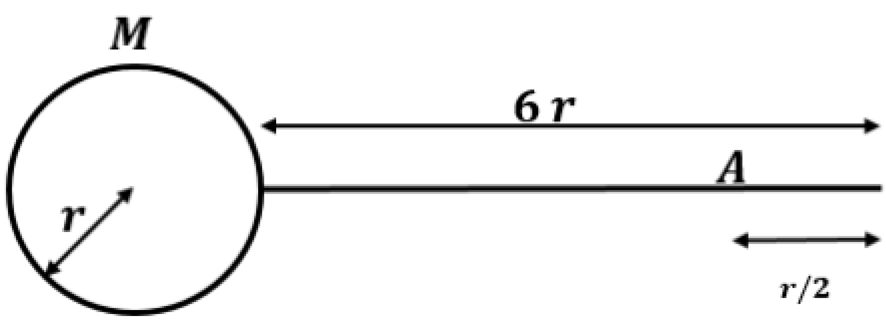
JEE Main 2021 August 26th Shift 1 Physics Question Paper

Question 1: Find the moment of inertia for a badminton racket about an axis passing through 'A' and perpendicular to the plane as shown in the figure. Mass of the circular portion is M and that of the straight is;



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

b.
$-\frac{173Mr^2}{4}+\frac{37mr^2}{4}$

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

d.
$-\frac{173mr^2}{4}+\frac{37Mr^2}{4}$

Answer: (a)

$$I_A=\left[Mr^2+M\left(7r-\frac{r}{2}\right)^2\right]+\left[\frac{m(6r)^2}{12}+\left(m\left(3r-\frac{r}{2}\right)^2\right)\right]$$
$$=\left\{Mr^2+\frac{M(169)r^2}{4}\right\}+\left\{m3r^2+\frac{m25r^2}{4}\right\}$$
$$=\frac{173Mr^2}{4}+\frac{37mr^2}{4}$$

Question 2: An amplitude modulated wave is represented by, $C_m = 10(1 + 0.2\sin 12560t)\sin(1.11 \times 10^4 t)$ V the modulating frequency in kHz will be;

Answer: 2 kHz

As we know that,

$$C_m = A_c\left[1 + \frac{A_m}{A_c} sin 2\pi f_m t\right]$$

$\Rightarrow 2\pi f_m = 12560$

f<su,,b>m = 2000 Hz = 2 kHz

Question 3: Two travelling waves produce a standing wave represented by equation $y = 1.0\text{mm} \cos(1.57\text{cm}^{-1} x) \sin(78.5\text{s}^{-1})$ t, the node closest to the origin in the region x > 0 will be at x = _____cm.

Answer: 1 cm

At node y = 0

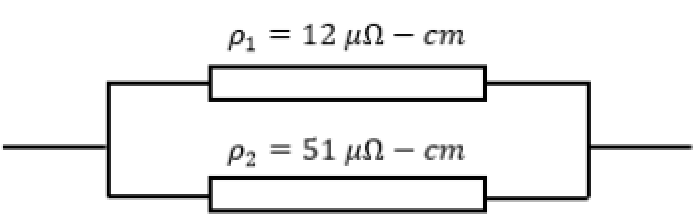
$\Rightarrow 1 \cos(1.57\ x) \sin(178.5)t = 0$

$\Rightarrow \cos(1.57\ x) = 0$

$\Rightarrow 1.57\ x = \pi/2$

$\Rightarrow x = 1$ cm

Question 4: Two wires of equal length with diameter 2 mm each having resistivity $\rho_1 = 12\ \mu\Omega$. cm and $\rho_2 = 51\ \mu\Omega$. cm respectively. They are connected in parallel so that their equivalent resistance is 3 Ω. Find the length of the wire.



