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IIT JEE PHYSICS PAPER SOLUTION
28 JUNE 2022
MORNING SHIFT

QUESTIONS
BASED ON

TANGENTIAL ACCELERATION , Q-VALUE OF NUCLEAR REACTOR,REALISATION OF LOGIC GATE,MAGNETIC FIELD DUE TO HOLLOW CYLINDER & END CORRECTION IN METER BRIDGE ARE TRICKY

Q1: Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: Product of pressure (P) and time (t) has the same dimensions as that of coefficient of viscosity.

Reason R: Coefficient of viscosity $= \frac{\text{Force}}{\text{Velocity gradient}}$ ✗

Choose the correct answer from the options given below:

(A) Both A and R true, and R is correct explanation of A.

(B) Both A and R are true but R is NOT the correct explanation of A

(C) A is true but R is false ✓

(D) A is false but R is true

ANS-1

$$(P)(t) = \frac{F}{A}(t)$$

$$= \frac{MLT^{-2}}{L^2}(T)$$

$$= ML^{-1}T^{-2}T$$

$$= ML^{-1}T^{-1}$$

$$F = \eta A \frac{dv}{dx}$$

$$\eta = \frac{F}{A\left(\frac{dv}{dx}\right)}$$

coeff of viscosity is not just force / velocity gradient

Q2: A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration (a) is varying with time t as $a = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is given as

(A) zero

(B) $mk^2r^2t^2$

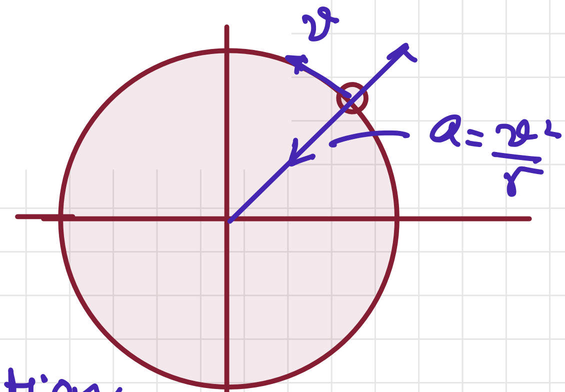
(C) ✓ mk^2r^2t

(D) mk^2rt

$$a = \frac{v^2}{r} = k^2rt^2$$

$$v^2 = k^2r^2t^2$$

$$v = krt$$



$$a_T = \frac{dv}{dt} = kr$$

└ tangential acceleration

$$P = \vec{F}\cdot\vec{v} = m\,a_T\,v_T$$

$$= m\,(kr)\,(krt)$$

$$P = mk^2r^2t$$

Q3: Motion of particle in x-y plane is described by a set of following equations $x = 4\sin\left(\frac{\pi}{2} - \omega t\right)m$ and $y = 4\sin(\omega t)m$. The path of the particle will be:

(A) Circular ✓

(B) Helical

(C) Parabolic

(D) Elliptical

ANS-3

$x = 4\sin(\pi/2 - \omega t)$

$x = 4\cos(\omega t)$ — (1)

$y = 4\sin\omega t$ — (2)

SQUARING AND ADDING EQUATION (1) & (2)

$x^2 + y^2 = 16\left[\sin^2\omega t + \cos^2\omega t\right]$

$$x^2 + y^2 = (4)^2$$

→ particle is moving in a circular motion with radius 4 mt

Q4: Match List I with List II

	List I		List II
A.	Moment of inertia of solid sphere of radius R about any tangent	I.	$\frac{5}{3}MR^2$
B.	Moment of inertia of hollow sphere of radius (R) about any tangent.	II.	$\frac{7}{5}MR^2$
C.	Moment of inertia of circular ring of radius (R) about its diameter	III.	$\frac{1}{4}MR^2$
D.	Moment of inertia of circular disc of radius (R) about any diameter	IV	$\frac{1}{2}MR^2$

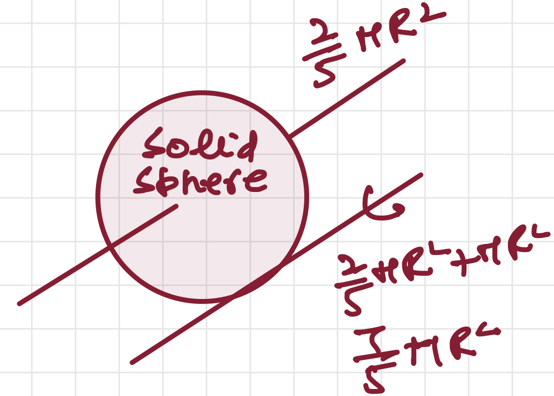
Choose the correct answer from the options given below:

