# JEE MAIN 2024 SESSION-2
# Paper with Solution

**PHYSICS | 09th April 2024 _ Shift-1**

## SECTION – A

**31.** A light emitting diode (LED) is fabricated using GaAs semiconducting material whose band gap is 1.42 eV. The wavelength of light emitted from the LED is :

(1) 875 nm (2) 1400 nm (3) 1243 nm (4) 650 nm

**Sol.** **1**

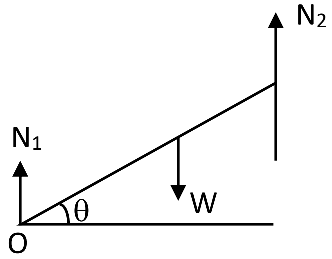
$\because E_{(ev)} = \dfrac{hc}{\lambda(A^o)}$

$\lambda\left(A^o\right) = \dfrac{hC}{E} = \dfrac{12430}{1.42} = 8753\ A^o = 875\ nm$

**32.** A heavy iron bar, of weight W is having its one end on the ground and the other on the shoulder of a person. The bar makes an angle θ with the horizontal. The weight experienced by the person is :

(1) $\dfrac{W}{2}$ (2) W sin θ (3) W (4) W cos θ

**Sol.** **1**




$\tau_0 = 0$

$W \times \dfrac{\ell}{2} \cos\theta = N_2 \times \ell \cos\theta$

$\boxed{N_2 = \dfrac{W}{2}}$

**33.** Given below are two statements :

**Statement (I) :** When currents vary with time, Newton's third law is valid only if momentum carried by the electromagnetic field is taken into account.

**Statement (II) :** Ampere's circuital law does not depend on Biot-Savart's law.

In the light of the above statements, choose the correct answer from the options given below :

(1) Both **Statement I** and **Statement II** are false

(2) **Statement I** is false but **Statement II** is true

(3) Both **Statement I** and **Statement II** are true

(4) **Statement I** is true but **Statement II** is false

**Sol.** **4**

Statement $I^{st}$ is true

Statement IInd is false as Ampere's law depends on Biot Savart's law.

**34.** A proton, an electron and an alpha particle have the same energies. Their de-Broglie wavelengths will be compared as :

(1) $\lambda_p > \lambda_e > \lambda_a$ (2) $\lambda_\alpha < \lambda_p < \lambda_e$ (3) $\lambda_p < \lambda_e < \lambda_\alpha$ (4) $\lambda_e > \lambda_\alpha > \lambda_p$

**Sol.** **2**

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mKE}}$$

KE is same for all.

$$\lambda \times \frac{1}{\sqrt{m}}$$

$m_e < m_p < m_\alpha$

$$\boxed{\lambda_e > \lambda_p > \lambda_\alpha}$$

**35.** A galvanmeter has a coil of resistance 200 Ω with a full scale deflection at 20 μA. The value of resistance to be added to use it as an ammeter of range (0-20) mA is :

(1) 0.50 Ω (2) 0.40 Ω (3) 0.20 Ω (4) 0.10 Ω

**Sol.** **3**

For Ammeter

$$i = i_g\left[1 + \frac{R_g}{S}\right]$$

$$20 \times 10^{-3} = 20 \times 10^{-6}\left[1 + \frac{200}{S}\right]$$

$$\frac{200}{S} = 999$$

$$S = \frac{200}{999} = 0.20\Omega$$

**36.** A bulb and a capacitor are connected in series across an AC supply. A dielectric is then placed between the plates of the capacitor. The glow of the bulb :

(1) remains same (2) decrease (3) increase (4) becomes zero

**Sol.** **3**

As dielectric is placed, capacitance will increase.

$$X_C = \frac{1}{C\omega}$$

So capacitive Reactance decreases. So impedance of circuit decreases. Hence current increases.
So power increases. So glow of the bulb increases.

