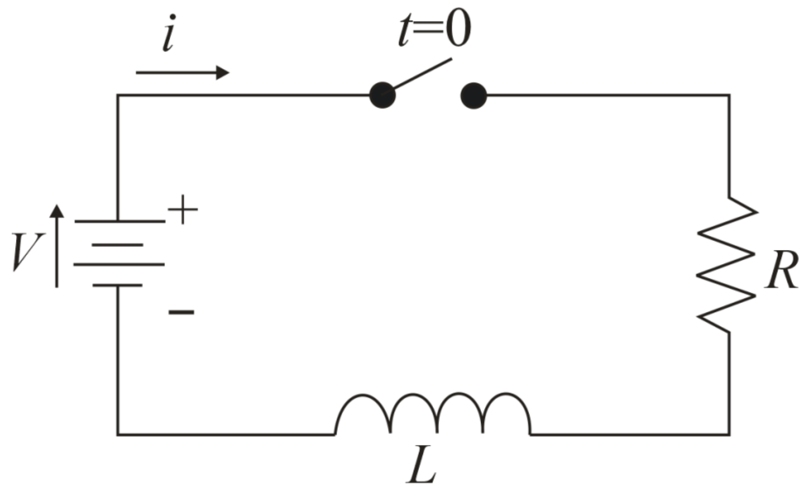
JEE Main 2021 August 26, Shift 1 Analysis (Physics)

1. In an LR circuit, at steady state energy stored in inductor is $64\ J$ and power consumed by circuit is $640\ W$. Find time constant in seconds for this LR circuit.



(i) 0.2

(ii) 0.1

(iii) 0.8

(iv) 0.25

Answer: (i)

At steady state, current will be constant power consumed in the circuit,

$P = I^2R = 640\ W$ ... (i)

Energy stored in inductor,

$U = \frac{1}{2}LI^2 = 64$ J ... (ii)

Dividing (ii) and (i),

$\frac{\text{(ii)}}{\text{(i)}} = \frac{L}{2R} = \frac{1}{10} \Rightarrow \frac{L}{R} = \frac{2}{10}$

Time constant for LR circuit,

$\frac{L}{R} = 0.2$ second

2. If $'E'$ represents energy, $'G'$ represents gravitational constant, $'M'$ represents mass, and $'L'$ represents angular momentum; find $[G^{-2}M^2E^{-3}L^3]$.

(i) $[M^4L^{-6}T^7]$

(ii) $[M^2L^2T^2]$

(iii) $[M^{-3}L^{-3}T^{-4}]$

(iv) $[M^{-4}L^{-2}T^2]$

Answer: (i)

Gravitational constant $[G] = \left[\frac{Fr^2}{m^2}\right] = \frac{MLT^{-2}L^2}{M^2} = [M^{-1}L^3T^{-2}]$

Mass, $[m] = [M]$

Angular Momentum,

$[L] = [mvr] = [ML^2T^{-1}]$

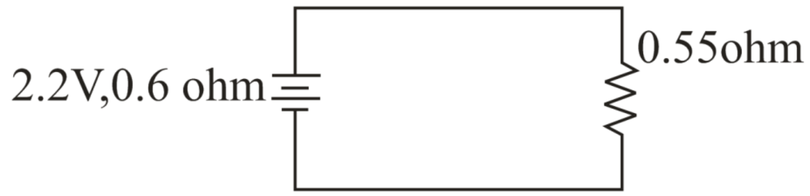
Energy $[E] == [ML^2T^{-2}]$

Now,

$[G^{-2}M^2E^{-3}L^3] = \frac{M^2(ML^2T^{-1})^3}{(M^{-1}L^3T^{-2})^2(ML^2T^{-2})^3} = \frac{[M^5L^6T^{-3}]}{[M^1L^{12}T^{-10}]}$

$= [M^4L^{-6}T^7]$

3.Find the power loss in a battery with the below mentioned approximate values:



(i) 2.2 W

(ii) 2.4 W

(iii) 4.2 W

(iv) 2.8 W

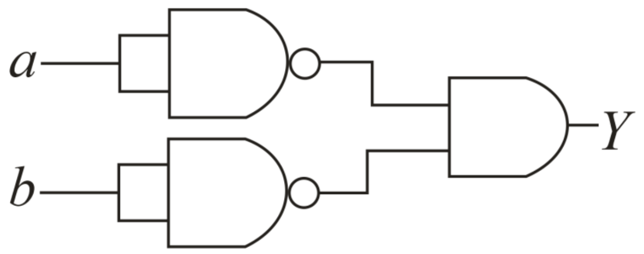
Answer: (i)

Current in the circuit, $I = \frac{2.2}{0.6+0.55} = \frac{2.2}{1.15}A$

Power loss in battery due to internal resistance

$$P = I^2r = \frac{2.2 \times 2.2 \times 0.6}{1.15 \times 1.15} = 2.2 \text{ W}$$

4. Which logic gate is this?



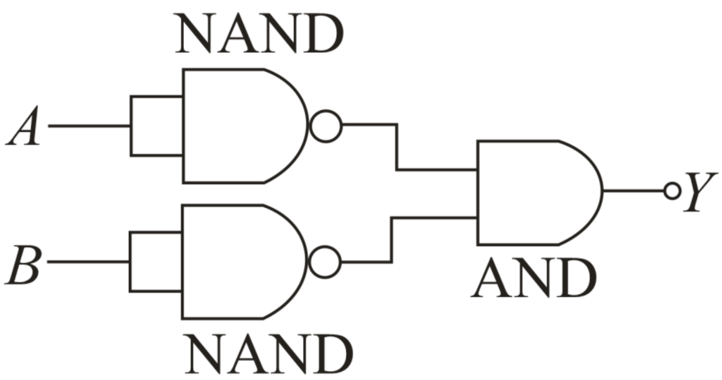
(i) AND

(ii) OR

(iii) NOR

(iv) NAND

Answer: (iii)