a. 50 m

b. 97 m

c. 197 m

d. 291 m

Answer: b

We have, equivalent resistance $R = 3\Omega$

$$\Rightarrow R = 3\,\Omega = \frac{R_1 R_2}{R_1 + R_2}$$

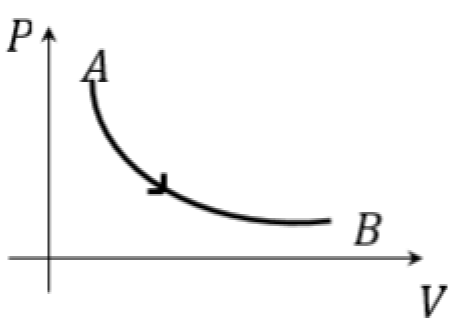
$$\Rightarrow \frac{\rho_1\rho_2}{\rho_1 + \rho_2}\left(\frac{l}{A}\right) = 3\,\Omega$$

$$\Rightarrow l = 3 \times A \times \frac{(\rho_1+\rho_2)}{\rho_1\rho_2}$$

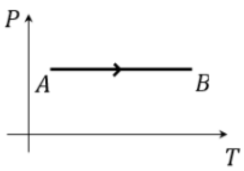
$$\Rightarrow \frac{3 \times \pi(10^{-3})^2 \times 63 \times 10^{-8}}{12 \times 51 \times 10^{-16}}$$

$$\Rightarrow l = 97\,m$$

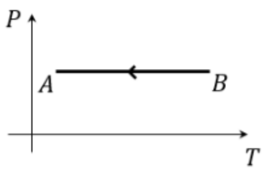
Question 5: Assume an ideal gas is taken from the state from A to state B. The process is isothermal. Then the corresponding P-T graph will be;



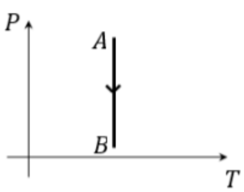
a.



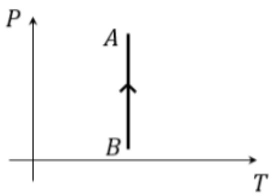
b.



c.



d.

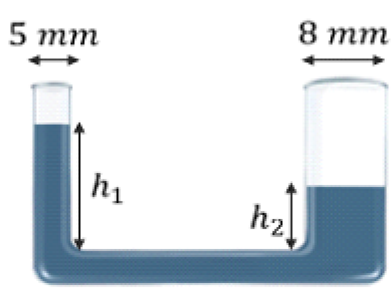


Answer: (c)

As T = constant, so

P $\propto$ 1/V

Question 6:Find the difference in heights in limbs as shown in the given data. Surface tension T =7.3 × 10^{-2} N/m, the density of water ρ = 1000 Kg/m^3 and the angle of contact θ = 0°.



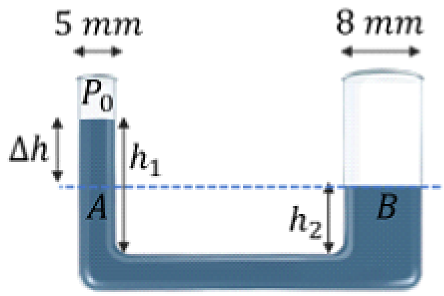
a. 1.19 m

b. 2.19 m

c. 3.19 m

d. 4.19 m

Answer: (b)



Comparing pressure at point A and point B

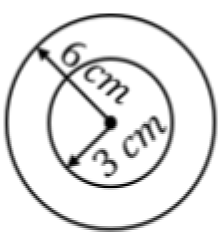
We have,

$$P_0 - \frac{2T}{R_1} + h_1\rho g = P_0 - \frac{2T}{R_2} + h_2\rho g$$

$$\Rightarrow (h_1 - h_2)\rho g = 2T\left[\frac{1}{\frac{5}{2}\times 10^{-3}} - \frac{1}{\frac{8}{2}\times 10^{-3}}\right]$$

$$\Rightarrow h_1 - h_2 = 2 \times 7.3 \times \frac{10^{-2}}{1000 \times 10 \times 10^{-3}} \times \frac{3}{20} = 2.19\ mm$$

Question 7: 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 the same excess pressure, as the pressure inside the bubble of radius 3 cm.



a. 2 cm

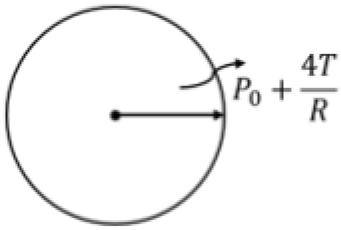
b. 1 cm

c. 9 cm

d. 3 cm

Answer: (a)

