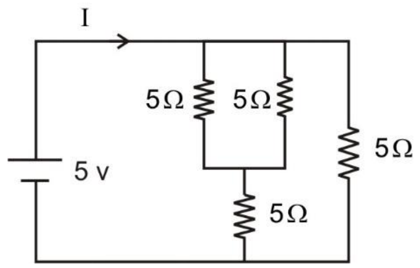
JEE Paper -2022

PHYSICS

1. In the following circuit the current through the cell is



(1) $\frac{3}{4}A$ (2) $\frac{5}{3}A$

(3) $\frac{5}{4}A$ (4) $\frac{4}{5}A$

Sol. Answer (2)

$$R_{eq} = \frac{5\times 7.5}{5+7.5} = \frac{5\times 7.5}{12.5}$$

$R_{eq} = 3\Omega$

$$I = \frac{V}{R_{eq}} = \frac{5}{3}A$$

2. Electric field due to a charged sheet at a distance of l and 4l at points A and B is (surface change density of sheet is σ).

(1) $E_A = \frac{\sigma}{\varepsilon_0}, E_B = \frac{\sigma}{2\varepsilon_0}$

(2) $E_A = E_B = \frac{\sigma}{2\varepsilon_0}$

(3) $E_A = E_B = \frac{\sigma}{\varepsilon_0}$

(4) $E_A = \frac{2\sigma}{\varepsilon_0}, E_B = \frac{\sigma}{\varepsilon_0}$

Sol. Answer (2)

Electric field due to thin non conducting sheet is independent of distance from the sheet.

Considering as very large thin sheet

$$E_A = \frac{\sigma}{2\varepsilon_0}$$

Also, $E_B = \frac{\sigma}{2\varepsilon_0}$

3. If $\hat{A}$ and $\hat{B}$ are unit vectors and θ is angle between them, then choose the correct option

(1) $|\hat{A}-\hat{B}| = |\hat{A}+\hat{B}|\tan\theta/2$

(2) $|\hat{A}+\hat{B}| = |\hat{A}-\hat{B}|\tan\theta/2$

(3) $|\hat{A}-\hat{B}| = |\hat{A}+\hat{B}|\cos\theta/2$

(4) $|\hat{A}+\hat{B}| = |\hat{A}-\hat{B}|\cos\theta/2$

Sol. Answer (1)

$$|\hat{A}+\hat{B}| = \sqrt{1^2+1^2+2\,\text{Cos}\theta}$$

$$= \sqrt{2(1+\text{Cos}\theta)} = \sqrt{2(2\text{Cos}^2\theta/2)} \text{ .....(i)}$$

$$|\hat{A}+\hat{B}| = 2\cos\theta/2$$

$$|\hat{A}-\hat{B}| = \sqrt{1^2+1^2-2\,\text{Cos}\theta}$$

$$\sqrt{2(1-\text{Cos}\theta)} = 2\text{Sin}\theta/2 \text{ ......(ii)}$$

$$\frac{|\hat{A}-\hat{B}|}{|\hat{A}+\hat{B}|} = \frac{\text{Sin}\theta/2}{\text{Cos}\theta/2} = \tan\theta/2$$

$$|\hat{A}-\hat{B}| = |\hat{A}+\hat{B}|\tan(\theta/2)$$

4. Find the ratio of speed for an electron in the third orbit of He^+ and third orbit of hydrogen atom

(1) 1:1 (2) 1:2

(3) 2:1 (4) 4:1

Sol. Answer (3)