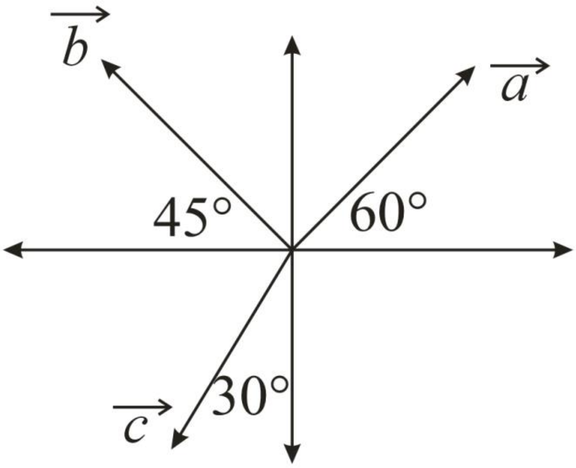


Giving inputs at A and B, we get the truth table:

A	B	P	Q	Y
0	0	1	1	1
0	1	1	0	0
1	0	0	1	0
1	1	0	0	0

Hence, it is NOR gate.

5. Three vectors of equal magnitude are shown in figure. Find angle θ formed by $\vec{a}+\vec{b}-\vec{c}$ with x axis, $tan\theta = ?$



(i) $\frac{\sqrt{6}+1}{\sqrt{2}-1}$

(ii) $\frac{\sqrt{6}-1}{\sqrt{2}+1}$

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

(iv) $\frac{\sqrt{2}-1}{\sqrt{6}+1}$

Answer: (i)

Let magnitude of the vectors be $'A'$

$\vec{a} = A\cos 60° \hat{i} + A\sin 60° \hat{j} = \frac{A}{2}\hat{i} + \frac{\sqrt{3}R}{2}\hat{j}$

$\vec{b} = -\frac{A}{\sqrt{2}}\hat{i} + \frac{A}{\sqrt{2}} j$

$\vec{c} = -A\sin 30° \hat{i} - A\cos 30^0 \hat{j} = \frac{-A}{2}\hat{i} - \frac{\sqrt{3}A}{2}\hat{j}$

Now,

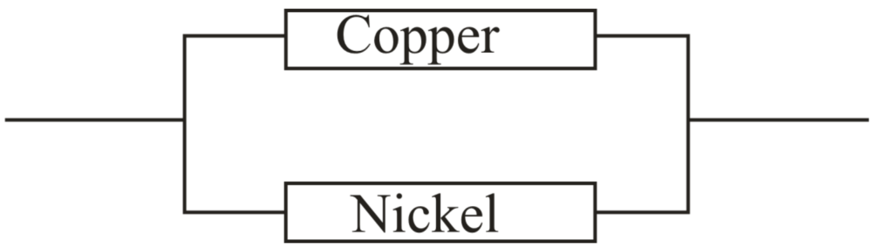
$\vec{a} + \vec{b} - \vec{c} == \left(\frac{A}{2} - \frac{A}{\sqrt{2}} + \frac{A}{2}\right)\hat{i} + \left(\frac{\sqrt{3}A}{2} + \frac{A}{\sqrt{2}} + \frac{\sqrt{3}A}{2}\right)\hat{j}$

$= \frac{1}{2}A[(2-\sqrt{2})\hat{i} + (2\sqrt{3}+\sqrt{2})\hat{j}]$

Now,

$\tan\theta = \frac{2\sqrt{3}+\sqrt{2}}{2-\sqrt{2}} = \frac{\sqrt{6}+1}{\sqrt{2}-1}$

6. Resistivity of copper and nickel is $12\ \mu\ ohm/cm$ and $51\ \mu\ ohm/cm$, respectively. The given two conductors are of equal length l and equal diameter $2mm$ and their equivalent resistance is $3ohm$. Find $'l'$?



Answer:

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$\Rightarrow \frac{1}{3} = \frac{10^{-2}\times\pi\times10^{-6}}{12\times10^{-6}\times l} + \frac{10^{-2}\times\pi\times10^{-6}}{51\times10^{-6}\times l}$

$\Rightarrow \frac{l}{3} = \frac{\pi}{1200} + \frac{\pi}{5100}$

$\Rightarrow l = -\frac{\pi}{100}\left[\frac{1}{4} + \frac{1}{17}\right]$ m

$= 0.97$ cm

7. What is the change in stopping potential when wavelength changes from 280 nm to 480 $nm. \phi = 2.65eV$.

Answer: (1.845 volts)

$KE = \mathrm{E} - \phi$

$e\Delta V_0 = (E_1 - E_2)$

$e\Delta V_0 = \left(\frac{12400}{2800} - \frac{12400}{4800}\right)$ eV

$e\Delta V_0 = (4.43 - 2.58) = 1.85\mathrm{eV}$

Change in stopping potential $= 1.85\ V$

8. Compare the RMS speeds of the gases at same temperature:

(i) $CO_2 > O_2 > H_2$

(ii) $CO_2 < O_2 < H_2$

(iii) $CO_2 < O_2 = H_2$

(iv) $CO_2 > O_2 = H_2$

Answer: (ii)

RMS Speed,

$V = \sqrt{\frac{3RT}{m}} \propto \frac{1}{\sqrt{m}}$

$m_{\mathrm{CO_2}} = 44, \quad m_{\mathrm{O_2}} = 32, \quad m_{\mathrm{H_2}} = 2$

For RMS speed, $\mathrm{H_2} > \mathrm{O_2} > \mathrm{CO_2}$

9. In a standard YDSE, distance between slits is d and distance between screen and slit plane is D. The location of 1^{st} maxima for red light is at Y_1 distance from central maxima and for violet light is Y_2 distance from central maxima. Find difference between wavelengths of red and violet lights.

