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JEE (Main) 2020

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 02 September, 2020 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT : PHYSICS

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PART : PHYSICS

Single Choice Type (एकल विकल्पीय प्रकार)

This section contains **20 Single choice questions.** Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

इस खण्ड में **20 एकल विकल्पी प्रश्न** हैं। प्रत्येक प्रश्न के 4 विकल्प (1), (2), (3) तथा (4) हैं, जिनमें से **सिर्फ एक सही** है।

1. A particle of mass m with an initial velocity $u\hat{i}$ collides perfectly elastically with a mass 3 m at rest. It moves with a velocity $v\hat{j}$ after collision, then, v is given by

(1) $v = \sqrt{\frac{2}{3}}u$ (2) $v = \frac{u}{\sqrt{3}}$ (3) $v = \frac{1}{\sqrt{6}}u$ (D) $v = \frac{u}{\sqrt{2}}$

Ans. **(4)**

Sol. From momentum conservation

$mu\hat{i} + 0 = mv\hat{j} + 3m\vec{v'}$

$\vec{v'} = \frac{u}{3}\hat{i} - \frac{v}{3}\hat{j}$

From kinetic energy conservation $\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + \frac{1}{2}(3m)\left(\left(\frac{u}{3}\right)^2 + \left(\frac{v}{3}\right)^2\right)$

Solving $v = \frac{u}{\sqrt{2}}$

2. Two identical strings X and Z made of same material have tension T_x and T_Z in then If their fundamental frequencies are 450 Hz and 300 Hz, respectively, then the ratio T_x/T_Z is :

(1) 1.25 (2) 0.44 (3) 1.4 (4) 2.25

Ans. **(4)**

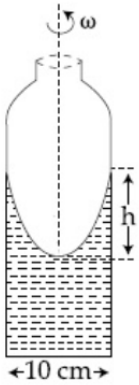
Sol. $f_x = \frac{1}{2\ell}\sqrt{\frac{T_x}{\mu}}$

$f_y = \frac{1}{2\ell}\sqrt{\frac{T_y}{\mu}}$

$\frac{f_x}{f_y} = \frac{450}{300} = \sqrt{\frac{T_x}{T_y}}$

$\Rightarrow T_x/T_y = 9/4 = 2.25$

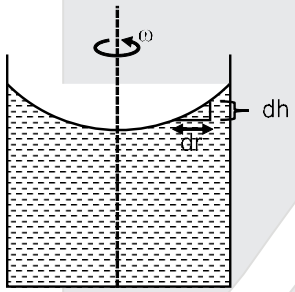
3. A cylindrical vessel containing a liquid is rotated about its axis so that the liquid rises at its sides as shown in the figure. The radius of vessel is 5 cm and the angular speed of rotation is ω rad s^{-1}. The difference in the height, h (in cm) of liquid at the centre of vessel and at the will be :



(1) $\frac{5\omega^2}{2g}$ (2) $\frac{2\omega^2}{25g}$ (3) $\frac{25\omega^2}{2g}$ (4) $\frac{2\omega^2}{5g}$

Ans. **(3)**

Sol.



$$\rho dr\omega^2 r = \rho g dh$$

$$\omega^2 \int_0^R r dr = g \int_0^h dh$$

$$\frac{\omega^2 R^2}{2} = gh$$

$$h = \frac{\omega^2 R^2}{2g} = \frac{25\omega^2}{2g}$$

4. The least count of the main scale of a vernier callipers is 1 mm. Its vernier scale is divided into 10 divisions and coincide with 9 divisions of the main scale. When jaws are touching each other, the 7^{th} division of vernier scale coincides with a division of main scale and the zero of vernier scale is lying right side of the zero of main scale. When this vernier is used to measure length of cylinder the zero of the vernier scale between 3.1 cm and 3.2 cm and 4^{th} VSD coincides with a main scale division. The length of the cylinder is (VSD is vernier scale division)

(1) 2.99 cm (2) 3.07 cm (3) 3.21 cm (4) 3.2 cm

Ans. **(2)**

Sol. Zero Error = 0 + 7 × 0.1 = 0.070

Vernier reading = (3.1 + 4 × 0.01) –0.07 = 3.07

5. A gas mixture consists of 3 moles of oxygen and 5 moles of argon at temperature T. Assuming the gases to be ideal and the oxygen bond to be rigid, the total internal energy (in units of RT) of the mixture is :

(1) 15 (2) 13 (3) 20 (4) 11

Ans. **(1)**

Sol. $\frac{f_1 n_1 RT_1}{2} + \frac{f_2 n_2 RT_2}{2} = 3 \times \frac{5}{2} RT + \frac{5}{2} \times 3RT = 15$

6. Interference fringes are observed on a screen by illuminating two thin slits 1 mm apart with a light source (λ = 632.8 nm). The distance between the screen and the slits is 100 cm. If a bright fringe is observed on a screen at distance of 1.27 mm from the central bright fringe, then the path difference between the waves, which are reaching this point from the slits is close to :