Velocity of electron to atomic no. Z and orbit n is,

$$\upsilon = \frac{e^2}{2\varepsilon_0 h}\cdot\frac{z}{n}$$

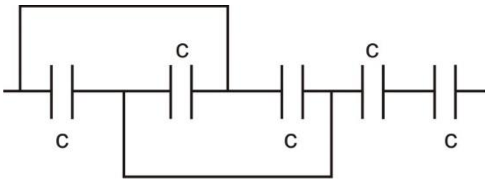
So, $\upsilon = \alpha \frac{z}{n}$

For He^{+} third orbit ; $\upsilon_1 = k \cdot \frac{(2)}{3}$

For H, third orbit ; $\upsilon_2 = k \cdot \frac{(1)}{3}$

$\frac{\upsilon_1}{\upsilon_2} = \frac{2}{1}$

5. Find the equivalent capacitance between A and B. (C = 8μf)



(1) $\frac{21}{8}\mu F$ (2) $\frac{27}{4}\mu F$

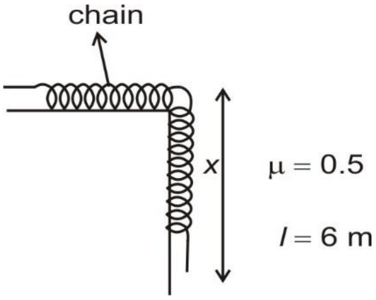
(3) $\frac{24}{7}\mu F$ (4) $\frac{29}{7}\mu F$

Sol. Answer (3)

$$C_{eq} = \frac{3C \times \frac{c}{2}}{3C + \frac{c}{2}} = \frac{3c}{7}$$

$$C_{eq} = \frac{3 \times 8}{7} = \frac{24}{7}\ \mu F$$

6. In the following figure x length is hanging from the table. For what maximum value of x the chain will not slip



(1) 3 m (2) 4 m

(3) 2 m (4) 1 m

Sol. Answer (3)

Let x is the hanging length, so for the chain not to slip the weight if hanging part must be balanced with force on the part of chain on the table

So we have $\lambda x g = \mu \lambda (L - x) g$

$$x = (0.5)(6 - x)$$

$$1.5x = 3$$

So, x = 2m

7. If on the surface of earth the gravitational acceleration is g_0, then the value of gravitational acceleration at height of 2R is (R is the radius of earth)

(1) $\frac{g_\circ}{4}$ (2) $\frac{g_\circ}{2}$

(3) $\frac{g_\circ}{3}$ (4) $\frac{g_\circ}{9}$

Sol. Answer (4)

Acc. Due to gravity at height h

$$g = \frac{GM}{(R+h)^2}$$

$$g = \frac{GM}{(R+2R)^2} = \frac{GM}{9R^2}$$

At surface-: $g_\circ = \frac{GM}{R^2}$

$$\Rightarrow g = \frac{g_0}{9}$$

8. A particle starts moving in the influence at force $\vec{F} = (10\hat{i} + 5\hat{j})\text{N}$, if mass of particle is 0.1 kg then its displacement $(\vec{S})$ in t = 2 Sec $\vec{S} = a\hat{i} + b\hat{j}$ then the value of $\frac{a}{b}$ is

(1) 1 (2) 2

(3) 3 (4) 4

Sol. Answer (2)

$$\vec{F} = 10\hat{i} + 5\hat{j}$$

$$\therefore \vec{a} = \frac{10\hat{i} + 5\hat{j}}{0.1} = 100\hat{i} + 50\hat{j}$$

$$\therefore \vec{S} = \vec{u}t + \frac{1}{2}\vec{a}t^2$$

$$= 0 + \frac{1}{2} \times (100\hat{i} + 50\hat{j}) \times 4$$

$$= 200\hat{i} + 100\hat{j}$$

$$\therefore a = 200; b = 100$$

$$\therefore \frac{a}{b} = \frac{200}{100} = 2$$

9. For O_2 ratio of rms speed of molecule and most probable speed of molecule is

(1) $\frac{\sqrt{3}}{2}$ (2) $\frac{\sqrt{2}}{3}$

(3) $\sqrt{\frac{3}{2}}$ (4) $\sqrt{\frac{2}{3}}$

Sol. Answer (3)

RMS speed (V_{rms})= $\sqrt{\frac{3RT}{M}}$

Most probable speed (V_{mp}) = $\sqrt{\frac{2RT}{M}}$

For O_2 molecule

$$\frac{V_{rms}}{V_{mp}} = \frac{\sqrt{\frac{3RT}{M}}}{\sqrt{\frac{2RT}{M}}} = \sqrt{\frac{3}{2}}$$