(i) $\frac{d}{D}(Y_1 + Y_2)$

(ii) $\frac{d}{2D}(Y_1 - Y_2)$

(iii) $\frac{d}{D}(Y_1 - Y_2)$

(iv) $\frac{d}{2D}(Y_1 + Y_2)$

Answer: (iii)

Fringe width $B = \frac{\lambda D}{d}$

For red light, $Y_1 = \frac{\lambda_R D}{d}$

For violet light, $Y_2 = \frac{\lambda_V D}{d}$

Now $Y_1 - Y_2 = (\lambda_R - \lambda_V)\frac{D}{d}$

$\Rightarrow (\lambda_R - \lambda_V) = \frac{d(Y_1 - Y_2)}{D}$

10. A rocket of mass 1000 kg starts by burning fuel at relative velocity 500 m/s. If it accelerates at a rate of 20 m/s^2, find the rate at which fuel is burning in kg/s.

(i) 20 kg/s

(ii) 10 kg/s

(iii) 30 kg/s

(iv) 60 kg/s

Answer: (iv)

Force due to reduced mass,

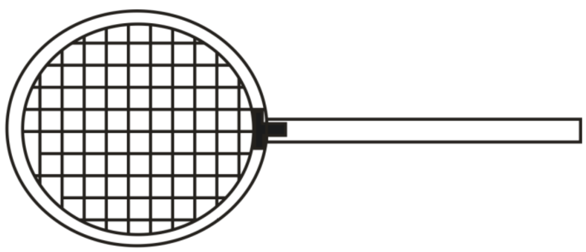
From force equation,

$F - mg = ma$

$\Rightarrow v_R(\frac{dm}{dt}) - mg = ma$

$\Rightarrow \ dm/dt = \frac{m(g+a)}{v_R} = \frac{1000(10+20)}{500} = 60$ kg/s

11. Badminton is in the shape of a ring connected with a handle (a rod). Radius of ring is r, length of rod is $6r$. If mass of ring is M, and of rod is m, find moment of inertia of system about the axis passing from a point at $\frac{r}{2}$ from end and perpendicular to ring plane.



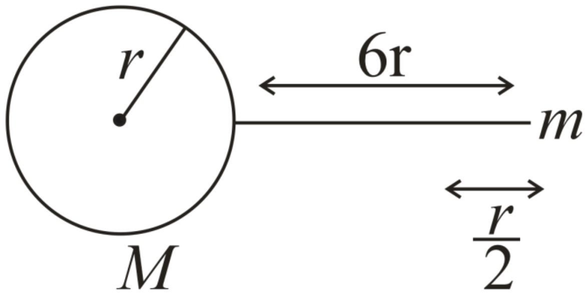
(i) $\frac{37}{4}mr^2 + \frac{173}{4}MR^2$

(ii) $\frac{37mr^2}{4} + Mr^2$

(iii) $3mr^2 + 16Mr^2$

(iv) $3mr^2 + \frac{229}{4}Mr^2$

Answer: (i)



$I = I_{\text{rod}} + I_{\text{ring}}$

$\frac{m(6r)^2}{12} + m\left(\frac{5}{2}r\right)^2 + Mr^2 + M\left(\frac{13}{2}r\right)^2$

$= 3mr^2 + \frac{25}{4}mr^2 + Mr^2 + M\frac{169}{4}r^2$

$= r^2\left(3 + \frac{25}{4}\right)m + r^2\left(1 + \frac{169}{4}\right)M$

$= \frac{37}{4}mr^2 + \frac{173}{4}Mr^2$

12. There is a soap bubble of radius 6 cm and it has another soap bubble of radius 3 cm inside it. Find the equivalent radius of the soap bubble which has same excess pressure inside it as a 3 cm bubble.

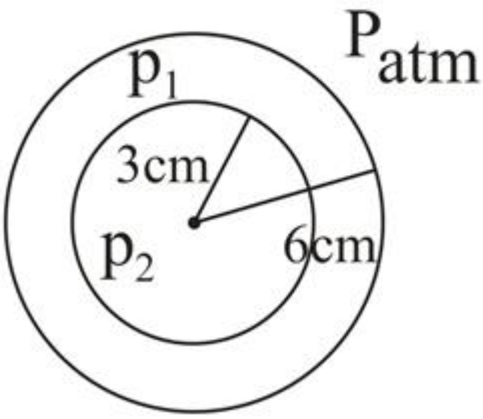
(i) 1 cm

(ii) 2 cm

(iii) 3 cm

(iv) 9 cm

Answer: (ii)



$P_1 - P_{\text{atm}} = \frac{4T}{(6\text{ cm})}$

$$P_2 - P_1 = \frac{4T}{(3\text{ cm})}$$

$$P_2 - P_{\text{atm}} = 4T\left(\frac{1}{6\text{ cm}} + \frac{1}{3\text{ cm}}\right)$$

$$= 4T\left(\frac{3+6}{18}\right) = \frac{4T}{(2\text{ cm})}$$

∴ radius of the required bubble is 2 cm.

