JEE MAIN 2023
Paper with Solution

PHYSICS | 31st Jan 2023 _ Shift-1

Umeed Rank Ki Ho Ya Selection Ki, JEET NISCHIT HAI!

Most Promising RANKS
Produced by MOTION Faculties

NEET / AIIMS

- AIR-1 to 10 — 25 Times
- AIR-11 to 50 — 83 Times
- AIR-51 to 100 — 81 Times

JEE MAIN+ADVANCED

- AIR-1 to 10 — 8 Times
- AIR-11 to 50 — 32 Times
- AIR-51 to 100 — 36 Times

Nation's Best SELECTION
Percentage (%) Ratio

Student Qualified in NEET

(2022)
4837/5356 = 90.31%
(2021)
3276/3411 = 93.12%

Student Qualified in JEE ADVANCED

(2022)
1756/4818 = 36.45%
(2021)
1256/2994 = 41.95%

Student Qualified in JEE MAIN

(2022)
4818/6653 = 72.41%
(2021)
2994/4087 = 73.25%

NITIN VIIJAY (NV Sir)
Founder & CEO

SECTION - A

1. The maximum potential energy of a block executing simple harmonic motion is 25 J. A is amplitude of oscillation. At $A/2$, the kinetic energy of the block is :

(1) 18.75 J (2) 9.75 J (3) 37.5 J (4) 12.5 J

Sol. **(1)**

Total Energy in SHM, $E = \frac{1}{2}m\omega^2A^2 = 25J$

$\text{at}\frac{A}{2}, U = PE = \frac{1}{2}m\omega^2x^2$

$U = \frac{1}{2}m\omega^2\left(\frac{A}{2}\right)^2$

$k + U = E$

$k = \frac{1}{2}m\omega^2A^2\left(1 - \frac{1}{4}\right)$

$k = 25 \times \frac{3}{4} = 18.75J$

2. The drift velocity of electrons for a conductor connected in an electrical circuit is V_d. The conductor in now replaced by another conductor with same material and same length but double the area of cross section. The applied voltage remains same. The new drift velocity of electrons will be

(1) V_d (2) $\frac{V_d}{4}$ (3) 2 V_d (4) $\frac{V_d}{2}$

Sol. **(1)**

$V = IR = I\left(\frac{\rho l}{A}\right)$

$A \rightarrow 2A$

$I \rightarrow 2I$

$I = AneV_d$

$V_d \propto \frac{I}{A}$

3. The initial speed of a projectile fired from ground is u. At the highest point during its motion, the speed of projectile is $\frac{\sqrt{3}}{2}u$. The time of flight of the projectile is :

(1) $\frac{2u}{g}$ (2) $\frac{u}{2g}$ (3) $\frac{\sqrt{3}u}{g}$ (4) $\frac{u}{g}$

Sol. **(4)**

At highest point -

$u\cos\theta = \frac{\sqrt{3}u}{2}$

$\theta = 30^\circ$

$T = \frac{2u\sin\theta}{g} = \frac{u}{g}$

4. The correct relation between $\gamma = \frac{c_p}{c_v}$ and temperature T is :

(1) $\gamma \alpha T^0$ (2) $\gamma \alpha T$ (3) $\gamma \alpha \frac{1}{\sqrt{T}}$ (4) $\gamma \alpha \frac{1}{T}$

Sol. **(1)**

$\gamma = \frac{C_p}{C_v}$, Independent on T

5. The effect of increase in temperature on the number of electrons in conduction band (n_e) and resistance of a semiconductor will be as:

(1) Both n_e and resistance increase (2) Both n_e and resistance decrease

(3) n_e decreases, resistance increases (4) n_e increases, resistance decreases

Sol. **(4)**

In semi conductors,

$T \uparrow, n_e$ in Conduction Band increases

$T \uparrow, R \downarrow$

6. The amplitude of $15\sin(1000\pi t)$ is modulated by $10\sin(4\pi t)$ signal. The amplitude modulated signal contains frequency (ies) of