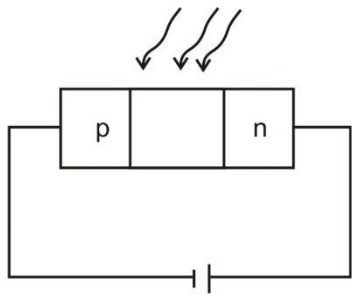
10. 5 MHz frequency is transmitted by
    (1) Coaxial
    (2) Optical fibres
    (3) Twisted copper wire
    (4) None of these

Sol. Answer (3)

5 MHz frequency can be transmitted through twisted copper wire.

11. Photodiode is reverse biased for which of the following reasons?
    (1) To increase the sensitivity
    (2) To increase the current flow
    (3) To decrease depletion width
    (4) To decrease the potential barrier

Sol. Answer (1)



Photodiode is reverse biased to facilitate collection of photons(defection) through large depletion region. Current sensitivity is increased in reverse biased photodiodes.

12. $\frac{A^2B^3}{C^4} = D$

Find the maximum percentage error in D

(1) $\left(\frac{2\Delta A}{A} + \frac{3\Delta B}{B} + \frac{4\Delta C}{C}\right)\times 100$

(2) $\frac{2\Delta A}{A} - \frac{3\Delta B}{B} + \frac{4\Delta C}{C}$

(3) $\frac{2\Delta A}{A} + \frac{3\Delta B}{B} - \frac{4\Delta C}{C}$

(4) $\frac{\Delta A}{A} + \frac{\Delta B}{B} + \frac{\Delta C}{C}$

Sol. Answer (1)

According to the given relation,

$$\Delta = \frac{A^2B^3}{C^4}$$

$$\Rightarrow \frac{\Delta D}{D} = 2.\frac{\Delta A}{A} + 3.\frac{\Delta B}{B} + 4\frac{\Delta C}{C}$$

$\Rightarrow$ Maximum percentage error in D is

$$\Rightarrow \frac{\Delta D}{D}\times 100 = \left[2\frac{\Delta A}{A} + 3\frac{\Delta B}{B} + 4\frac{\Delta C}{C}\right]\times 100$$

13. Choose the correct option matching entries of Column-1 and Column-2

	Column-1		Column-2
(i)	AC-Generator	(a)	Detects current
(ii)	Transformer	(b)	Changes AC Voltage
(iii)	Metal detector	(c)	Identify the resonance in circuit
(iv)	Galvanometer	(d)	Converts mechanical energy into electrical energy

(1) (i)a, (ii)c, (iii)d, (iv)b

(2) (i)d, (ii)(b), (iii)(c), (iv)(a)

(3) (i)d, (ii)b, (iii)a, (iv)c

(4) (i)a, (ii)c, (iii)b, (iv)d

Sol. Answer (3)

(i)	AC generator	Converts mechanical energy into electrical
(ii)	Transformer	Changes AC voltage
(iii)	Metal detector	To identify resonance in circuit
(iv)	Galvanometer	To detect current

(i)d, (ii)(b), (iii)(c), (iv)(a)

14. Terminal velocity of rain drop of radius r depends on.

(1) $r^{1/2}$ (2) $r^{3/2}$

(3) r^2 (4) r

Sol. Answer (3)

$\because$ Terminal velocity $= V_T = \dfrac{2r^2 g(\rho - \sigma)}{9\eta}$

$\Rightarrow V_T \propto r^2$

15. If $I_1 = 9I, I_2 = I$ at point *P,* phase difference is $\frac{\pi}{2}$ and at point *Q,* phase difference is π. Find the difference between the intensity of waves at *P* and *Q*.