13. Two spheres, each of radius $r = 5\ cm$ are thrown upwards at an interval of $3s$. At what height will they collide? If initial speed is $30\ m/s$.

(i) $45\ m$

(ii) $30\ m$

(iii) $33.7\ m$

(iv) $43.3\ m$

Answer: (iii)

Two sphere each of radius $r = 5$ cm

Solution: They collide when displacement is equal for both

$$h = ut - \frac{1}{2}gt^2$$

$$h = 30t - 5t^2$$

$$5t^2 - 30t + h = 0$$

$$t = \frac{30 \pm \sqrt{30^2 - 20h}}{10}$$

Time gap between them is 35

$$\Rightarrow \frac{30 - \sqrt{30 - 20h}}{10} + 3 = \frac{30 + \sqrt{30^2 - 20h}}{10}$$

$$\Rightarrow -\sqrt{30^2 - 20h} + 30 = \sqrt{30^2 - 20h}$$

$$30^2 - 20h = 15^2$$

$$h = \frac{30^2 - 15^2}{20} = \frac{900 - 225}{20}$$

$= 33.75$ m

14. In a series LCR circuit, find the capacitance to get maximum power.

Given $X_L = 250\Omega;\ \text{f} = 50\text{Hz}$.

(i) $10\mu F$

(ii) $12.7\mu F$

(iii) $20\mu F$

(iv) $27.3\mu F$

Answer: (ii)

In a LCR circuit,

$x_L = 250\Omega \;\; f = 50\ Hz$

We get maximum power at resonance.

$\Rightarrow \;\; x_C = x_L = 250\ \Omega$

$\Rightarrow \;\; \frac{1}{WC} = 250$

$\Rightarrow \;\; C = \frac{1}{2\pi f \times 250} = \frac{1}{2 \times 3.14 \times 50 \times 250}$

$\Rightarrow \;\; C = 12.7 \times 10^{-6} = 12.7\ \mu\text{F}$

15. Statement 1: In silicon semiconductor pentavalent doping increases electro density.

Statement 2: In n-type semiconductor net charge is negative.

(i) Statement -1 is true, Statement -2 is false

(ii) Statement -1 & Statement -2 is true

(iii) Statement -1 and Statement -2 is false

(iv) Statement -1 is false and Statement -2 is true

Answer: (i)

Solution:

All semiconductors either intrinsic or extrinsic are electrically neutral. On adding pentavalent impurity like phosphorus, it becomes n-type extrinsic semiconductor and electron density increases. Hence, S-1 is true and S-2 is false.

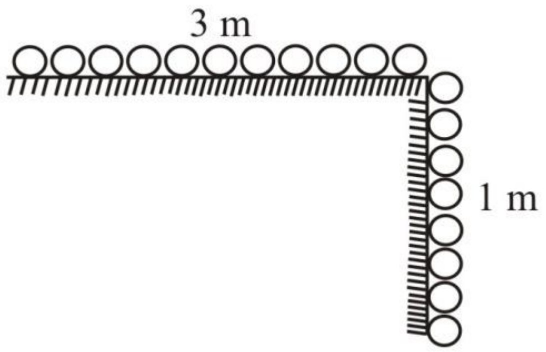
16. Chain of length 3 m is hanging as shown in figure. Mass of chain is 3 kg. It is released and allowed to move, find kinetic energy of chain, when it is completely in air.

(i) 56 J

(ii) 90 J

(ii) 100 J

(iv) 121 J



Answer: (i)

Solution:

If the table surface is zero potential energy level. Mechanical energy conservation,

$$U_1 + K_2 = U_2 + K_2$$

$$\Rightarrow -\left(\frac{m}{4}\right) g \times \frac{1}{2} + 0 = -mg \times 2 + K_2$$

$$\Rightarrow K_2 = \left(2 - \frac{1}{8}\right) \times 3 \times 10 = \frac{15}{8} \times 3 \times 10 = 56 \text{ J}$$

17. A sound source and a detector are moving away from each other with equal speed of 20 m/s. The detector heard a sound of frequency 1800 Hz from the source. What is the original frequency released by the source? Assume speed of sound $= 340 \text{ m/s}$.

(i) 2200 Hz

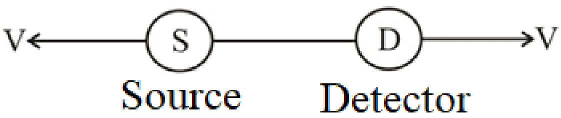
(ii) 1800 Hz

(iii) 2025 Hz

(iv) 1500 Hz

Answer: (iii)

Solution:



From Doppler's effect,

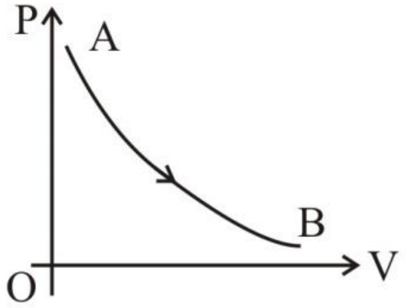
$$f = f_0 \left[\frac{C \pm V_0}{C \pm V_s}\right]$$