We have from the given condition



[latex]P_{0}+\frac{4T}{6}+\frac{4T}{3}=P_{0}+\frac{4T}{R}[/latex]

⇒[latex]\Rightarrow \frac{1}{6}+\frac{1}{3}=\frac{1}{R}[/latex]

⇒R = 2 cm

Question 8: In YDSE, d is the distance between slits and D is the distance between screen and slit plane. If y_1 is the distance of 1^{st} maxima from the central maxima for red light and y_2 is the distance for violet light then what is the difference between the wavelength of red and violet?

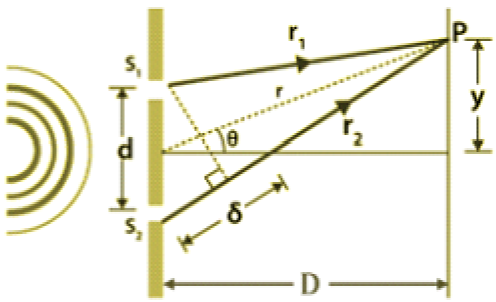
a. $\frac{(y_1+y_2)d}{D}$

b. $\frac{(y_1-y_2)d}{D}$

c. $\frac{(y_1-y_2)D}{d}$

d. $\frac{(y_1+y_2)D}{d}$

Answer: (b)



From the condition of maximum we have

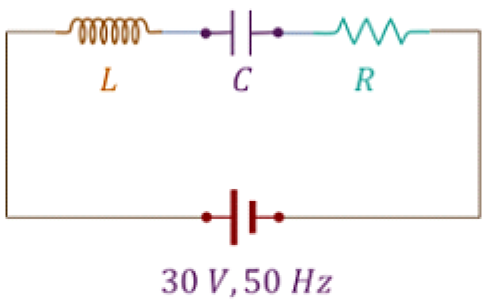
$$y_1 = \frac{\lambda_r D}{d}$$

$$y_2 = \frac{\lambda_v D}{d}$$

$$\Rightarrow$$

$$\lambda_r - \lambda_v = \frac{(y_1 - y_2)d}{D}$$

Question 9: Find the capacitance in a series LCR circuit in order to get maximum power. (XL = 250 Ω and f = 50 Hz).



a. 10.7 µF

b. 12.7 µF

c. 14.7 µF

d. 14.9 µF

Answer: (b)

As we know that, for maximum power, $X_C = X_L$ (Condition of resonance)

$\Rightarrow$ 1/Cω = ωL

$\Rightarrow$ 1/Cω = 250

As, ω = 2πf = 2π x 50 = 100 π

$\Rightarrow$ C = 1/(100π x 250) = 12.7 μF

Question 10: For a hydrogen-like atom, the frequency of transition from n = 3 to n = 1 is 192 × 10^{15} Hz, then find the frequency of transition from n = 2 to n = 1

a. 162 x 10^{15} Hz

b. 226 x 10^{15} Hz

c. 162 x 10^{18} Hz

d. None

Answer: (a)

For the given condition we have,

$$h\nu = E_0 z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

As, h and E_0 are constants,

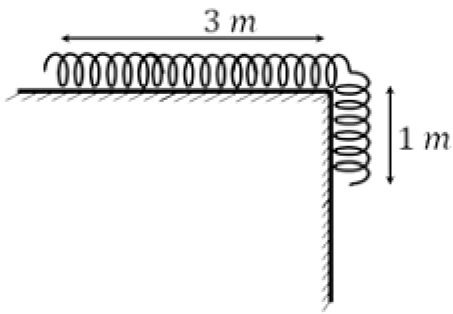
$$\therefore \nu \propto \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\Rightarrow \frac{192 \times 10^{15}}{\nu} = \frac{\left[\frac{1}{1^1} - \frac{1}{3^2}\right]}{\left[\frac{1}{1^1} - \frac{1}{2^2}\right]}$$

$$\Rightarrow \nu = 192 \times 10^{15} \times \left(\frac{3}{4}\right) \times \left(\frac{9}{8}\right)$$

$$\therefore \nu = 162 \times 10^{15}\ Hz$$

Question 11: Chain of length 1 m is hanging as shown in the figure. The mass of the chain is 3 kg. It is released and allowed to move, find kinetic energy (approximate) of the chain when it is completely in the air.