(1) 9I (2) 6I

(3) 8I (4) 10I

Sol. Answer (3)

Given :

$I_1 = 9I$

$I_2 = I$

At *P* phase difference $(\phi) = \dfrac{\pi}{2}$

At *Q* phase defence $(\phi) = \pi$

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$I_p = 9I + I = 2\sqrt{9I^2}\cos\dfrac{\pi}{2} = 10I$

$I_Q = 9I + I + 2\sqrt{9I^2}\cos\pi$

$= 10I - 6I = 4I$

$\Rightarrow I_P - I_Q = 10I - 4I = 6I$

16. Dielectric constant of material is 4 and relative permeability is 1, then find critical angle for the refraction with the air.

(1) 10° (2) 20°

(3) 30° (4) 16°

Sol. Answer (3)

$\mu = \sqrt{\varepsilon_r \mu_r} = 2$

$c = \sin^{-1}\left(\dfrac{1}{2}\right) = 30^\circ$

Given, $\varepsilon_r = 4, \mu_r = 1$

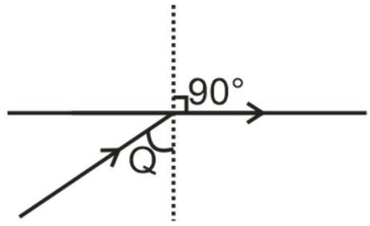
Speed of light in medium is

$\vartheta = \dfrac{1}{\sqrt{\varepsilon_0 \varepsilon_r \times \mu_0 \mu_r}}$ $\left\{\dfrac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3\times 10^8 \text{ m/s}\right\}$

$= \dfrac{1}{\sqrt{\varepsilon_0 \mu_0}\sqrt{\varepsilon_r \mu_r}}$

$= \dfrac{3\times 10^8}{\sqrt{4\times 1}} = 1.5\times 10^8$ m/s

Refractive index of medium $(n) = \dfrac{c}{v} = \dfrac{3\times 10^8}{1.5\times 10^8} = 2$



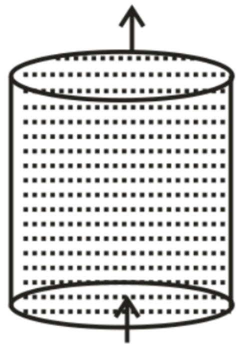
Using shell's law,

$2\sin\theta_c = 1\sin 90^\circ$

$\Rightarrow \sin\theta_c = \dfrac{1}{2}$

So, $\theta_c = 30^\circ$

17. Current flows through a cross-section of radius *R* as shown:



The value of this current is *I*. For radial distance r < R, magnetic field depends on r as :

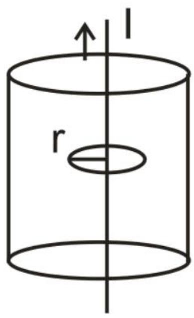
(1) B α r^1

(2) B α r^2

(3) B α $\dfrac{1}{r}$

(4) B α r^0

Sol. Answer (1)



Curren density $\rightarrow J = \dfrac{I}{\pi R^2}$

Far r < R

$I_{enclosed}$ = J.A

$$= \frac{I}{\pi R^2} \times \pi r^2$$

$$= \frac{Ir^2}{R^2}$$

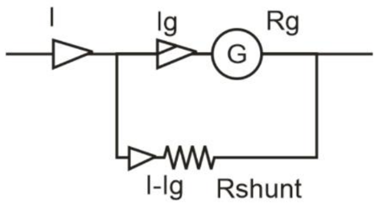
Acc. To ampere's circuital law

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I_{enc}$$

$$B(2\pi r) = \mu_0 \frac{Ir^2}{R^2}$$

$$B = \frac{\mu_0 Ir}{2\pi R^2} \Rightarrow B \propto r$$

18. A teacher uses 3 times the reading of shunted galvanometer for an experiment



(1) Shunt resistance is double the resistance of galvanometer

(2) Shunt resistance is half of the resistance of galvanometer

(3) Shunt resistance has the value equal to that of galvometer

(4) None of these

Sol. Answer (2)