A. 500 Hz B. 2 Hz C. 250 Hz D. 498 Hz E. 502 Hz

Choose the correct answer from the options given below:

(1) A Only (2) B Only (3) A and *B* Only (4) A, D and E Only

Sol. **(4)**

$f_c = \frac{1000\pi}{2\pi} = 500\text{Hz}$

$f_m = \frac{4\pi}{2\pi} = 2\text{Hz}$

Upper side Band, $USB = f_c + f_m$

$USB = 502HZ$

Lower side Band, $LSB = f_c - f_m$

$LSB = 498\text{Hz}$

7. Two polaroide A and B are placed in such a way that the pass-axis of polaroids are perpendicular to each other. Now, another polaroid *C* is placed between *A* and *B* bisecting angle between them. If intensity of unpolarized light is I_0 then intensity of transmitted light after passing through polaroid B will be:

(1) $\frac{I_0}{4}$ (2) $\frac{I_0}{2}$ (3) Zero (4) $\frac{I_0}{8}$

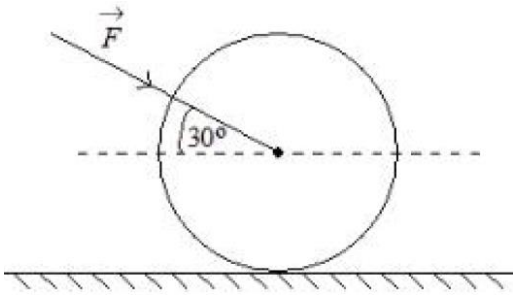
Sol. **(4)**

After A, $I = \frac{I_\circ}{2}$

After C, $I = \frac{I_0}{2}\cos^2 45^\circ = \frac{I_0}{4}$

After B, $I = \frac{I_0}{4}\cos^2 45^\circ = \frac{I_0}{8}$

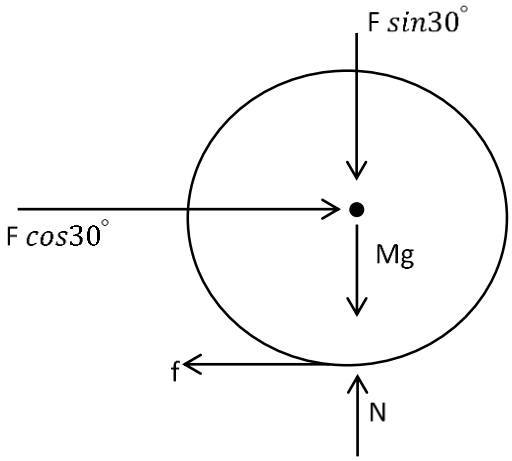
8. As shown in figure, a 70 kg garden roller is pushed with a force of $\vec{F} = 200$ N at an angle of 30° with horizontal. The normal reaction on the roller is
(Given g = 10 m s^{-2})



(1) $800\sqrt{2}$ N (2) $200\sqrt{3}$ N (3) 600 N (4) 800 N

Sol. **(4)**

FBD of Sphere $\Rightarrow$



N= Mg + F$sin30^\circ$

N= 700 +200 $sin30^\circ$

N= 800 N

9. If 1000 droplets of water of surface tension 0.07 N/m, having same radius 1 mm each, combine to from a single drop. In the process the released surface energy is-
(Take $\pi = \frac{22}{7}$)