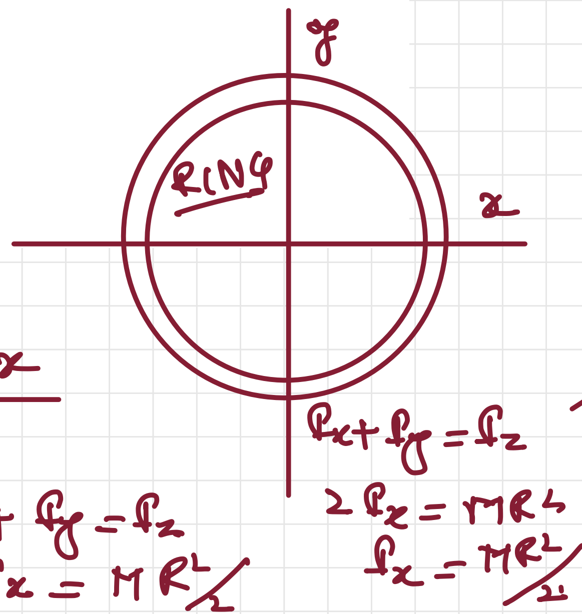
(A) $A \rightarrow II, B \rightarrow I, C \rightarrow IV, D \rightarrow III$

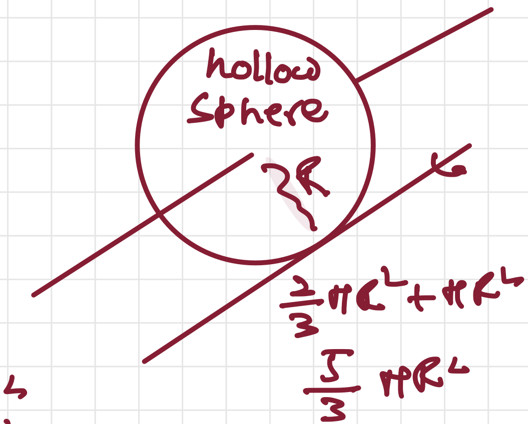
(B) $A \rightarrow I, B \rightarrow II, C \rightarrow IV, D \rightarrow III$

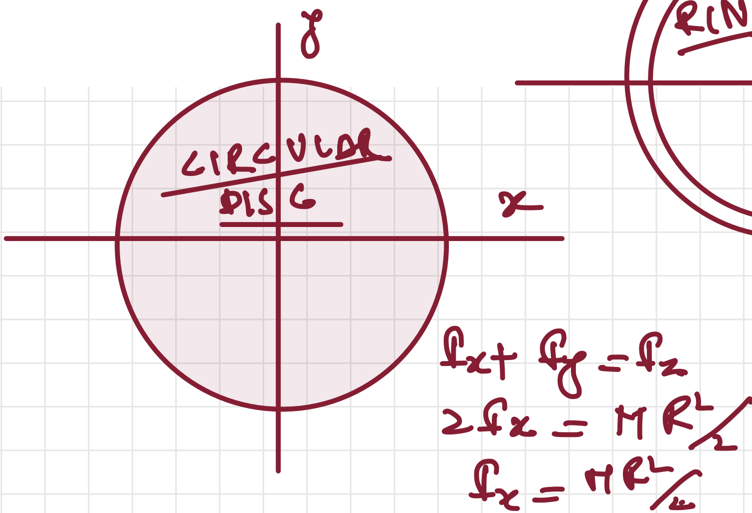
(C) $A \rightarrow II, B \rightarrow I, C \rightarrow III, D \rightarrow IV$

(D) $A \rightarrow I, B \rightarrow II, C \rightarrow III, D \rightarrow IV$









Q5: Two planet A and B of equal mass are having their of revolutions T_A and T_B such that $T_A = 2T_B$. These planets are revolving in the circular orbits of radii r_A and r_B respectively. Which out of the following would be the correct relationship of their orbits?