**37.** A sphere of relative density σ and diameter D has concentric cavity of diameter d. The ratio of $\frac{D}{d}$, if it just floats on water in a tank is :

(1) $\left(\frac{\sigma-1}{\sigma}\right)^{1/3}$ (2) $\left(\frac{\sigma}{\sigma-1}\right)^{1/3}$ (3) $\left(\frac{\sigma-2}{\sigma+2}\right)^{1/3}$ (4) $\left(\frac{\sigma+1}{\sigma-1}\right)^{1/3}$

**Sol.** **2**

It just floats on water in a tank means.

$F_b = mg$ $[\rho_{sphere} = \sigma\rho_w]$

$$\rho_w g \frac{4}{3}\pi\frac{D^3}{8} = \sigma\rho_w g\frac{4\pi}{3\times 8}[D^3 - d^3]$$

on solving

$$\frac{D}{d} = \left(\frac{\sigma}{\sigma-1}\right)^{1/3}$$

**38.** The dimensional formula of latent heat is :

(1) $[MLT^{-2}]$ (2) $[ML^2T^{-2}]$ (3) $[M^oLT^{-2}]$ (4) $[M^oL^2T^{-2}]$

**Sol.** **4**

Q = mxL.

$$[L]=\left[\frac{ML^2T^{-2}}{M}\right]=\left[M^oL^2T^{-2}\right]$$

**39.** An astronaut takes a ball of mass m from earth to space. He throws the ball into a circular orbit about earth at an altitude of 318.5 km. From earth's surface to the orbit, the change in total mechanical energy of the ball is $x\frac{GM_em}{21R_e}$. The value of $x$ is (take $R_e$ = 6370 km) :

(1) 11 (2) 10 (3) 9 (4) 12

**Sol.** **1**

$\because$ Total mechanical energy = $\frac{PE}{2}$ $\left(\because \frac{R_e}{20}=318.5\right)$

ME on surface of earth = $\frac{-GM_em}{R_e}$ (KE on surface =0)

ME at an altitude $=\frac{-GM_em}{2\left(R_e+\frac{R_e}{20}\right)}=-\frac{20GM_em}{2\times 21R_e}$

$=\frac{-10Gm_em}{21R_e}$

Change in Total M.E. = $E_f - E_i$

$=-\frac{10GM_em}{21R_e}+\frac{GM_em}{Re}$

$=\frac{-10GM_em+21GM_em}{21R_e}=\frac{11GM_em}{21R_e}$

x = 11

**40.** The volume of an ideal gas ($\gamma$ = 1.5) is changed adiabatically from 5 litres to 4 litres. The ratio of initial pressure to final pressure is :

(1) $\frac{4}{5}$ (2) $\frac{8}{5\sqrt{5}}$ (3) $\frac{16}{25}$ (4) $\frac{2}{\sqrt{5}}$

**Sol.** **2**

$\because$ For adiabatic process

$Pv^{\gamma}=k$

$P_1v_1^{3/2}=P_2V_2^{3/2}$

$P_1\times(5)^{3/2}=P_2\times(4)^{3/2}$

$$\frac{P_1}{P_2}=\left(\frac{4}{5}\right)^{3/2}=\frac{(2)^3}{(125)^{1/2}}=\frac{8}{5\sqrt{5}}$$

**41.** Given below are two statements :

**Statement (I) :** When an object is placed at the centre of curvature of a concave lens, image is formed at the centre of curvature of the lens on the other side.

**Statement (II) :** Concave lens always forms a virtual and erect image.

In the light of the above statements, choose the correct answer from the options given below :

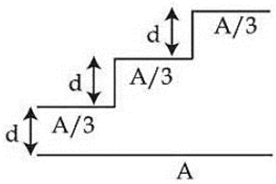
(1) Both **Statement I** and **Statement II** are true
(2) Both **Statement I** and **Statement II** are false
(3) **Statement I** is false but **Statement II** is true
(4) **Statement I** is true but **Statement II** is false

**Sol.** **3**

Statement – I $\rightarrow$ False. (Image is formed on same side not on other side).