(1) 8.8×10^{-5} J (2) 7.92×10^{-4} J (3) 7.92×10^{-6} J (4) 9.68×10^{-4} J

Sol. **(2)**

$V_1 = V_2$

$1000 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$R = 10r$

$E = U_1 - U_2$

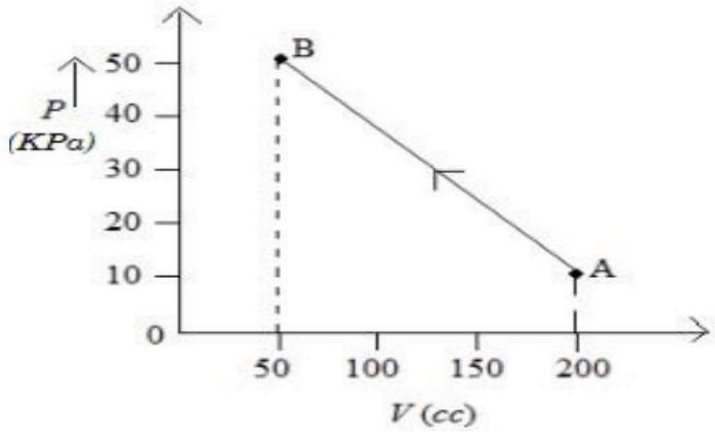
$= 1000\left(T \times 4\pi r^2\right) - T \times 4\pi R^2$

$E = 4\pi T\left(1000 \times r^2 - 100r^2\right)$

$E = 4 \times \frac{22}{7} \times 0.07 \times 900 \times 10^{-6}$

$E = 7.92 \times 10^{-4}\,J$

10. The pressure of a gas changes linearly with volume from *A* to *B* as shown in figure. If no heat is supplied to or extracted from the gas then change in the internal energy of the gas will be



(1) −4.5 J (2) zero (3) 4.5 J (4) 6 J

Sol. **C**

W = Area of *PV* Graph

$W = -\frac{1}{2} \times [50 + 10] \times 10^3 \times 150 \times 10^{-6}$

$W = -4.5J$

$Q = \Delta U + W$

$0 = \Delta U - 4.5$

$= \Delta U = 4.5J$

11. Given below are two statements: One is labelled as Assertion **A** and the other is labelled as Reason **R**
Assertion A: The beam of electrons show wave nature and exhibit interference and diffraction.
Reason R: Davisson Germer Experimentally verified the wave nature of electrons.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Both A and R are correct and R is the correct explanation of A
(2) A is not correct but R is correct
(3) A is correct but R is not correct
(4) Both A and R are correct but R is Not the correct explanation of A

Sol. **(1)**

Theoritical

12. A free neutron decays into a proton but a free proton does not decay into neutron. This is because
(1) proton is a charged particle
(2) neutron is an uncharged particle
(3) neutron is a composite particle made of a proton and an electron
(4) neutron has larger rest mass than proton

Sol. **(4)**

Rest mass of neutron is greater than proton.

13. Spherical insulating ball and a spherical metallic ball of same size and mass are dropped from the same height. Choose the correct statement out of the following Assume negligible air friction}
(1) Insulating ball will reach the earth's surface earlier than the metal ball
(2) Metal ball will reach the earth's surface earlier than the insulating ball
(3) Both will reach the earth's surface simultaneously.
(4) Time taken by them to reach the earth's surface will be independent of the properties of their materials

Sol. **(1)**

In Conductor, A portion of the Gravitational Potential Energy goes into generating eddy current.

14. If R, X_L, and X_C represent resistance, inductive reactance and capacitive reactance. Then which of the following is dimensionless :

(1) $\frac{R}{X_L X_C}$ (2) $\frac{R}{\sqrt{X_L X_C}}$ (3) $R\frac{X_L}{X_C}$ (4) $RX_L\,X_C$

Sol. **(2)**

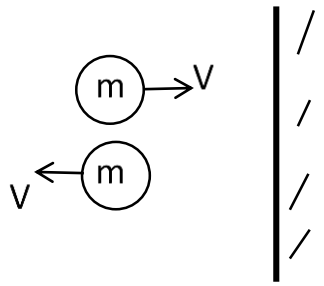
R, X_L, X_C have same unit i.e. ohm

$$\frac{R}{\sqrt{X_L X_C}} \rightarrow \frac{ohm}{\sqrt{ohm^2}} \rightarrow \text{Dimensionless}$$

15. 100 balls each of mass m moving with speed v simultaneously strike a wall normally and reflected back with same speed, in time t sec. The total force exerted by the balls on the wall is