(A) $2r_A^2 = r_B^3$

(B) $r_A^3 = 2r_B^3$

(C) $r_A^3 = 4r_B^3$ ✓

(D) $T_A^2 - T_B^2 = \frac{\pi^2}{GM}(r_B^3 - 4r_A^3)$

$T_A = 2T_B$

$T^2 \propto r^3$ → As per Kepler's 3RD LAW

$$\left(\frac{r_A}{r_B}\right)^3 = \left(\frac{T_A}{T_B}\right)^2$$

$$\left(\frac{r_A}{r_B}\right)^3 = \left(\frac{2T_B}{T_B}\right)^2$$

$$r_A^3 = 4r_B^3$$

Q6: A water drop of diameter 2 cm is broken into 64 equal droplets. The surface tension of water is 0.075N/m. In this process the gain in surface energy will be:

(A) ✓ $2.8 \times 10^{-4} J$

(B) $1.5 \times 10^{-3} J$

(C) $1.9 \times 10^{-4} J$

(D) $9.4 \times 10^{-5} J$

$$64\left(\frac{4}{3}\pi r^3\right) = \frac{4}{3}\pi R^3$$

$$R = 4r \Rightarrow r = R/4 = \frac{2}{4} \text{ cm} = \frac{1}{2}\times 10^{-2} \text{ mt}$$

$$\Delta E = S(\Delta A)$$

$$\Delta E = S\left[64(4\pi r^2) - 4\pi R^2\right]$$

$$= 4\pi(S)\left[64 r^2 - R^2\right]$$

$$= 4\pi(S)\left[64\left(\frac{R}{4}\right)^2 - R^2\right]$$

$$= 4\pi(S)\left[4R^2 - R^2\right]$$

$$= 4\pi(S)R^2(3)$$

$$= 4 \times 3.14 \times .075 \times (2\times 10^{-2})^2 \times 3$$

$$= 2.8 \times 10^{-4} J$$

Q7: Given below are two statements:

Statement – I: When μ amount of an ideal gas undergoes adiabatic change from state (P_1, V_1, T_1) to state (P_2, V_2, T_2) then work done is $W = \frac{\mu R(T_2 - T_1)}{1-\gamma}$, where $\gamma = \frac{C_p}{C_v}$ and R = universal gas constant.

Statement – II: In the above case, when work is done on the gas, the temperature of the gas would rise.

Choose the correct answer from the options given below.

(A) Both statement – I and statement – II are true ✓

(B) Both statement – I and statement – II are false

(C) Statement – I is true but statement – II is false

(D) Statement – I is false but statement – II is true

$$W = \frac{\mu R (T_2 - T_1)}{(1-\gamma)}$$ — STATEMENT I TRUE

→ STATEMENT IS TRUE AND IT IS AN ADIABATIC PROCESS

$\Delta Q = \Delta U + \Delta W$

$\Delta Q = 0$ FOR ADIABATIC PROCESS

$\Delta U = -\Delta W$

If work is done on the gas

ΔW (-ve)

ΔU (positive) or temp increases

STATEMENT – II — TRUE

Q8: Given below are two statements

Statement – I: A point charge is brought in an electric field. The value of electric field at a point near to the charge may increase of the charge is positive.

Statement – II: An electric dipole is placed in a non-uniform electric field. The net electric force on the dipole will not be zero

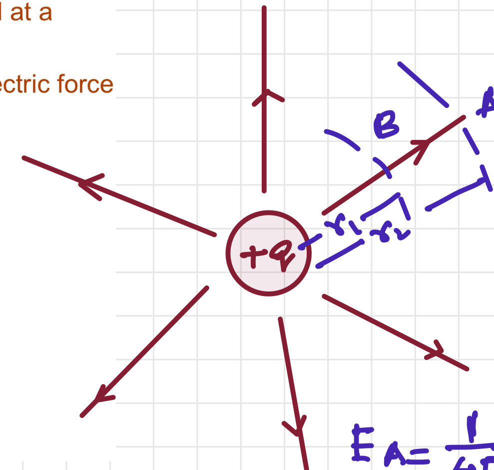
Choose the correct answer from the options given below:

(A) Both statement – I and statement – II are true ✓

(B) Both statement – I and statement – II are false

(C) Statement – I is true but statement – II is false

(D) Statement – I is false but statement – II is true



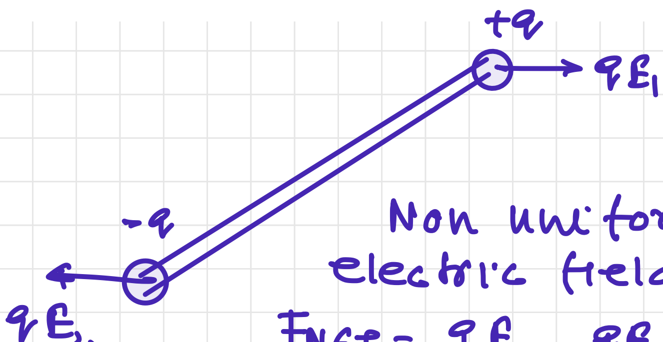
$E_A = \frac{1}{4\pi\epsilon_0}\frac{q}{r_2^2}$

$E_B = \frac{1}{4\pi\epsilon_0}\frac{q}{r_1^2}$

TRUE Since $r_2 > r_1$

$E_B > E_A$

Hence electric field increase when we move towards the charge.