a. 56 J

b. 90 J

c. 100 J

d. 121 J

Answer: (a)

Mass of hanging part of chain is $\frac{1}{4}(3\ kg)$

$Initial\ P.E. = P.E.$ of hanging part is,

$$U_1 = \int_0^1 -\left(\frac{m}{l}\right) gxdx = -\frac{mg}{4}\left(\frac{x^2}{2}\right)_0^1 = -\frac{30}{8}\ J$$

$Final\ P.E. = P.E.$ of full chain when it just slips off,

$$U_2 = \int_0^4 -\left(\frac{m}{l}\right) gxdx = -\frac{mg}{4}\left(\frac{x^2}{2}\right)_0^4 = -60\ J$$

$$K.E.\ gain = P.E.\ loss$$

$$\frac{1}{2}mv^2 = -\frac{30}{8} - (-60) = \left(60 - \frac{30}{8}\right) J = 56.25\ J \approx 56\ J$$

Question 12: A sound source and a detector are moving away from each other with an 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 m/s.

a. 2200 HZ

b. 1800 HZ

c. 2025 HZ

d. 1500 HZ

Answer: (c)

f_{app} = 1800 Hz = f_0 ((330−20)/(300+20))

f_o = (350/310)× 1800 = 2032.25 Hz ≈ 2025 Hz

Question 13: Given statements are based on Bohr's atomic model for hydrogen-like atoms:

Statement-1. As the principal quantum number increases, the speed of the electron also increases.

Statement-2. Speed of electron increases as energy increases.

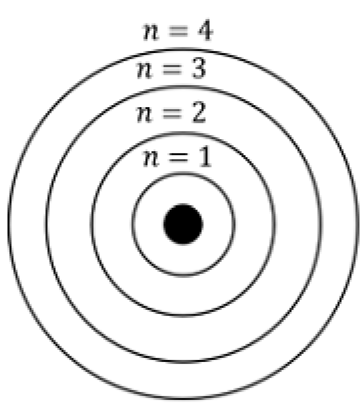
a. Both Statement-1 and Statement-2 are true

b. Only Statement-1 is true

c. Only Statement-2 is true

d. Both Statement-1 and Statement-2 are false

Answer: (d)



$V = V_0 z/n$

as n increases, velocity increases

The energy of electrons,

[latex]E = \frac{-13.6z^{2}}{n^{2}}[/latex]

As n increases, energy increases

Question 14: **Find the dimensions of A × (B + C)D where A is mass, dimensions of B is unknown, C is energy and D is dimensionless constant:**

a. $M^2L^2T^{-1}$

b. $M^2L^2T^{-2}$

c. $M^2L^1T^{-2}$

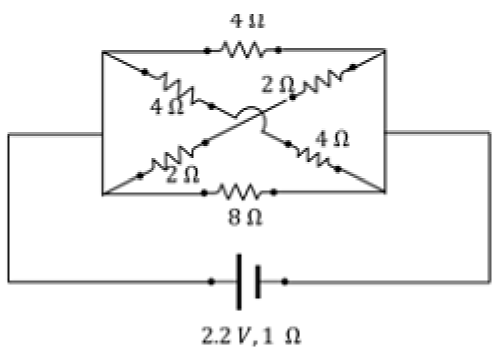
d. $M^1L^2T^{-2}$

Answer: (b)

Dimension of A × (B + C)D equal to dimension of A × C × D

$M \times ML^2T^{-2} = M^2L^2T^{-2}$

Question 15: In the given circuit, find the power consumed by the circuit.