(1) $\frac{100mv}{t}$ (2) $200mvt$ (3) $\frac{mv}{100t}$ (4) $\frac{200mv}{t}$

Sol. **(4)**



Change in momentum,

$|\overrightarrow{\Delta p}| = 2mV$

Average force,

$$F_{avg} = N\frac{|\overrightarrow{\Delta p}|}{t}$$

$$F_{avg} = 100\left(\frac{2mV}{t}\right)$$

$$F_{avg} = \frac{200mV}{t}$$

16. If a source of electromagnetic radiation having power 15 kW produces 10^{16} photons per second, the radiation belongs to a part of spectrum is.
(Take Planck constant h = 6×10^{-34}Js)
(1) Micro waves (2) Ultraviolet rays (3) Gamma rays (4) Radio waves

Sol. **(3)**

$$P = \frac{N}{t}\left(\frac{hc}{\lambda}\right)$$

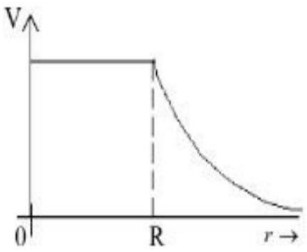
$$15\times10^{3} = 10^{16} \times \frac{6\times10^{-34}\times3\times10^{8}}{\lambda}$$

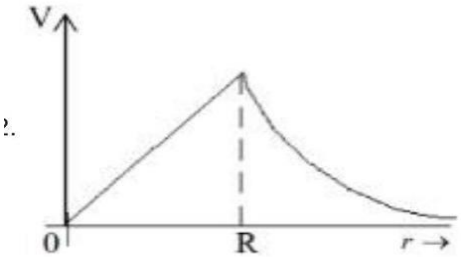
$$\lambda = 1.2\times10^{-13}\,m$$

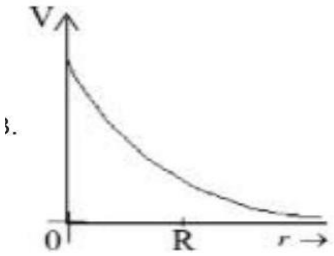
$$\lambda = 0.0012A^{0}$$

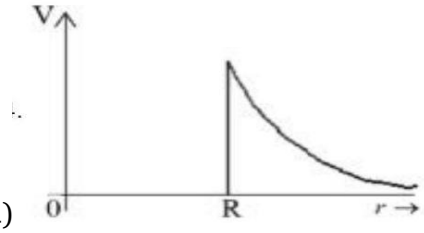
Corresponds to Gamma rays

17. Which of the following correctly represents the variation of electric potential (V) of a charged spherical conductor of radius (R) with radial distance (r) from the center?

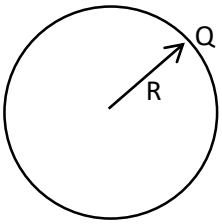
(1) 

(2) 

(3) 

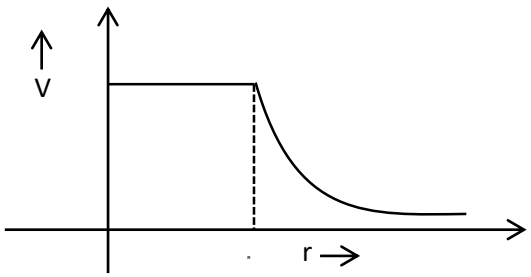
(4) 

Sol. **(1)**



$$V_{in} = \frac{kQ}{R} \rightarrow \text{Constant}$$

$$V_{out} = \frac{kQ}{r} \propto \frac{1}{r}$$



18. A bar magnet with a magnetic moment 5.0Am^2 is placed in parallel position relative to a magnetic field of 0.4 T. The amount of required work done in turning the magnet from parallel to antiparallel position relative to the field direction is _____.