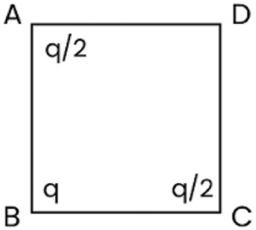


Non uniform electric field.

$F_{NET} = qE_1 - qE_2$ → NOT-ZERO

TRUE

Q9: The three charges $\frac{q}{2}$, q and $\frac{q}{2}$ are placed at the corners A,B and C of a square of side 'a' as shown in figure. The magnitude of electric field (E) at the corner D of the square, is:

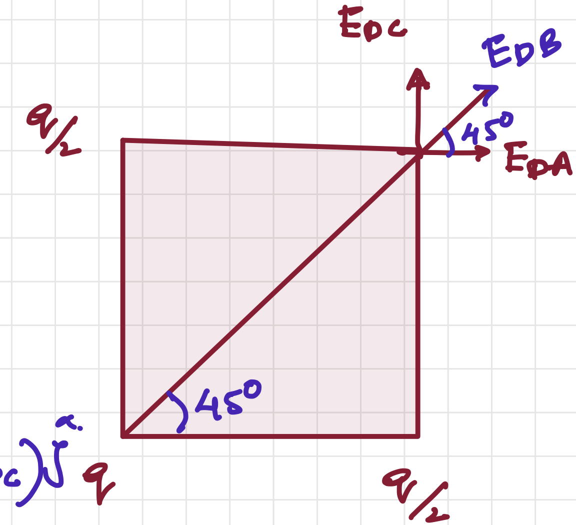


(A) $\frac{q}{4\pi\epsilon_0 a^2}\left(\frac{1}{\sqrt{2}}+\frac{1}{2}\right)$ ✓

(B) $\frac{q}{4\pi\epsilon_0 a^2}\left(1+\frac{1}{\sqrt{2}}\right)$

(C) $\frac{q}{4\pi\epsilon_0 a^2}\left(1-\frac{1}{\sqrt{2}}\right)$

(D) $\frac{q}{4\pi\epsilon_0 a^2}\left(\frac{1}{\sqrt{2}}-\frac{1}{2}\right)$



$$\vec{E} = (E_{DA})\hat{i} + (E_{DB}\cos 45\,\hat{i} + E_{DB}\sin 45\,\hat{j}) + E_{DC}(\hat{j})$$

$$\vec{E} = \left(E_{DA} + \frac{E_{DB}}{\sqrt{2}}\right)\hat{i} + \left(\frac{E_{DB}}{\sqrt{2}} + E_{DC}\right)\hat{j}$$

$$= \left(\frac{kq/2}{a^2} + \frac{kq}{\sqrt{2}(a\sqrt{2})^2}\right)\hat{i} + \left(\frac{kq}{(a\sqrt{2})^2\sqrt{2}} + \frac{kq/2}{a^2}\right)\hat{j}$$

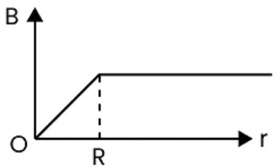
$$= \frac{kq}{a^2}\left(\frac{1}{2} + \frac{1}{2\sqrt{2}}\right)\hat{i} + \frac{kq}{a^2}\left(\frac{1}{2\sqrt{2}} + \frac{1}{2}\right)\hat{j}$$

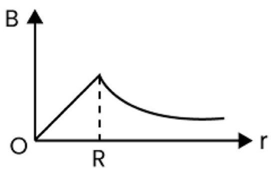
$$|E| = \sqrt{2}\,\frac{kq}{a^2}\left(\frac{1}{2} + \frac{1}{2\sqrt{2}}\right)\ N/C$$

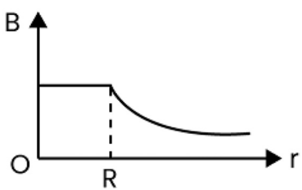
$$= \frac{1}{4\pi\epsilon_0}\frac{q}{a^2}\left(\frac{1}{\sqrt{2}} + \frac{1}{2}\right)$$

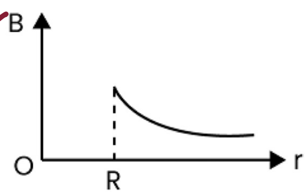
Q10: An infinitely long yellow conducting cylinder with radius R carries a uniform current along its surface.