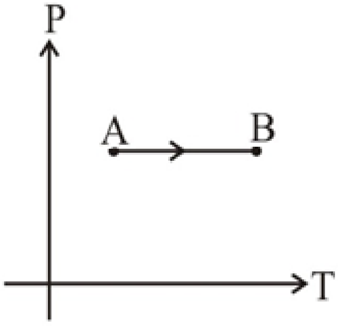
$$\Rightarrow 1800 = f_0 \left[\frac{340 - 20}{340 + 20}\right]$$

$$\Rightarrow f_0 = 1800 \times \frac{360}{320} = 2025 Hz$$

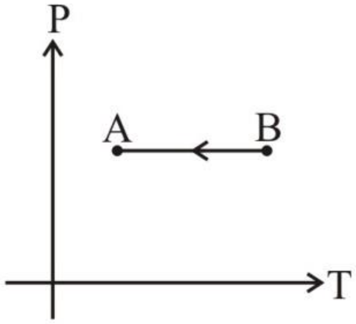
18. Assume an ideal gas is taken from state A to state B. The process is isothemal.

Then corresponding $P - T$ graph is:

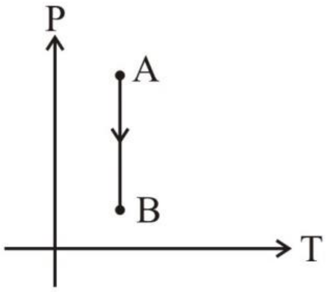




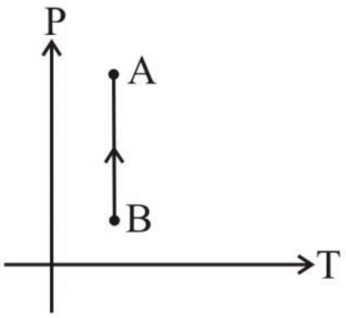
(i)



(ii)



(iii)



(iv)

Answer: (iii)

Solution:

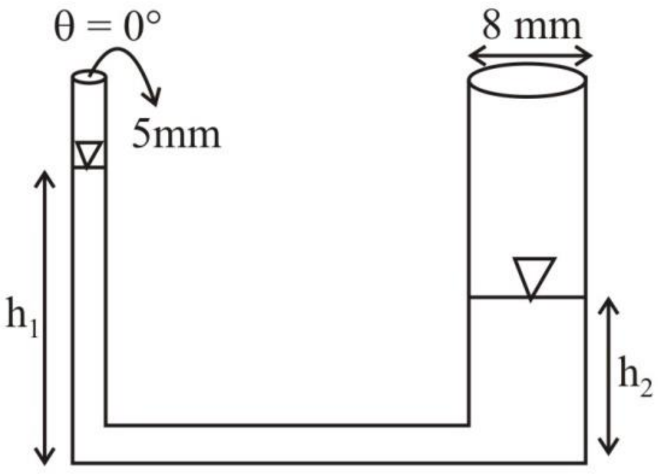
PV graph shows that, $PV =$ constant. Hence, it is an isothermal process. $= T =$ constant

From graph, $P_B < P_A$. and in PT graph curve will be parallel to pressure axis.

19. Find the difference in height in limbs as shown for the given data:

Surface tension, $T = 7.3 \times 10^{-2} \mathrm{N/m}$

Density of wates, δ= $1000 \mathrm{~kg/m^3}$ and angle of contact is zero.



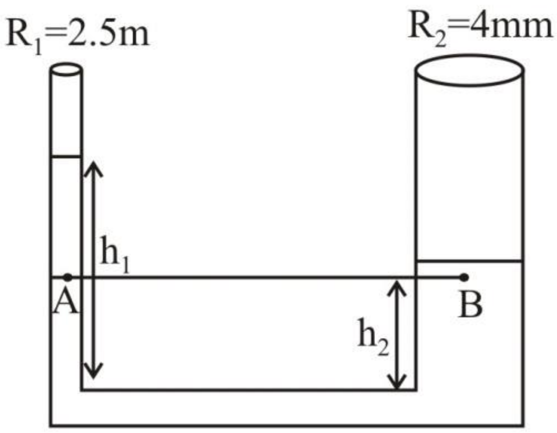
(i) 1.095 mm

(ii) 2.095 mm

(iii) 3.095 mm

(iv) 4.095 mm

Answer: (ii)



Solution:

A & B are two points in liquid at some level.

$$P_A = P_0 - \frac{2T}{R_1} + \delta g(h_1 - h_2)$$

$$\therefore P_B = P_0 - \frac{2T}{R_2}$$

$$\Rightarrow P_0 - \frac{2T}{R_1} + \delta g(h_1 - h_2) = P_0 - \frac{2T}{R_2}$$

$$\Rightarrow (h_1 - h_2) = \frac{2T}{\delta g}\left(\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$= \frac{2 \times 7.3 \times 10^{-2}}{10^3 \times 10}\left[\frac{1}{2.5} - \frac{1}{4}\right] \times 10^3$$

$$= 2.095 \text{ mm}$$

20. For hydrogen-like atom transition from $n = 3$ to $n = 1$, frequency of emitted radiation is 192×10^{15}Hz. Find the frequency when transition takes place from $n = 2$ to $n = 1$.