(1) 1 J (2) 4 J (3) 2 J (4) zero

Sol. **(2)**

$W = MB\left(\cos\theta_1 - \cos\theta_2\right)$

$W = MB\left(\cos 0^\circ - \cos 180^\circ\right)$

$W = 2MB$

$W = 2\times 5\times 0.4$

$W = 4\text{J}$

19. At a certain depth "d " below surface of earth, value of acceleration due to gravity becomes four times that of its value at a height $3R$ above earth surface. Where R is Radius of earth (Take $R = 6400$ km). The depth d is equal to

(1) 4800 km (2) 2560 km (3) 640 km (4) 5260 km

Sol. **(A)**

Given

$$g\left(1-\frac{d}{R}\right) = 4\frac{g}{\left(1+\frac{h}{R}\right)^2}$$

$$1-\frac{d}{R} = \frac{4}{(1+3)^2} = \frac{1}{4}$$

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

$$d = \frac{3R}{4} = \frac{3}{4}\times 6400$$

$$d = 4800\text{km}$$

20. A rod with circular cross-section area 2 cm^2 and length 40 cm is wound uniformly with 400 turns of an insulated wire. If a current of 0.4 A flows in the wire windings, the total magnetic flux produced inside windings is $4\pi \times 10^{-6}$ Wb. The relative permeability of the rod is

(Given : Permeability of vacuum $\mu_0 = 4\pi \times 10^{-7}\text{NA}^{-2}$)

(1) $\frac{5}{16}$ (2) 12.5 (3) 125 (4) $\frac{32}{5}$

Sol. **(1)**

NTA Ans. (3)

Magnetic field in the Solenoid,

$\text{B} = \mu_0\mu_r\text{nI}$

Magnetic flux, $\phi = \text{N}(\text{BA})$

$\phi = N\left(\mu_0\mu_r nIA\right)$

$$4\pi\times 10^{-6} = 400\left(4\pi\times 10^{-7}\mu_\gamma \times \frac{400}{0.4}\times 0.4\times 2\times 10^{-4}\right)$$

$$\frac{1}{40} = \mu_r \times 8\times 10^{-2}$$

$$\mu_r = \frac{100}{320} = \frac{5}{16}$$

SECTION - B

21. In a medium the speed of light wave decreases to 0.2 times to its speed in free space The ratio of relative permittivity to the refractive index of the medium is $x:1$. The value of x is (Given speed of light in free space $= 3 \times 10^8$ m s^{-1} and for the given medium $\mu_r = 1$)

Sol. **(5)**

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

$n \rightarrow$ refractive index

$$n = \frac{c}{0.2c} = 5$$

$$n = \sqrt{\mu_r \varepsilon_r}$$

$$\varepsilon_r = n^2 = 25$$

$$\frac{\varepsilon_r}{n} = \frac{25}{5} = \frac{5}{1}$$

22. A solid sphere of mass 1 kg rolls without slipping on a plane surface. Its kinetic energy is 7×10^{-3} J. The speed of the centre of mass of the sphere is _____ cms^{-1}

Sol. **(10)**

On Rolling,

$$KE = \frac{1}{2}MV^2 + \frac{1}{2}I\omega^2$$

$$KE = \frac{1}{2}MV^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v}{R}\right)^2$$

$$KE = \frac{7}{10}MV^2 = 7\times10^{-3}$$

$$V^2 = 10^{-2}$$

$$V = 10^{-1}\text{m/s}$$

$$V = 10\text{cm/s}$$

23. A lift of mass $M = 500$ kg is descending with speed of 2 ms^{-1}. Its supporting cable begins to slip thus allowing it to fall with a constant acceleration of 2 ms^{-2}. The kinetic energy of the lift at the end of fall through to a distance of 6 m will be _____ kJ.

Sol. **(7)**

Acceleration is constant,

$$v^2 = u^2 + 2as$$

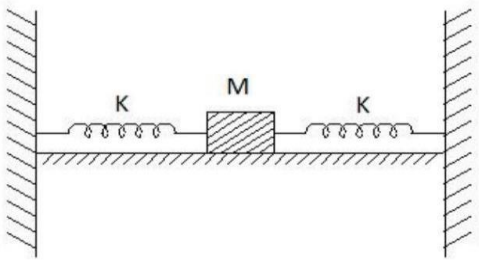
$$v^2 = 2^2 + 2(2)(6)$$

$$v^2 = 28$$

$$\frac{1}{2}Mv^2 = \frac{1}{2}\times500\times28$$

$$KE = 7kJ$$

24. In the figure given below, a block of mass $M = 490$ g placed on a frictionless table is connected with two springs having same spring constant ($K = 2$ N m^{-1}). If the block is horizontally displaced through ' X ' m then the number of complete oscillations it will make in 14π seconds will be _____.