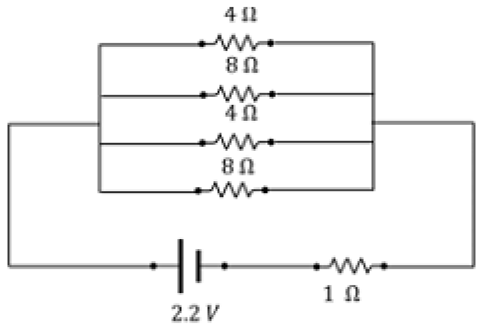


a. 1.07 W

b. 2.07 W

c. 3.07 W

d. 4.07 W



Answer: (b)

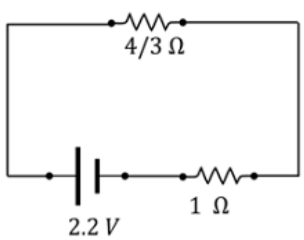
As we know that,

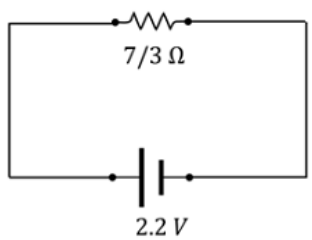
$P = V^2/R$

$\Rightarrow P = (2.2)^2/(7/3)$

$\Rightarrow P = 2.07$ W

Question 16:Two balls are projected vertically upward with the same speed 35 m/s in a 3-second interval, find height in m at which both balls collide.





a. 50

b. 30

c. 80

d. 100

Answer: (a)

$$S_1 = S_2$$
$$35t + \frac{1}{2}(-g)t^2 = 35(t-3) + \frac{1}{2}(-g)(t-3)^2$$
$$35t - \frac{1}{2}gt^2 = 35t - 35 \times 3 - \frac{1}{2}g(t^2 - 6t + 9)$$
$$35 \times 3 + 45 = 30t$$
$$t = \frac{150}{30} = 5$$
$$\text{height } h = 35 \times 5 - \frac{1}{2} \times 10 \times 5^2$$
$$h = 175 - 125 = 50\ m$$

Question 17: A heater is supplying heat at the rate of 6000 J/min. If power produced by gas is 90 W. Find the time taken to increase internal energy by 2.5×10^3 J?

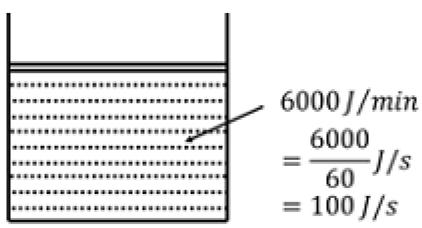
a. 250 s

b. 150 s

c. 500 s

d. 100 s

Answer: (a)



$\triangle U = Q - w$

$2500 = 100t - 90t$

$t = 250$ s

Question 18: Compare the RMS speed of hydrogen, oxygen, and carbon dioxide at the same temperature.

a. $V_{H2} < V_{O2} < V_{CO2}$

b. $V_{H2} > V_{O2} > V_{CO2}$

c. $V_{H2} > V_{O2} < V_{CO2}$

d. $V_{H2} < V_{O2} > V_{CO2}$

Answer: (b)

As we know that

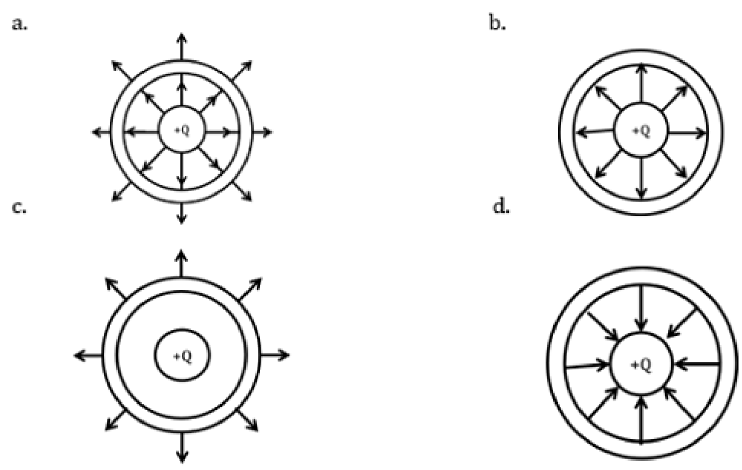
$$V_{RMS} = \sqrt{\frac{3RT}{M}}$$

$\propto 1/\sqrt{M}$

$M_{H2} < M_{O2} < M_{CO2}$

$V_{H2} > V_{O2} > V_{CO2}$

Question 19: Charge Q is given to a spherical conductor of radius R. It is surrounded by a concentric conducting shell of inner radius a and outer radius b. Corresponding electric field diagram will be:



Answer: (a)

Question 20: If a wavelength of incident light changes from 300 nm to 400nm, then find the change in sloping potential. If the work function of metal = 2.5 eV?

a. 1.03 eV

b. 2.10 eV

c. 1.85 eV

d. 2.03 eV

Answer: (a)

We know that,

$$eV_0 = \frac{hc}{\lambda} - \phi$$

$$eV_1 = \frac{hc}{300nm} - \phi$$

$$eV_2 = \frac{hc}{400nm} - \phi$$

$$e(V_1 - V_2) = 1240\left(\frac{100}{300 \times 400}\right) = 1.03\ eV$$

Question 21: Initial fuel in a rocket is 1000 kg. If it was given an acceleration of 20 m/s^2 the velocity of fuel with respect to the rocket is 500 m/s. Find the rate of consumption of fuel.

a. 30 kg/s

b. 60 kg/s

c. 900 kg/s

d. 80 kg/s

Answer: (b)

As we know that for varying mass system

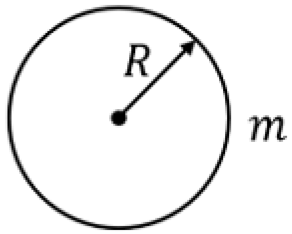
$f_T - mg = ma$

$(dm/dt)\ v_r = mg + ma$

$(dm/dt)\ 500 = 1000(10 + 20)$

$(dm/dt) = 60$ kg/s

Question 22: A spherical shell of mass′m′ and radius ′R′ is given, then which of the following is incorrect for inside the shell?



a. Gravitational field is zero

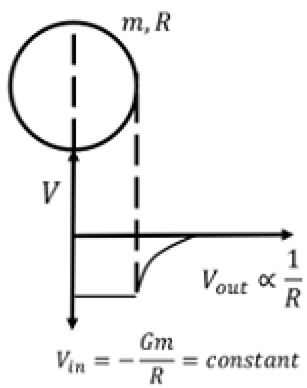
b. Gravitation potential is zero

c. The gravitational field is the same everywhere

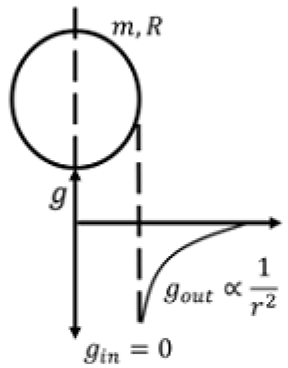
d. Gravitational potential is the same everywhere

Answer: (b)

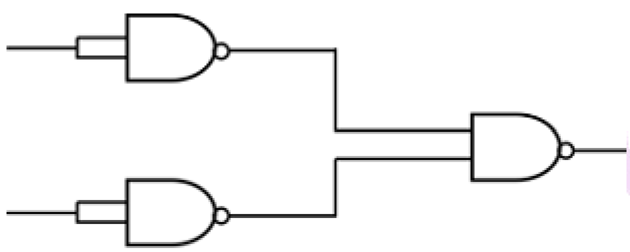
Gravitational potential due to a uniform spherical shell