Statement – II $\rightarrow$ True (As object is real it's virtual & erect image is formed)

**42.** A capacitor is made of a flat plate of area A and a second plate having a stair-like structure as shown in figure. If the area of each stair is $\frac{A}{3}$ and the height is d, the capacitance of the arrangement is :




(1) $\frac{18\epsilon_o A}{11d}$ (2) $\frac{11\epsilon_o A}{20d}$ (3) $\frac{13\epsilon_o A}{17d}$ (4) $\frac{11\epsilon_o A}{18d}$

**Sol.** **4**

All capacitors are in parallel.

$C_{eq} = C_1 + C_2 + C_3$

$$= \frac{\epsilon_0 A}{3\times d} + \frac{\epsilon_0 A}{3\times 2d} + \frac{\epsilon_0 A}{3\times 3d}$$

$$= \frac{6\epsilon_0 A + 3\epsilon_0 A + 2\epsilon_0 A}{18d} = \frac{11\epsilon_0 A}{18d}$$

**43.** One main scale division of a vernier caliper is equal to m units. If $n^{th}$ division of main scale coincides with $(n+1)^{th}$ division of vernier scale, the least count of the vernier caliper is :

(1) $\frac{1}{(n+1)}$ (2) $\frac{n}{(n+1)}$ (3) $\frac{m}{n(n+1)}$ (4) $\frac{m}{(n+1)}$

**Sol.** **4**

1MSD – m units

(n + 1) VSD = n MSD

$$1VSD = \left(\frac{n}{n+1}\right)MSD$$

$$= \frac{n}{(n+1)} \times m \text{ units}$$

$$L.C. = 1MSD - 1VSD = m - \frac{nm}{n+1}$$

$$= \frac{mn + m - nm}{n+1} = \left(\frac{m}{n+1}\right)\text{units}$$

**44.** The energy equivalent of 1 g of substance is :

(1) $11.2 \times 10^{24}$ MeV (2) $5.6 \times 10^{26}$ MeV (3) 5.6 eV (4) $5.6 \times 10^{12}$ MeV

**Sol.** **2**

$E = 10^{-3} \times 9 \times 10^{16}$ J $(\because\ E = MC^2)$

$E = 9 \times 10^{13}$J

$$1J = \frac{1}{1.6\times10^{-19}} ev$$

$$E = 9\times10^{13}\times\frac{1}{1.6\times10^{-19}} ev = 5.6\times10^{26} Mev$$

**45.** A plane EM wave is propagating along $x$ direction. It has a wavelength of 4 mm. If electric field is in y direction with the maximum magnitude of 60 $Vm^{-1}$, the equation for magnetic field is :

(1) $B_z = 2\times10^{-7}\sin\left[\frac{\pi}{2}\times10^3\left(x-3\times10^8 t\right)\right]kT$ (2) $B_z = 60\sin\left[\frac{\pi}{2}\left(x-3\times10^8 t\right)\right]kT$

(3) $B_x = 60\sin\left[\frac{\pi}{2}\left(x-3\times10^8 t\right)\right]\hat{i}T$ (4) $B_z = 2\times10^{-7}\sin\left[\frac{\pi}{2}\left(x-3\times10^8 t\right)\right]kT$

**Sol.** **1**

$\lambda = 4mm = 4 \times 10^{-3}$ m

$$K = \frac{2\pi}{4\times10^{-3}} = \frac{\pi}{2}\times10^3.m^{-1}$$

$$w = v\times K = 3\times10^8\times\frac{\pi}{2}\times10^3 = \frac{3\pi}{2}\times10^{11}$$

$$\hat{E}\times\hat{B} = \hat{C}\ \&\ B_0 = \frac{E_0}{C} = 2\times10^{-7}T$$

$$B_z = 2\times10^{-7}\sin\left[\frac{\pi}{2}\times10^3\left[x-3\times10^8 t\right]\right]\hat{k}T$$

**46.** A light unstretchable string passing over a smooth light pulley connects two blocks of masses $m_1$ and $m_2$. If the acceleration of the system is $\frac{g}{8}$, then the ratio of the masses $\frac{m_2}{m_1}$ is :