Sol. **(20)**

$$T = 2\pi\sqrt{\frac{m}{k_{eq}}}$$

$$T = 2\pi\sqrt{\frac{m}{2k}}$$

$$T = 2\pi\sqrt{\frac{0.49}{2\times 2}}$$

$$T = 2\pi\times\frac{0.7}{2} = 0.7\pi$$

$$\text{in } 14\pi\,\text{sec}, \frac{14\pi}{0.7\pi} = 20$$

25. An inductor of 0.5mH, a capacitor of 20μF and resistance of 20Ω are connected in series with a 220 V ac source. If the current is in phase with the emf, the amplitude of current of the circuit is $\sqrt{x}$ A. The value of x is-

Sol. **(242)**

Current is in phase with EMF. Hence, Circuit is at Resonance.

$$I_{rms} = \frac{V_{rms}}{R} = \frac{220}{20}$$

$$I_{rms} = 11\text{A}$$

$$I_0 = \sqrt{2}\,I_{rms} = \sqrt{242}\text{A}$$

26. The speed of a swimmer is 4 km h^{-1} in still water. If the swimmer makes his strokes normal to the flow of river of width 1 km, he reaches a point 750 m down the stream on the opposite bank. The speed of the river water is _____ kmh^{-1}.

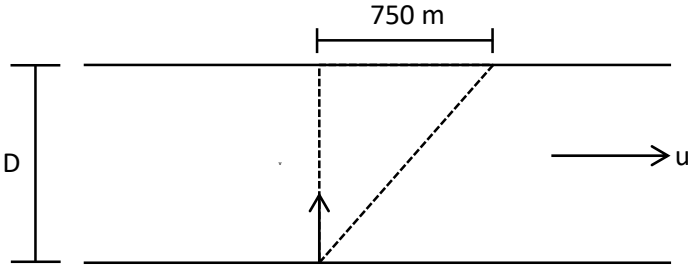
Sol. **(3)**

$$T = \frac{D}{V} = \frac{1}{4}hr$$

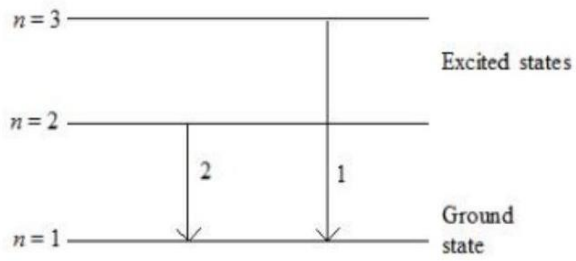
$$\text{Drift} = uT$$

$$\frac{750}{1000}\text{kM} = u\times\frac{1}{4}hr$$

$$u = 3\text{km/hr}$$



27. For hydrogen atom, λ_1 and λ_2 are the wavelengths corresponding to the transitions 1 and 2 respectively as shown in figure. The ratio of λ_1 and λ_2 is $\frac{x}{32}$. The value of x is



Sol. **(27)**

$$\frac{1}{\lambda_1}=R\left(\frac{1}{1^2}-\frac{1}{3^2}\right)$$

$$\lambda_1=\frac{9}{8R}$$

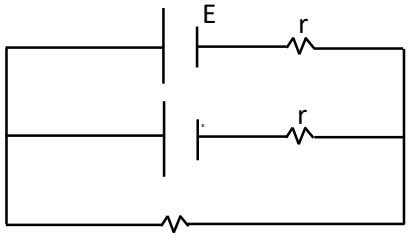
$$\frac{1}{\lambda_2}=R\left(\frac{1}{1^2}-\frac{1}{2^2}\right)$$

$$\lambda_2=\frac{4}{3R}$$

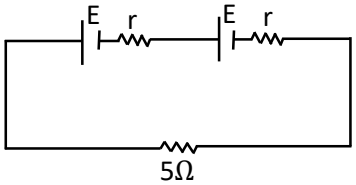
$$\frac{\lambda_1}{\lambda_2}=\frac{27}{32}$$

28. Two identical cells, when connected either in parallel or in series gives same current in an external resistance 5Ω. The internal resistance of each cell will be _____ Ω.