Gravitational field due to a uniform spherical shell



Question 23: Find the equivalent gate



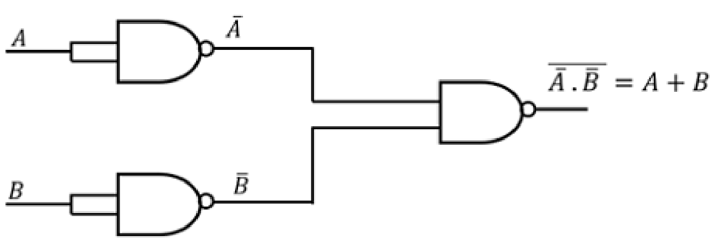
a. AND gate

b. NOR gate

c. NAND gate

d. OR gate

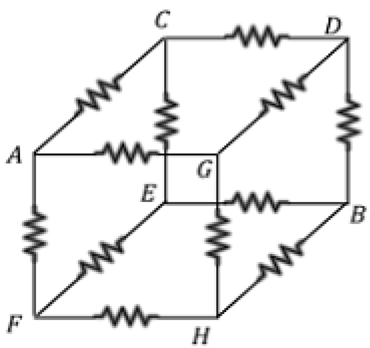
Answer: (d)



$\overline{\bar{A}.\bar{B}} = \bar{\bar{A}} + \bar{\bar{B}} = A + B$

Thus, it is an OR gate

Question 24: A cube made up of wire each of resistance R. Then find equivalent resistance across its diagonal.



a. 5R/6

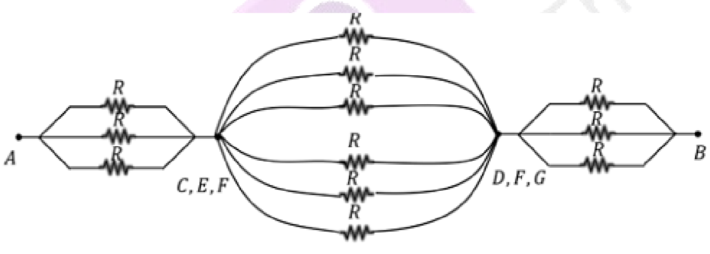
b. 3R/4

c. 7R/12

d. R

Answer: (a)

Due to symmetry C, E, F, same potential and G, D, H, same potential



$$R_{AB} = \frac{R}{3} + \frac{R}{6} + \frac{R}{3}$$

$$R_{AB} = \frac{5R}{6}$$

Question 25: Two cars A and B moving on a straight road. Car B passes car A by a relative speed of 45 m/s. At what speed does the driver of car B observe car A in the side mirror of focal length 10 cm when car A is at a distance of 1.9 m from car B?

a. 9/80

b. −9/80

c. −7/80

d. 7/80

Answer: (b)

Given,

$u = -1.9$ m

$f = 10$ cm

$m = f/(f - u)$

$=10/(10 - (-190))$

$=1/20$

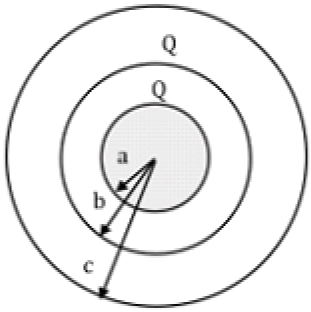
$\Rightarrow P_2/P_1 = 2$

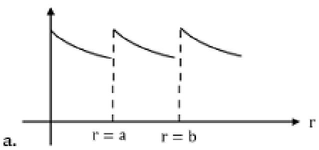
$v_i = -m^2 vo$

$v_i = -(1/20)^2 \times 45$

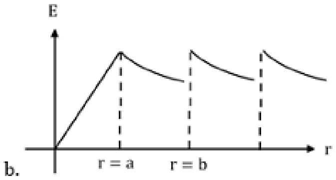
$v_i = -9/80$ m/s

Question 26:Find the graph between electric field intensity and distance r from the centre, for the given arrangement of concentric spheres. Charge in the inner solid sphere is uniformly distributed in volume.

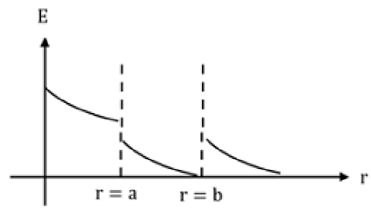




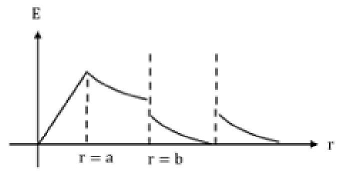
a.



b.



d.



Answer: (b)

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

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

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

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