'I' is 3 times reading of shunted galvanometer

So, $I = 3I_g$

Now $I_g \cdot R_g = (I - I_g)\, R_{shunt}$

$I_g R_g = (3I_g - I_g)\, R_{shunt}$

$$R_{shunt} = \frac{R_g}{2}$$

19. The difference of speed of light in the medium *A* and *B* ($V_A - V_B$) is 2.6 x 10^7 m/s. If the refractive index of medium *B* is 1.47, then the ratio of refractive index of medium A is -

(1) 1.303 (2) 1.4

(3) 1.5 (4) 1.12

Sol. Answer (4)

$$v_A - v_B = 2.6 \times 10^7$$

$$n_B = 1.47$$

$$\frac{n_A}{n_B} = ?$$

$$n = \frac{c}{v}$$

$$\frac{c}{v_B} = 1.47$$

$$v_B = \frac{3 \times 10^8}{1.47}$$

$$v_A = v_B + 2.6 \times 10^7$$

$$= \frac{30 \times 10^7}{1.47} + 2.6 \times 10^7$$

$$v_A = 10^7 [23]$$

$$\frac{n_A}{n_B} = \frac{\frac{c}{v_A}}{\frac{c}{v_B}} = \frac{v_B}{v_A} = \frac{20.4 \times 10^7}{23 \times 10^7}$$

$$= 0.88$$

$$\boxed{or\ \frac{n_B}{n_A} = 1.12}$$

20. A block of mass 0.5 kg with velocity 12m/s compresses a spring by 30cm when its velocity is halved. Find the spring constant.

Sol. Answer (600 N/m)

Conservation of energy states at

$$\frac{1}{2}mv^2 = \frac{1}{2}m\left[\frac{v}{2}\right]^2 + \frac{1}{2}kx^2$$

$$\frac{1}{2}mv^2\left[1 - \frac{1}{4}\right] = \frac{1}{2}kx^2$$

$$\frac{3}{4}mv^2 = kx^2$$

$$k = \frac{3mv^2}{4x^2} = \frac{3 \times 0.5 \times 12^2}{4 \times (0.3)^2}$$

$$k = \frac{216}{0.36} = 600 \text{ N/m}$$

21. If the current is 2A then the energy in 15 seconds is 300 Joule. Find the energy if current is 3A and time is 10 seconds (integer type)

Sol. Answer (450)

$$H = I^2 Rt$$

$$300 = (2)^2 (R)(15) \quad ....(1)$$

$$H' = (3)^2 (R)(10) \quad ....(2)$$

$$\frac{(1)}{(2)}$$

$$\frac{300}{H'} = \frac{4 \times 15}{9 \times 10}$$

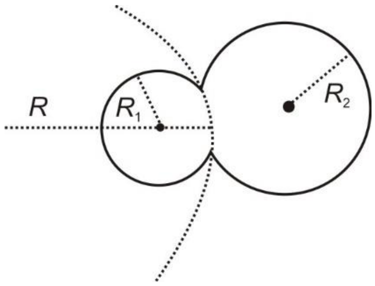
$$\Rightarrow H' = \frac{300 \times 9 \times 10}{4 \times 15} = 450 \text{ joule}$$

22. A soap bubbles of radius 6 cm and 9 cm respectively placed in contact with each other. Find the radius of curvature of interface is.

(1) 18 (2) 16

(3) 12 (4) 14

Sol. Answer (1)



Pressure difference at common interface is,

$$\Delta P = \frac{4T}{R_1} - \frac{4T}{R_2}$$

so, $\frac{4T}{R_{comm.}} = \frac{4T}{R_1} - \frac{4T}{R_2}$

$$\Rightarrow \frac{1}{R_{comm.}} = \frac{1}{R_1} - \frac{1}{R_2}$$

$$\Rightarrow \frac{1}{R_{comm.}} = \frac{1}{6} - \frac{1}{9}$$

$$= \frac{1}{3}\left(\frac{1}{2} - \frac{1}{3}\right)$$

$$= \frac{1}{3}\left(\frac{3-2}{6}\right)$$

$$\Rightarrow R_{comm.} = 18 \text{ cm}$$

23. If a mass travels 2m in its first second then the distance travelled by it in 9th second

Sol. Answer (34)

$$S_{n^{th}} = u + \frac{a}{2}(2n - 1)$$

$$\Rightarrow S_{1^{st}} = u + \frac{a}{2}((2 \times 1) - 1)$$

$$\Rightarrow 2 = u + \frac{a}{2}(2 - 1) = u + \frac{a}{2} \quad \text{......(1)}$$