(1) 4 : 3 (2) 5 : 3 (3) 8 : 1 (4) 9 : 7

**Sol.** **4**

$$a_c = \frac{(m_2-m_1)g}{(m_1+m_2)}$$

$$\frac{g}{8} = \left(\frac{m_2-m_1}{m_1+m_2}\right)g$$

$$\frac{1}{8} = \left(\frac{\frac{m_2}{m_1}-1}{\frac{m_2}{m_1}+1}\right)$$

$$\frac{m_2}{m_1}+1 = 8\frac{m_2}{m_1}-8 \Rightarrow \frac{7m_2}{m_1} = 9$$

$$\boxed{\frac{m_2}{m_1} = \frac{9}{7}}$$

**47.** A particle of mass m moves on a straight line with its velocity increasing with distance according to the equation $v = \alpha\sqrt{x}$, where $\alpha$ is a constant. The total work done by all the forces applied on the particle during its displacement from x = 0 to x = d, will be :

(1) $\frac{m}{2\alpha^2 d}$ (2) $\frac{md}{2\alpha^2}$ (3) $\frac{m\alpha^2 d}{2}$ (4) $2m\alpha^2 d$

**Sol.** **3**

$WD = \int \vec{F}.\vec{dx}$

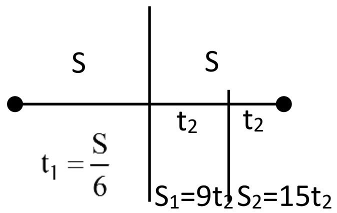
$a = \frac{vdv}{dx} = \alpha\sqrt{x} \times \frac{\alpha 1}{2\sqrt{x}} = \frac{\alpha^2}{2}$

$WD = \int_0^d \frac{m\alpha^2}{2}.dx = \frac{m\alpha^2 d}{2}$

**48.** A particle moving in a straight line covers half the distance with speed 6 m/s. The other half is covered in two equal time intervals with speeds 9 m/s and 15 m/s respectively. The average speed of the particle during the motion is :

(1) 8.8 m/s (2) 8 m/s (3) 9.2 m/s (4) 10 m/s

**Sol.** **2**




$S_1 + S_2 = S = 24t_2$

$t_2 = \frac{S}{24}$

average speed $= \frac{2S}{t_1 + 2t_2} = \frac{2S}{\frac{S}{6} + \frac{S}{12}} = 8m/s$

**49.** A sample of 1 mole gas at temperature T is adiabatically expanded to double its volume. If adiabatic constant for the gas is $\gamma = \frac{3}{2}$, then the work done by the gas in the process is:

(1) $RT\left[2-\sqrt{2}\right]$ (2) $RT\left[2+\sqrt{2}\right]$ (3) $\frac{T}{R}\left[2+\sqrt{2}\right]$ (4) $\frac{R}{T}\left[2-\sqrt{2}\right]$

**Sol.** **1**

WD by gas in adiabatic process $= \frac{P_2v_2 - P_1v_1}{1-\gamma}$

OR

$\frac{nR\left[T_2 - T_1\right]}{1-\gamma}$

$T_1v_1^{\gamma-1} = T_2v_2^{\gamma-1}$

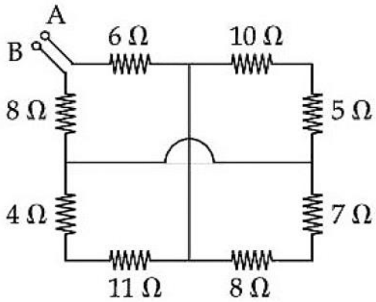
$$T \times v^{\frac{1}{2}} = T_2 \times (2v)^{1/2}$$

$$T_2 = \frac{T}{\sqrt{2}}$$

$$WD = \frac{R\left[\frac{T}{\sqrt{2}} - T\right]}{1 - \frac{3}{2}} = \frac{2R}{\sqrt{2}}\left[\sqrt{2}T - T\right]$$

