Q23. For a simple pendulum if percentage error in gravitational acceleration is 1% and percentage error in time period T is 1 % then find maximum percentage error in energy.

Correct answer: 2

Solution:

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

$$\therefore\ \ \ell = \frac{gT^2}{4\pi^2}$$

Hence, relation in terms of fractional change will be (for small change)

$$\frac{\Delta\ell}{\ell} = \frac{\Delta g}{g} + 2\left(\frac{\Delta T}{T}\right)$$

$\therefore$ % change in $\ell$

$$= \big(1 + 2(1)\big) = 3\%$$

Expression of energy is given by

$= \frac{1}{2} m\omega^2 A^2 = \frac{1}{2} m \left(\frac{g}{l}\right) A^2$

$= \frac{mA^2}{2}\left(\frac{g}{l}\right)$

$= \frac{mA^2}{2} g l^{-1}$

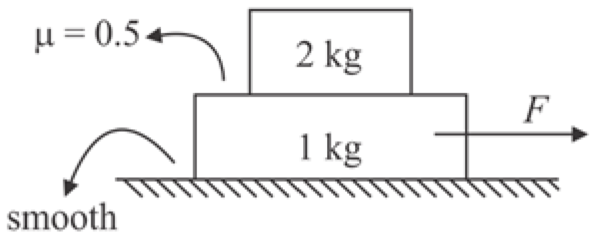
∴ Fractional change in energy

$= \frac{\Delta g}{g} + \frac{\Delta \ell}{\ell}$

∴ % percentage change in energy

$= (1+3)\% = 4\%$

Q24. Two blocks of mass 2 $kg$ & 1 $kg$ are resting on a smooth surface as shown in figure. There is friction between 2 $kg$ & 1 $kg$ block with coefficient of friction $\mu = 0.5$. Find maximum force to be applied on 1 $kg$ for the two blocks to move together.




(A) 5 $N$

(B) 10 $N$

(C) 15 $N$

(D) 20 $N$

Correct option: (C)

Solution: For maximum force on lower block $F_{max}$, the friction between them will be limiting friction which causes acceleration in the upper block. with relative rest, $f_s$ between $2kg$ & $1kg$ must be maximum.

$$f_{s\,max} = \mu N = 0.5 \times 2 \times 10 = 10\ N$$


Maximum possible common acceleration of blocks, $a_{max} = \frac{f_{s\,max}}{2} = 5\ \mathrm{m}/s^2$

Since blocks are moving together, for maximum force,

$$F_{max} = ma = 3 \times 5 = 15\ N$$

Q25. A Solid sphere of radius R and charge Q, what is the ratio of electric potential at a point inside and outside the sphere with distance $R/2$ from surface:

(A) 33 / 16

(B) 35 / 16

(C) 37 / 16

(D) 40/16

Correct option: (A)

Electric potential at any point inside a solid sphere

$= \frac{KQ}{2R}\left[3 - \frac{r^2}{R^2}\right]$

In equation,

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

$\therefore \quad V_1 = \frac{KQ}{2R}\left[3 - \frac{(R/2)^2}{R^2}\right]$

$= \frac{KQ}{2R}\left[3 - \frac{1}{4}\right]$

$= \frac{11\,KQ}{8R}$

Electric potential at any point outside the solid sphere

$= \frac{KQ}{r}$

In question, $r = 3R/2$

$\therefore \quad V_2 = \frac{KQ}{\left(\frac{3R}{2}\right)} = \frac{2KQ}{3R}$

$\therefore \ \frac{V_1}{V_2} = \frac{33}{16}$

Q26. Equation of two travelling waves is given as:

$$Y_1 = A_1 sin[k(x - vt)]$$

$$Y_2 = A_2 sin[k(x - vt + x_0)]$$

Given $A_1 = 12,\ A_2 = 7, k = 6.28,\ x_0 = 3.5$

Calculate the resultant amplitude after superposition of the given waves.

(A) 10

(B) 5

(C) 8

(D) 12

Correct option: (B)

Solution:

The phase difference between the waves is $\Delta\phi = kx_0 = 2\pi \times 3.5 = 7\pi$

Resultant amplitude, $A_R = \sqrt{12^2 + 7^2 + 2 \times 12 \times 7 \times cos\,(7\pi)} = \sqrt{25} = 5$