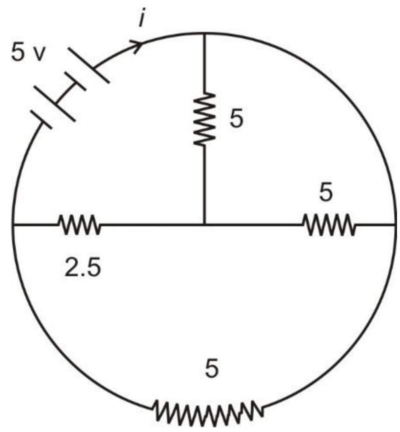
$$S_{9^{th}} = u + \frac{a}{2}((2 \times 9) - 1)$$

$$= u + \frac{a}{2}(17)$$

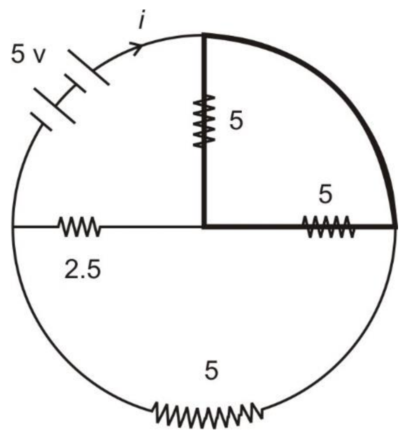
*consider u = 0 (as starting from rest at t = 0)

So, $S_{9^{th}} = \frac{a}{2}(17) = (2)(17) = 34$ m

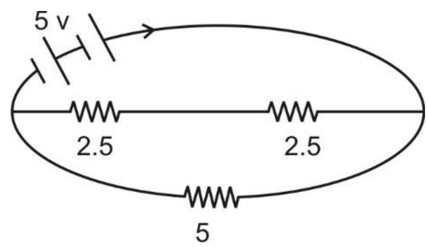
24. Find i in the circuit given below :



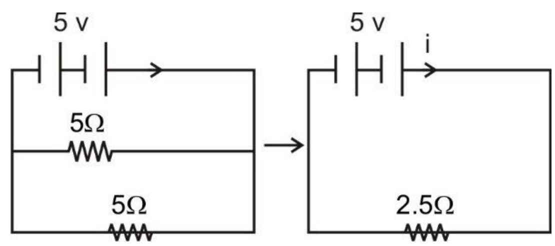
Sol. Answer (2A)



5Ω and 5Ω are in parallel connection



2.5 and 2.5 are in series connection



Have 5Ω and 5Ω are in parallel connection.

$$I = \frac{5}{2.5} = 2A$$

25. **Statement 1:** Davisson Germer Experiment established wave nature of electron.

Statement 2: If electron has wave nature they show interference and diffraction.

(1) S_1 is true S_2 is false

(2) S_1 is false S_2 is true

(3) S_1 & S_2 both true

(4) S_1 & S_2 both false

Sol. Answer (3)

S_1 and S_2 both true

Davisson Germer experiment experimentally configured de-broglie hypothesis of wave-particle duality. In 1989, wave nature of a beam of electron was experimentally demonstrated in a double slit experiment, similar to that used for the wave nature of light.

26. Wattless current flows through AC circuit, then the circuit is

(1) RLC (2) R only

(3) L only (4) RC only

Sol. Answer (3)

A current is said to be wattles if the average power consumed by the circuit is zero

$< P_{avg} > \; = V_{rms} I_{rms} \cos\phi$

Wattless component of current

$I_{rms} \sin\phi = I_{wattless}$

In the given combination

Only L (inductor) connected across a AC source will have zero average power.

□□□□□