Answer: $(166 \times 10^{15}$Hz)

Solution:

Energy emitted, $E = hv = -13.6\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

Now, $h \times 192 \times 10^{15} = -13.6\left[\frac{1}{3^2} - \frac{1}{1^2}\right]$

and $h \times f = -13.6\left[\frac{1}{2^2} - \frac{1}{1^2}\right]$

Dividing the equations,

$$\frac{f}{192 \times 10^{15}} = \frac{1-\frac{1}{4}}{1-1/9} = \frac{3}{4} \times \frac{9}{8} = \frac{27}{32}$$

$$\Rightarrow f = \frac{27}{32} \times 192 \times 10^{15} = 166 \times 10^{15} \text{Hz}$$

21. Heat supplied to a system of gas is 6000 J/min. The rate of work done by the

system is found to be 90 W. Find the time taken to increase the internal energy by $2.5 \times 10^3 \text{J}$ in seconds.

(i) 100

(ii) 150

(iii) 200

(iv) 250

Answer: (iv)

Solution:

Let the time be ‘t’ seconds.

Heat, $Q = \left(\frac{6000}{60} \times t\right) \text{J}$

Work, $W = (90 \times t) \text{J}$

Change in internal energy, $\Delta U = 2.5 \times 10^3 \text{J}$

From FLOT, $Q = \Delta U + W$

$\Rightarrow 100t = 2.5 \times 10^3 + 90t$

$\Rightarrow t = 250$ seconds

22. Car A overtakes the car B with relative velocity 20 m/s. Find the velocity of the

image of the car B as seen in rear view mirror of car B of focal length 10 cm when car B is at 1.9 m from car A.

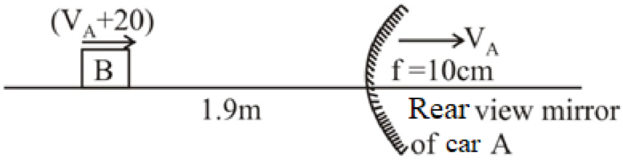
(i) 6 cm/s

(ii) 5 cm/s

(iii) 2 cm/s

(iv) 4 cm/s

Answer: (ii)



Velocity of B wrt A, $V_{BA} = 20$ m/s

Mirror Formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v} + \frac{1}{-1.9} = \frac{1}{0.1} \Rightarrow V = \frac{19}{28}\text{m}$$

Differentiate mirror formula wrt time,

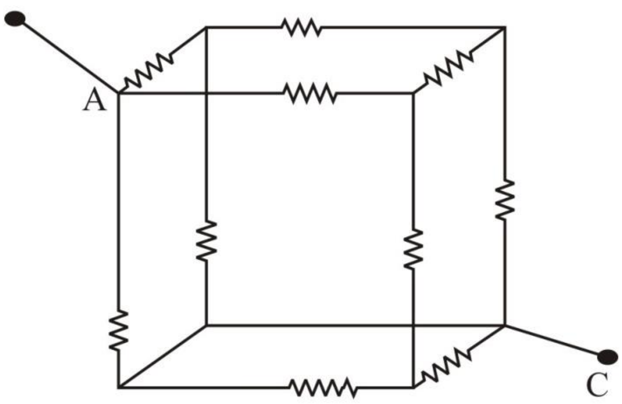
$$\frac{(-1)}{v^2}\frac{dv}{dt} - \frac{1}{u^2}\frac{du}{dt} = 0$$

$$\Rightarrow \frac{dv}{dx} = -\frac{v^2}{u^2}\frac{du}{dt}$$

velocity of image,

$$\frac{dv}{dt} = -\frac{19^2}{200^2 \times 1.9^2} \times 20 = 0.05\text{m/s} = 5\text{cm/s}$$

23. 12 wires each of resistance R form the sides of a cube as shown. Find the resistance between the end of the diagonal.



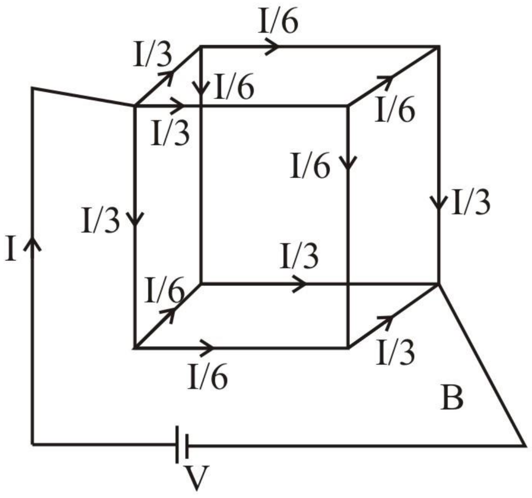
(i) 3R/2

(ii) 5R/6

(iii) 5 R

(iv) 6R/5

Answer: (ii)



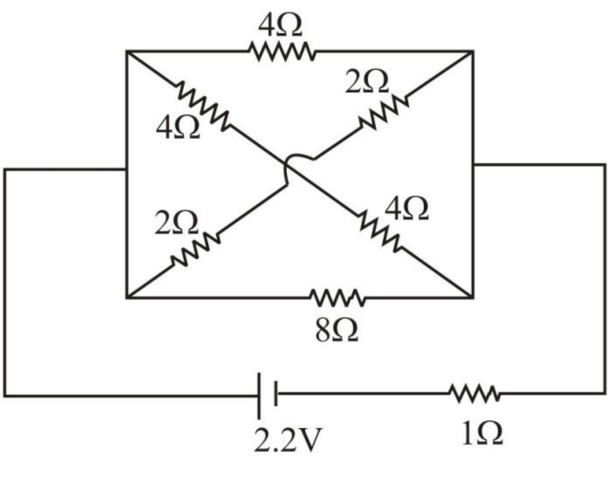
From KVL,

$$V - \frac{IR}{3} - \frac{IR}{6} - \frac{IR}{3} = 0$$

$$\Rightarrow \frac{V}{I} = \frac{R}{3} + \frac{R}{6} + \frac{R}{3} = \frac{5R}{6}$$