Choose the correct representation of magnetic field (B) as a function of radial distance (r) from the axis of cylinder.

(A)


(B)


(C)


(D) ✓


cases: $r = a < R$, $r = R$, $r = b > R$

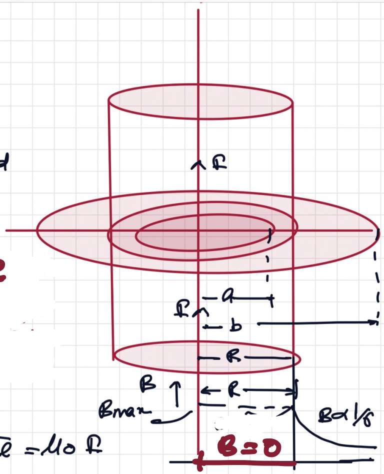
Case-I

$\oint \vec{B}\cdot d\vec{l} = \mu_0 I$

current enclosed is equal to I'

Since hollow conductor then current inside the hollow cylinder = 0

$B = 0$



Case-2 → $r = R$ apply A.C.L $\oint \vec{B}\cdot d\vec{l} = \mu_0 I$

current enclosed = I

$B\,2\pi R = \mu_0 I \Rightarrow B = \frac{\mu_0}{2\pi}\frac{I}{R} = B_{max}$

Case-3 $r = b > R$

A.C.L. $\oint \vec{B}\cdot d\vec{l} = \mu_0 I$

$B\,2\pi b = \mu_0 I \Rightarrow B = \frac{\mu_0}{2\pi}\frac{I}{b}$, $B \propto 1/b \propto 1/r$

constant

Q11: A radar sends an electromagnetic signal of electric field $(E_0) = 2.25V/m$and magnetic field $(B_0) = 1.5 \times 10^{-8}T$which strikes a target on line of sight at a distance of 3 km in a medium. After that, a part of signal (echo) reflects back towards the radar with same velocity and by same path. If the signal was transmitted at time $t = 0$from radar, then after how much time echo will reach to the radar?

(A) $2.0 \times 10^{-5} s$

(B) $4.0 \times 10^{-5} s$ ✓

(C) $1.0 \times 10^{-5} s$

(D) $8.0 \times 10^{-5} s$

$E_0 = 2.25$ Volt/mt

$B_0 = 1.5 \times 10^{-8}$ T

$c = \frac{E_0}{B_0} = 1.5 \times 10^{8}$ mt/sec

Total distance travelled = 6 km

velocity = $\frac{\text{distance}}{\text{time}}$

time = $\frac{6 \times 10^{3}}{1.5 \times 10^{8}} = 4 \times 10^{-5}$ mt

B → correct

Q12: The refracting angle of a prism is A and refractive index of the material of the prism is $\cot\left(\frac{A}{2}\right)$. Then the angle of minimum deviation will be-

(A) 180 – 2A

(B) 90 – A

(C) 180 + 2A

(D) 180 – 3A ✓

Refracting angle = angle of prism.

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin A/2} = \cot(A/2)$$

$$\frac{\sin\left(\frac{A+\delta_m}{2}\right)}{(\sin A/2)} = \frac{\cos(A/2)}{(\sin A/2)}$$

$$\sin\left(\frac{A+\delta_m}{2}\right) = \sin\left(\pi/2 - A/2\right)$$

$$A + \delta_m = \pi - A$$

$$\boxed{\delta_m = \pi - 2A}$$

Q13: The aperture of the objective is 24.4 cm. The resolving power of this telescope, if a light of wavelength $2440 \mathring{A}$ is used to see the object will be:

(A) 8.1×10^{6}

(B) 10.0×10^{7}

(C) 8.2×10^{5} ✓

(D) 1.0×10^{-8}

$$RP = \frac{1}{1.22\lambda / a}$$

$$= \frac{24.4 \times 10^{-2}}{1.22 \times 2440 \times 10^{-10}}$$

$$= 8.2 \times 10^{5}$$

Q14: The de Broglie wavelengths for an electron and a photon are λ_e and λ_p respectively. For the same kinetic energy of electron and proton. Which of the following presents the correct relation between the de Broglie wavelengths of two?