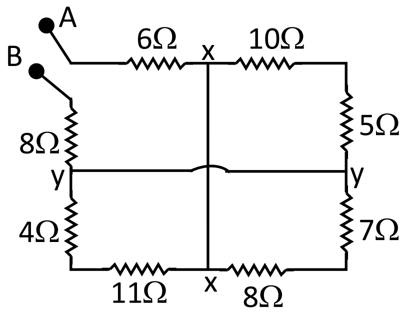
$$= RT\left[2 - \sqrt{2}\right]$$

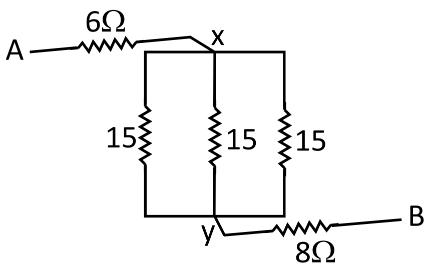
**50.** The equivalent resistance between A and B is :




(1) 27 Ω (2) 19 Ω (3) 25 Ω (4) 18 Ω

**Sol.** **2**




$R_{eq} = 5\Omega + 6\Omega + 8\Omega$

$= 19\Omega$

## SECTION – B

**51.** When a coil is connected across a 20 V dc supply, it draws a current of 5 A. When it is connected across 20 V, 50 Hz ac supply, it draws a current of 4 A. The self inductance of the coil is _______ mH. (Take $\pi = 3$)

**Sol.** **10**

In DC circuit

$$I = \frac{V}{R} \text{ (at steady state)}$$

$$R = \frac{20}{5} = 4\Omega$$

In AC CKt

$$I = \frac{V}{Z}$$

$$4 = \frac{20}{\sqrt{R^2 + (L\omega)^2}}$$

$16 + (L\omega)^2 = 25$

$L\omega = 3$

$$L = \frac{3}{2\times\pi\times f} = \frac{3}{2\times3\times50} = \frac{1}{100} = 10\,mH$$

**52.** A star has 100% helium composition. It starts to convert three $^4He$ into one $^{12}C$ via triple alpha process as $^4He + {}^4He + {}^4He \rightarrow {}^{12}C + Q$. The mass of the star is $2.0 \times 10^{32}$ kg and it generates energy at the rate of $5.808 \times 10^{30}$ W. The rate of converting these $^4He$ to $^{12}C$ is $n \times 10^{42}\ s^{-1}$, where n is __________.

[Take, mass of $^4He$ = 4.0026 u, mass of $^{12}C$ = 12 u]

**Sol.** **5**

$$3\,{}^4_2He \rightarrow {}^{12}_6C + Q$$

Power generated = $\frac{N}{t}Q$ (N = No. of reactions/sec)

$Q = (3m_{4He} - m_{12c})C^2$

$Q = (3 \times 4.0026 - 12)\ C^2 = 7.266$ Mev

$$\frac{N}{t} = \frac{power}{Q} = \frac{5.808\times10^{30}}{7.266\times10^6\times1.6\times10^{-19}} = 15\times10^{42}$$

rate of conversion of $^4He$ in $^{12}C = 5 \times 10^{42}$

**53.** At the centre of a half ring of radius R = 10 cm and linear charge density 4n $Cm^{-1}$, the potential is x $\pi$ V. The value of x is _________.

**Sol.** **36**

$$V = \frac{KQ}{R} = \frac{9\times10^9\times4\times10^{-9}\times\pi\times10\times10^{-2}}{10\times10^{-2}}$$

$= 36\ \pi\ \nu$

**54.** If $\vec{a}$ and $\vec{b}$ makes an angle $\cos^{-1}\left(\frac{5}{9}\right)$ with each other, then $|\vec{a}+\vec{b}|=\sqrt{2}|\vec{a}-\vec{b}|$ for $|\vec{a}|=n|\vec{b}|$ The integer value of n is ________.