$$\Rightarrow R_{eq} = \frac{V}{I} = \frac{5R}{6}$$

24. Find the total power consumed in the circuit.



(i) 1.070W

(ii) 2.070W

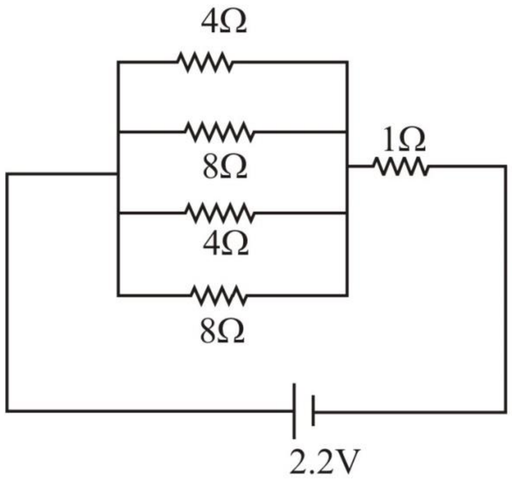
(iii) 3.070W

(iv) 4.070W

Answer: (ii)

Solution:

On rearranging



$$\frac{1}{R_p}=\frac{1}{4}+\frac{1}{8}+\frac{1}{4}+\frac{1}{8}$$

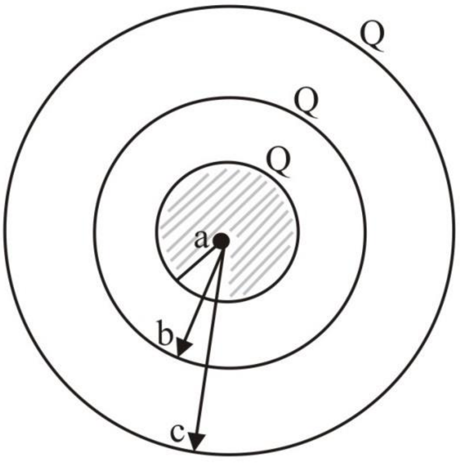
$$\Rightarrow R_p=\frac{8}{6}=\frac{4}{3}\Omega$$

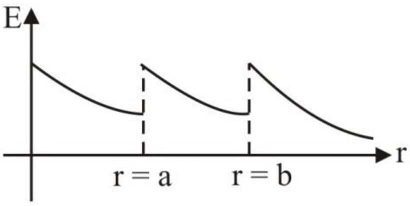
$$R_{eq}=\frac{4}{3}+1=\frac{7}{3}\Omega$$

Power, $P=\frac{V^2}{R}=\frac{2.2\times2.2\times3}{7}$

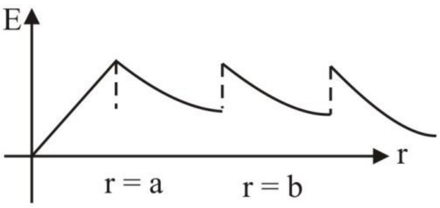
$= 2.07$ W

25. Find the graph between electric field intensity and distance 'r' from the centre. For the given arrangement of concentric spheres. Charge in inner solid sphere is uniformly distributed in volume.

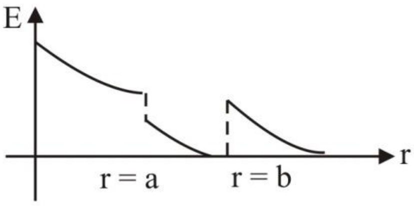




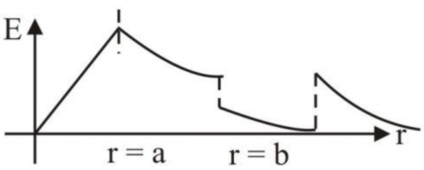
(i)



(ii)



(iii)



(iv)

Answer: (ii)

Solution:

$0 < r < a , \qquad E = \frac{KQr}{R^3}$

$a = r = b , \qquad E = \frac{KQ}{r^2}$

$b < r = c , \qquad E = \frac{2KQ}{r^2}$

$r > c \ , \qquad E = \frac{3kQ}{r^2}$

26. Given statements are based on Bohr's atomic model for hydrogen-like atom:

Statement 1- As principal quantum number increases, the speed of electron also increases. Statement 2- Speed of electron increases as energy increases.

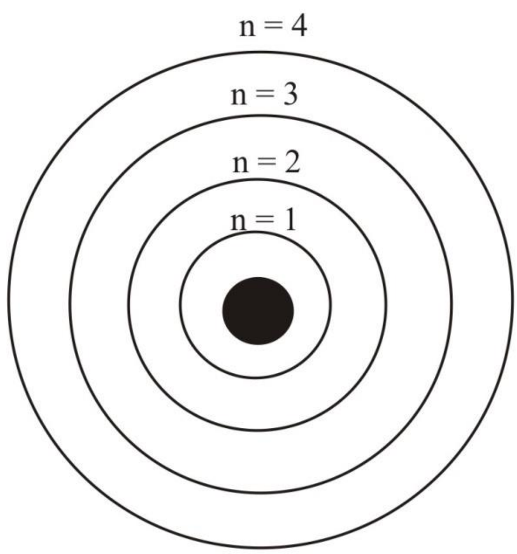
(i) Both, Statement 1 and Statement 2 are true.

(ii) Only Statement 1 is true.