(A) $\lambda_p \propto \lambda_e^2$ ✓

(B) $\lambda_p \propto \lambda_e$

(C) $\lambda_p \propto \sqrt{\lambda_e}$

(D) $\lambda_p \propto \sqrt{\frac{1}{\lambda_e}}$

FOR PHOTON

$$\lambda = \frac{h}{p}$$

$$E = mc^2 = cp$$

$$p = E/c$$

$$\lambda_p = \frac{h(c)}{(KE)} \quad -(1)$$

$$\lambda_p = \frac{hc}{(KE)}$$

$$KE = \frac{1}{2} m v^2$$

$$v = \sqrt{\frac{2(KE)}{m}}$$

$$\lambda_e = \frac{h}{mv} = \frac{h}{m\sqrt{\frac{2(KE)}{m}}}$$

$$\lambda_e = \frac{h}{\sqrt{2m(KE)}} \quad -(2)$$

→ FOR ELECTRON.

$$\lambda_e^2 = \frac{h^2}{2m(KE)}$$

$$\frac{\lambda_p}{\lambda_e^2} = \frac{hc}{(KE)} \cdot \frac{2(m)(KE)}{h^2}$$

$$\lambda_p = \frac{2mc}{h} \lambda_e^2$$

$$\lambda_p \propto \lambda_e^2$$

Q15: The Q-value of a nuclear reaction and kinetic energy of the projectile particle, K_p are related as:

(A) $Q = K_p$

(B) $(K_p + Q) < 0$

(C) $Q < K_p$

(D) $(K_p + Q) > 0$ ✓

$k_p = 0$

If Q is released

$\Rightarrow Q > 0$

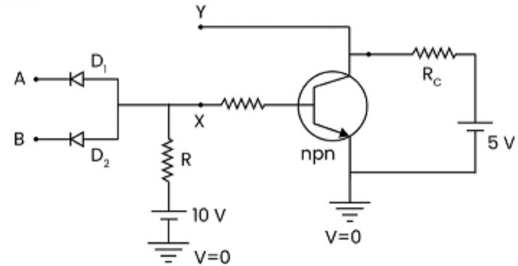
If Q is absorbed

$\Rightarrow Q < 0$

Even then particle has to be given KE greater than magnitude of Q to maintain momentum conservation.

$k + Q > 0$

Q16: In the following circuit, the correct relation between output (Y) and inputs A and B will be:



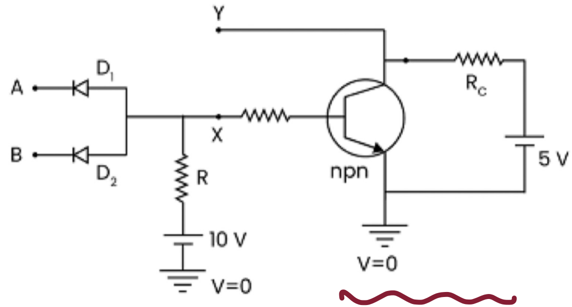
(A) $Y = AB$

(B) $Y = A + B$

(C) $Y = \overline{AB}$ ✓

(D) $Y = \overline{A + B}$

be:



AND GATE

AB

NOT GATE

$\overline{AB}$

Q17: For using a mustimeter to identify diode from electrical components. choose the correct statement out of the following about the diode

(A) It is two terminal device which conducts current in both directions

(B) It is two terminal device which conducts current in one direction only

(C) It does not conduct current gives an initial deflection which decays to zero

(D) It is three terminal device which conducts current in one direction only between central terminal and either of the remaining two terminals

DIODE

└ two terminal device conducts current in one direction under forward bias.

Q18: Given below are two statements : One is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : n-p-n transistor penults more current than a p-n-p transistor.

Reason R : Electrons have greater mobility as a charge carrier.

Choose the correct answer from the options given below

(A) ✓ Both A and R true. and R is correct explanation of A

(B) Both A and R are true but R is NOT the correct explanation of A

(C) A is true but R is false

(D) A is false but R is true

NPN — PNP

more current than

majority charge carrier in npn (electron) has more mobility than hole

For high current gain.
Common emitter NPN transistor as an amplifier preferred.