**Sol. 3**

Angle b/w $\vec{a}$ and $\vec{b}$ is $\cos^{-1}\left(\frac{5}{9}\right)$

$$\left|\vec{a}+\vec{b}\right|=\sqrt{2}\left|\vec{a}-\vec{b}\right|$$

$$a^2+b^2+2ab\cos\theta = 2(a^2+b^2-2ab\cos\theta)$$

$$n^2\cancel{b^2}+\cancel{b^2}+2n\cancel{b^2}\times\frac{5}{9}=2n^2\cancel{b^2}+2\cancel{b^2}-4n\cancel{b^2}\times\frac{5}{9}$$

$$n^2+1+\frac{10n}{9}=2n^2+2-\frac{20n}{9}$$

$$n^2-\frac{30n}{9}+1=0$$

$$9n^2-30n+9=0$$

$$n=3,\frac{1}{3}$$

**55.** In a Young's double slit experiment, the intensity at a point is $\left(\frac{1}{4}\right)^{th}$ of the maximum intensity, the minimum distance of the point from the central maximum is __________ μm.
(Given : $\lambda$ = 600 nm, d = 1.0 mm, D = 1.0 m)

**Sol. 200**

$$I=I_0\cos^2\frac{\Delta\phi}{2}$$

$$\frac{I_0}{4}=I_0\cos^2\frac{\Delta\phi}{2}$$

$$\Delta\phi=\frac{\cancel{2}\pi}{3}=\frac{\cancel{2}\pi}{\lambda}(\Delta n)$$

$$\frac{dy}{D}=\frac{600\times10^{-9}}{3}$$

$$y=\frac{2\times10^{-7}\times1}{10^{-3}}=2\times100\mu m$$

= 200 μm

**56.** A square loop of edge length 2 m carrying current of 2 A is placed with its edges parallel to the x-y axis. A magnetic field is passing through the x-y plane and expressed as $\vec{B} = B_o(1+4x)\hat{k}$, where $B_o$ = 5 T. The net magnetic force experienced by the loop is ___________ N.

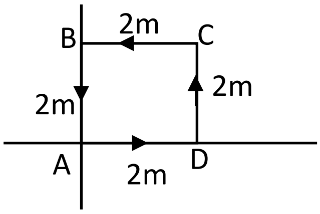
**Sol.** **160**

$F_{net}$ on AD & CB = 0

$F_{net}$ AB = 2 × 2 × 5 = 20 N $\left(-\hat{i}\right)$

$F_{net}$ DC = 2 × 2 × 45 = 180 N $\left(\hat{i}\right)$

$F_{net}$ = 160N $\left(\hat{i}\right)$




**57.** The position, velocity and acceleration of a particle executing simple harmonic motion are found to have magnitudes of 4 m, 2 ms$^{-1}$ and 16 ms$^{-2}$ at a certain instant. The amplitude of the motion is $\sqrt{x}$ , m where x is __________.

**Sol.** **17**

X = 4m

$2 = \omega\sqrt{A^2 - X^2} = \omega\sqrt{A^2 - 16} \Rightarrow 4 = \omega^2\left(A^2 - 16\right)$

$16 = \omega^2 \times 4 \Rightarrow \omega^2 = 4 \Rightarrow \boxed{\omega = 2}$

$\cancel{4} = \cancel{4}\left[A^2 - 16\right]$

$1 = A^2 - 16$

$A^2 = 17$

$\boxed{A = \sqrt{17}}$

**58.** A string is wrapped around the rim of a wheel of moment of inertia 0.40 kgm$^2$ and radius 10 cm. The wheel is free to rotate about its axis. Initially the wheel is at rest. The string is now pulled by a force of 40 N. The angular velocity of the wheel after 10 s is x rad/s, where x is _________.