(iii) Only Statement 2 is true.

(iv) Both, Statement 1 and Statement 2 are false.

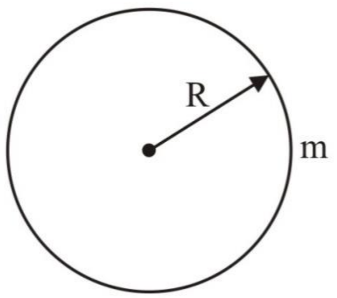
Answer: (iii)



Velocity of electron, $V=\frac{V_0 z}{n}$ as n increases, velocity decreases

Energy of electron, $E=\frac{-13.6z^2}{n^2}$ as n increases, energy increases

27. A spherical shell of mass 'm' and radius ' R ' is given, then which of the following is incorrect for inside the shell.



(i) Gravitation field is zero.

(ii) Gravitation potential is zero.

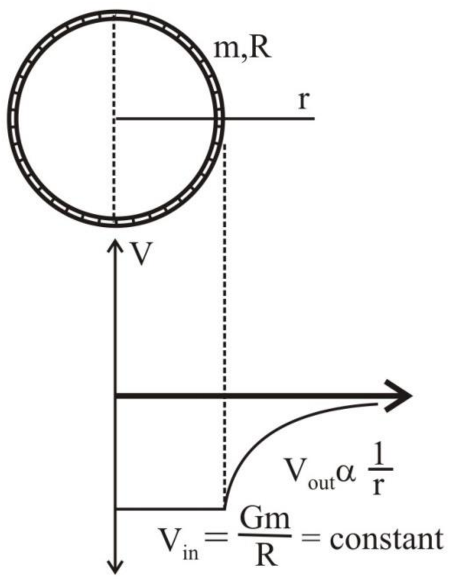
(iii) Gravitational field is same everywhere.

(iv) Gravitational potential is same everywhere.

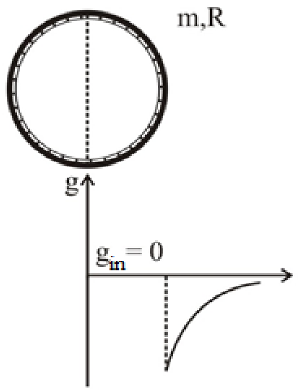
Answer: (ii)

Solution:

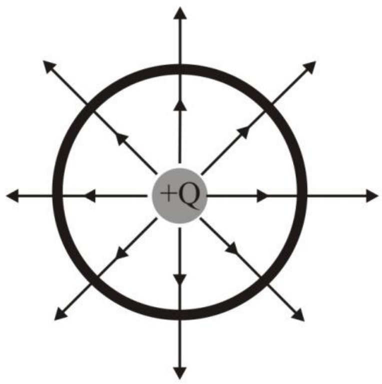
(i)



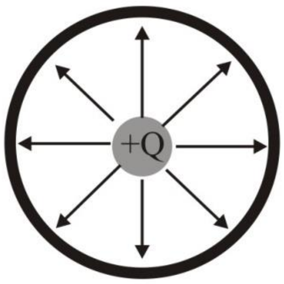
Gravitational field due to uniform spherical shell



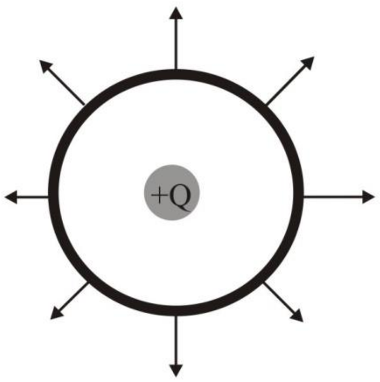
28. Charge Q is given to a spherical conductor of radius R. It is surrounded by a neutral concentric conducting shell of inner radius a and outer radius b. Corresponding electric field diagram will be:



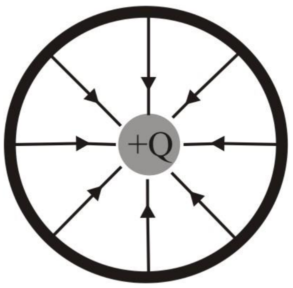
(i)



(ii)



(iii)



(v)

Answer: (i)

Solution:
Negative charge (-Q) will induce on inner surface of the shell. Therefore, positive charge (+Q) on the outer surface. There is no electric field in conductor on electrostatic conditions. Hence, electric lines of forces will originate from centre, terminate at inner surface of the shell. Then, they start from outer surface of shell and go till infinity.

29. Two travelling waves produce a standing wave represented by equation:

$y = 1.0\text{mm} \cos(1.57\text{cm}^{-1}\text{x}) \sin(78.5 s^{-1} t)$

The node closest to the origin in the region $x > 0$ will be at x _____cm.

Answer: (1)

At node,

$y = 0$

$$\Rightarrow 1\cos(1.57x)\sin(178.5t) = 0$$

$$\Rightarrow 1.57x = \frac{\Pi}{2}$$

$$\Rightarrow x = 1 \text{ cm}$$

30. An amplitude modulated wave is represented by:

$C_m = 10(1 + 0.2 \sin 12560\, t)\sin(1.11 \times 10^4 t)$.

The modulating frequency in KHz will be.

Answers- (2)

$C_m = A_C\left[1 + \frac{A_m}{A_C}\sin(2\Pi f_m t)\right]$

$\Rightarrow 2\Pi fm = 12560$

$\Rightarrow f_m = 2000\text{Hz} = 2\text{KHz}$