Sol. **(5)**



(I)



(II)

$$r_{eq}=\frac{r}{2}\ ,r_{eq}=2r$$

$$E_{eq}=\frac{r}{2}\left(\frac{E}{r}+\frac{E}{r}\right)=E\ ,\ E_{eq}=2E$$

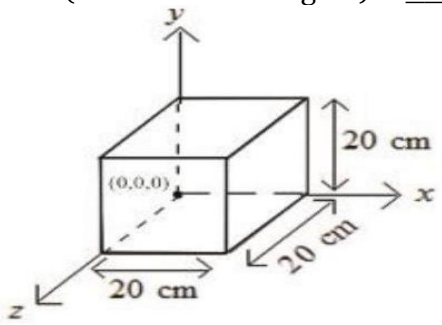
$$I_1=\frac{E}{5+\frac{r}{2}},\ I_2=\frac{2E}{2r+5}$$

$$I_1=I_2$$

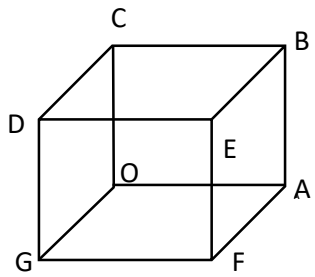
$$2r+5\ =2\left(5+\frac{r}{2}\right)$$

$$r\ =5\Omega$$

29. Expression for an electric field is given by $\vec{E} = 4000x^2\hat{i}\frac{V}{m}$. The electric flux through the cube of side 20 cm when placed in electric field (as shown in the figure) is _____ V cm



Sol. **(640)**



$\vec{E} \perp \vec{A}, \phi_{Top} = \phi_{Bottom} = \phi_{front} = \phi_{Back} = 0$

for $OCDG, x = 0, E = 0, \phi = 0$

for $ABEF, x = 0.2\text{m}$

$E = 4000 \times (0.2)^2$

$E = 160\text{V/m}$

$\phi = E\left(a^2\right) = 160\text{V/m} \times (0.2)^2\text{m}^2$

$\phi = 6.4\text{V} - \text{m}$

$\phi = 640\text{V} - \text{cm}$

30. A thin rod having a length of 1 m and area of cross-section 3×10^{-6} m^2 is suspended vertically from one end. The rod is cooled from 210°C to 160°C. After cooling, a mass M is attached at the lower end of the rod such that the length of rod again becomes 1 m. Young's modulus and coefficient of linear expansion of the rod are 2×10^{11} N m^{-2} and 2×10^{-5} K^{-1}, respectively. The value of M is _____ kg. (Take g = 10 m s^{-2})

Sol. **(60)**

$$Y = \frac{FL}{A\Delta L}$$

$$F = YA\left(\frac{\Delta L}{L}\right)$$

$$F = YA(\alpha\Delta T)$$

$$Mg = YA(\alpha\Delta T)$$

$$M \times 10 = 2 \times 10^{11} \times 3 \times 10^{-6} \times 2 \times 10^{-5} \times 50$$

$$M = 60\text{kg}$$

मोशन है, तो भरोसा है।

#RankBhiSelectionBhi

ADMISSION ANNOUNCEMENT

Session 2023-24 (English & हिन्दी Medium)

Target: JEE/NEET 2025
Nurture & प्रयास Batch
Class 10th to 11th Moving

Target: JEE/NEET 2024
Enthuse & प्रयास Batch
Class 11th to 12th Moving

Target: JEE/NEET 2024
Dropper & प्रयास Batch
Class 12th to 13th Moving

Target: PRE FOUNDATION
SIP, Evening & Tapasya Batch
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