**Sol.** **100**

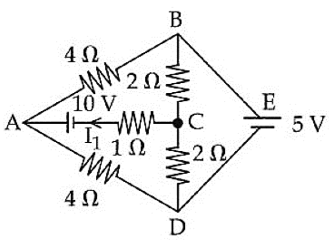
$\tau = I\alpha$

$\frac{10}{100} \times 40 = 4 \times \alpha$

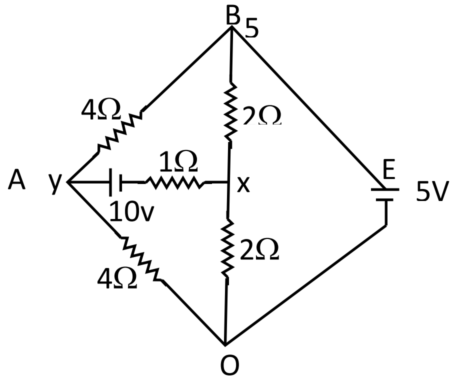
$\alpha = \frac{4}{0.4} = 10 \text{ rad/S}^2$

$w_f$ = 0 + 10 × 10 = 100 rad/sec.

**59.** The current flowing through the 1 Ω resistor is $\frac{n}{10}$ A. The value of n is ________.



**Sol.** **25**




$$\frac{x-5}{2}+\frac{x-0}{2}+\frac{x-(y-10)}{1}=0$$

$x - 5 + x + 2x - 2y + 20 = 0$

$15 = 2y - 4x$ ...(1)

$$\frac{y-5}{4}+\frac{y-0}{4}+\frac{y-10-x}{1}=0 \quad y - 5 + y + 4y - 40 - 4x = 0$$

$6y - 4x = 45$ ...(2)

on solving (1) and (2)

$(x = 0, y = 7.5v)$ $i = 0-\frac{(y-10)}{1}$

$\boxed{i = 2.5A}$

**60.** Two persons pull a wire towards themselves. Each person exerts a force of 200 N on the wire. Young's modulus of the material of wire is $1 \times 10^{11}$ N m$^{-2}$. Original length of the wire is 2 m and the area of cross section is 2 cm$^2$. The wire will extend in length by __________ μm.

**Sol.** **20**

$$y=\frac{F\ell}{A\Delta\ell}$$

$$\Delta\ell=\frac{F\ell}{Ay}$$

$$=\frac{200\times 2}{2\times 10^{-4}\times 10^{11}}=200\times 10^{4}\times 10^{-11}$$

$= 2 \times 10^{-5}$

$= 20\mu m$

MOTION

JEE MAIN 2024
SESSION-2

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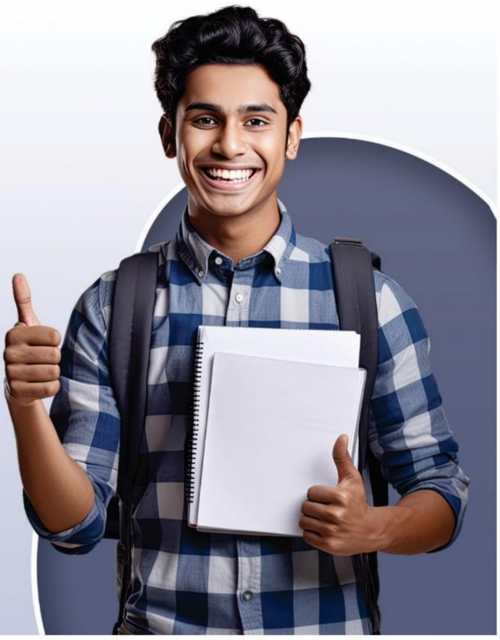

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**Produced by MOTION Faculties**

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- **AIR-1 to 10** — 25 Times
- **AIR-11 to 50** — 84 Times
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### JEE MAIN+ADVANCED

- **AIR-1 to 10** — 8 Times
- **AIR-11 to 50** — 37 Times
- **AIR-51 to 100** — 41 Times

## Nation's Best **SELECTION**
**Percentage (%) Ratio**

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(2023)
6492/7084 = **91.64%**
(2022)
4837/5356 = **90.31%**

**Student Qualified in JEE ADVANCED**

(2023)
2747/5182 = **53.01%**
(2022)
1756/4818 = **36.45%**

**Student Qualified in JEE MAIN**

(2024-First Attemp)
6495/10592 = **61.31%**
(2023)
5993/8497 = **70.53%**
(2022)
4818/6653 = **72.41%**

NITIN VIJAY (NV Sir)
Founder & CEO

**MOTION**

Revise