For high voltage gain.
Common base PNP transistor is preferred

Q19: Match List I with List II

	List I		List II
A.	Television signal	I.	03 KHz
B.	Radio signal	II.	20 KHz
C.	High Quality Music	III.	02 MHz
D.	Human speech	IV	06 MHz

Choose the correct answer from the options given below:

(A) $A \rightarrow I, B \rightarrow II, C \rightarrow III, D \rightarrow IV$

(B) $A \rightarrow IV, B \rightarrow III, C \rightarrow I, D \rightarrow II$

✓ (C) $A \rightarrow IV, B \rightarrow III, C \rightarrow II, D \rightarrow I$

(D) $A \rightarrow I, B \rightarrow II, C \rightarrow IV, D \rightarrow III$

Television signal → 6 MHz
Radio signal → 2 MHz
High quality music → 20 KHz
Human speech → 3 KHz

Q20: The velocity of sound in a gas, in which two wavelengths 4.08 m and 4.16 m produce 40 beats in 12 s, will be:

(A) $282.8\,ms^{-1}$

(B) $175.5ms^{-1}$

(C) $353.6ms^{-1}$

(D) $707.2ms^{-1}$ ✓

$\lambda_1 = 4.08$ mt

$\lambda_2 = 4.16$ mt

$f_1 = \frac{v}{\lambda_1}$, $f_2 = \frac{v}{\lambda_2}$

$= \frac{v}{4.08}$ $f_2 = \frac{v}{4.16}$

$f_1 - f_2 = \frac{40}{12}$

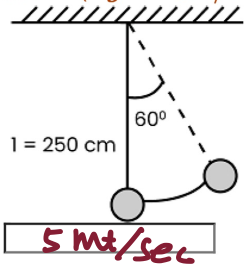
$\frac{v}{4.08} - \frac{v}{4.16} = \frac{40}{12} = 10/3$

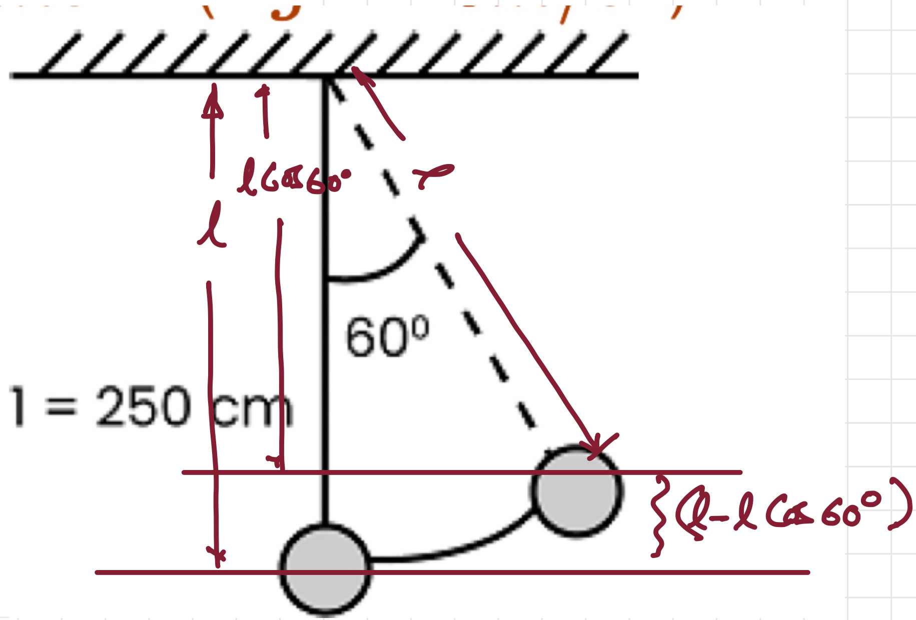
$v\left(\frac{1}{4.08} - \frac{1}{4.16}\right) = 10/3$

$v\left(\frac{4.16 - 4.08}{4.08 \times 4.16}\right) = 10/3$

$v = \frac{10}{3} \times \frac{4.08 \times 4.16}{.08} = 707.2\,ms^{-1}$

Q21: The pendulum is suspended by a string a length 250 cm. The mass of the bob of the pendulum is 200g. The bob is pulled aside until the string is at 60° with vertical as shown in the figure. After releasing the bob, the maximum velocity attained by the bob will be _______ ms^{-1}.(If $g = 10m/s^2$)



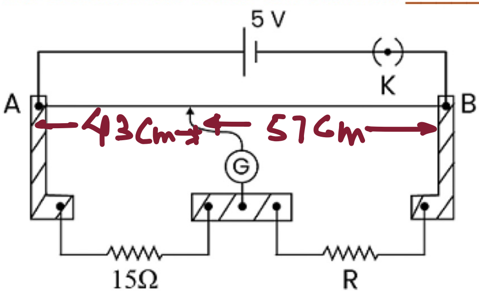


$$mg\,l(1-\cos 60^{\circ}) = \frac{1}{2}mv^2$$

$$gl\left(1-\frac{1}{2}\right) = \frac{v^2}{2}$$

$$\frac{gl}{2} = \frac{v^2}{2} \Rightarrow v = \sqrt{gl} = \sqrt{\frac{10 \times 250}{100}} = 5 \text{ mt/sec}$$

Q22: A meter bridge setup is shown in the figure. It is used to determine an unknown - resistance R. using a given resistor of 15Ωa The galvanometer (G) shows null deflection when tapping key is at 43 cm mark from end A. If the end correction for end A is 2 cm. then the determined value of R will be 19 ____ Ω

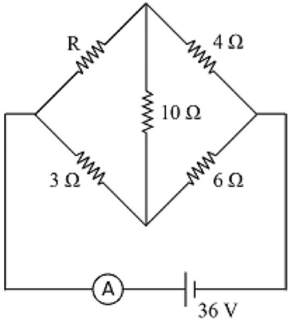


19-ohm

$$\frac{43 + \text{end correction}}{15} = \frac{57}{R}$$

$$R = \frac{57 \times 15}{45} = 19\text{-ohm}$$

Q23: Current measured by the ammeter (A) in the reported circuit when no current flows through 10Ω resistance. will be

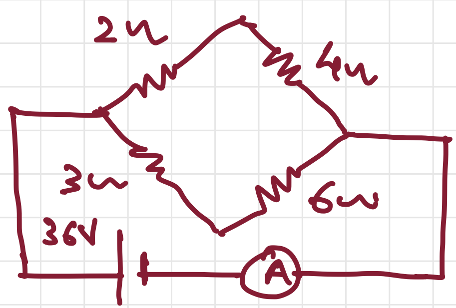


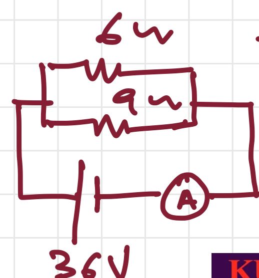
No current flows only when 10-ohm shows no current ie Balanced wheat stone bridge.

$$\frac{R}{3} = \frac{4}{6}$$

$$R = \frac{4 \times 3}{6} = 2\text{-ohm}$$

New circuit

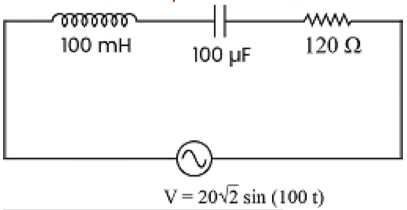




$$\Rightarrow \frac{6 \times 9}{6+9} = \frac{9 \times 6}{15} = 18/5$$

$$I = \frac{36 \times 5}{18} = 10A$$

Q24: An AC source is connected to an inductance of 100 mH. a capacitance of $100\mu F$ and a resistance of 120Ω as shown in figure. The time in which the resistance having a thermal capacity $2J/^{\circ}C$will get heated by 16°C is _______ s.



$$X_L = \omega L = 100 \times 100 \times 10^{-3} = 10\text{ ohm}$$

$$X_C = \frac{1}{\omega C} = \frac{1000000}{100 \times 100} = 100\text{ ohm}$$

$$X_C - X_L = 90\text{ ohm}$$

$$Z = \sqrt{(120)^2 + (90)^2} = 150\text{ ohm}$$

$$I = \frac{V}{Z} = \frac{20}{150} = \frac{2}{15}\text{ Amp}$$

$$\left(\frac{2}{15}\right)^2 (120) \times t = 2 \times 16$$

$$t = \frac{32 \times 15 \times 15}{2 \times 2 \times 120} = 15\text{ sec}$$

Q25: The position vector of 1 kg object is $\vec{r}\ (3\hat{i}-\hat{j})\ m$ and its velocity $\vec{v}=\left(3\hat{j}+\hat{k}\right) ms^{-1}$. The magnitude of its angular momentum is $\sqrt{x} Nm$ where x is

$$L = m(\vec{r} \times \vec{v})$$

$$\vec{r} \times \vec{v} = \begin{vmatrix} i & j & k \\ 3 & -1 & 0 \\ 0 & 3 & 1 \end{vmatrix}$$

$$= i\left((-1)(1)-0\right) + j\,(0-3) + \hat{k}\,(9-0)$$

$$= -\hat{i} - 3\hat{j} + 9\hat{k}$$

$$L = 1(-\hat{i} - 3\hat{j} + 9k)$$

$$|L| = \sqrt{1+9+81} = \sqrt{91} = \sqrt{x}$$

$$x = 91$$

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