(1) 2.87 (2) 2 nm (3) 1.27 μm (4) 2.05 μm

Ans. **(3)**

Sol. $\Delta P = d\sin\theta$

$= d\theta$

$= \frac{dy}{D} = \frac{10^{-3} \times 1.270\text{mm}}{1\text{m}} = 1.27\ \mu\text{m}$

7. An amplitude modulated waves is represented by expression $v_m = 5\ (1 + 0.6 \cos 6280t) \sin(211 \times 10^4 t)$ volts. The minimum and maximum amplitudes of the amplitude modulated wave are, respectively:

(1) 5V, 8V (2) $\frac{5}{2}$V , 8V (3) 3V, 5V (4) $\frac{3}{2}$V , 5V

Ans. **(2)**

Sol. From Given Equation

$\mu = 0.6$

$A_m = \mu A_c$

$\frac{A_{max.} + A_{min}}{2} = A_c = 5$ .....(1)

$\frac{A_{max.} - A_{min}}{2} = 3$ .....(2)

From Equation (1) + (2)

$A_{max} = 8$

From Equation (1) – (2)

$A_{min} = 2$

8. The mass density of a spherical galaxy varies as $\frac{K}{r}$ over a large distance 'r' from its center. In that region, a small star is in a circular orbit of radius R. Then the period of revolution, T depends on R as :

(1) $T^2 \alpha \frac{1}{R^3}$ (2) $T^2 \alpha R$ (3) $T \alpha R$ (4) $T^2 \alpha R^3$

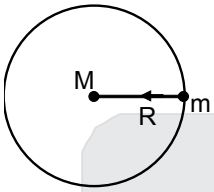
Ans. **(2)**

Sol. $M = \int \rho dV$

$M = \int_0^{r=R_0} \frac{k}{r} 4\pi r^2 dr$

$$M = 4\pi k\int_0^{R_0} rdr$$

$$M = \frac{4\pi kR_0^2}{2} = 2\pi kR^2$$



$$F_G = \frac{GMm}{R_0^2} = m\omega_0^2 R$$

$$\Rightarrow \quad \frac{G\frac{4\pi kR^2}{2}}{R^2} = \omega_0^2 R \qquad \Rightarrow \qquad \omega_0 = \sqrt{\frac{2\pi KG}{R}}$$

$$\because\ T = \frac{2\pi}{\omega_0} = \frac{2\pi\sqrt{R}}{\sqrt{2\pi KG}} = \sqrt{\frac{2\pi R}{KG}}$$

$$\Rightarrow T^2 \propto R$$

9. A beam of protons with speed 4×10^5 ms^{-1} enters a uniform magnetic field of 0.3T at an angle of 60º to the magnetic field. the pitch of the resulting helical path of protons is close to : (Mass of the proton = 1.67×10^{-27} kg, charge of the proton = 1.69×10^{-19} C)

(1) 12 cm (2) 2 cm (3) 4 cm (4) 5 cm

Ans. **(3)**

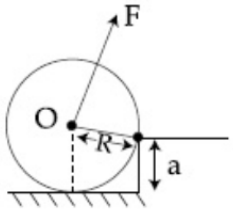
Sol. Pitch $= (V\cos\theta)T$

$$= (V\cos\theta)\frac{2\pi m}{eB}$$

$$= (4 \times 10^5 \cos 60°)\frac{2\pi}{0.3\times 10}\left(\frac{1.67\times 10^{-27}}{1.69\times 10^{19}}\right)$$

$$= 4 \text{ cm}$$

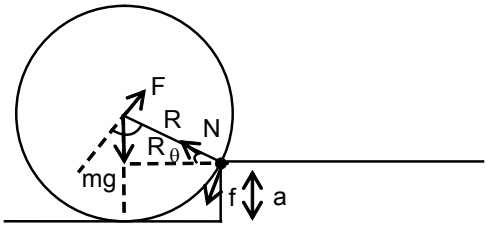
10. A uniform cylinder of mass M and radius R is to be pulled over a step of height a (a < R) by applying a force F at its centre 'O' perpendicular to the plane through the axes of the cylinder on the edge of the step (see figure). The minimum value of F required is :



(1) $Mg\sqrt{1-\left(\frac{R-a}{R}\right)^2}$ (2) $Mg\sqrt{1-\frac{a^2}{R^2}}$ (3) $Mg\sqrt{\left(\frac{R}{R-a}\right)-1}$ (4) $Mg\frac{a}{R}$

Ans. **(1)**

Sol.

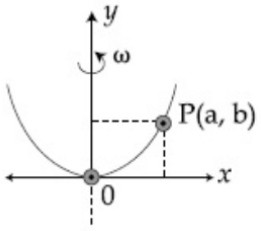


$FR > mg\cos\theta R$

$F > mg\cos\theta$

$$F > mg\frac{\sqrt{R^2-(R-a)^2}}{R} \Rightarrow Mg\sqrt{1-\left(\frac{R-a}{R}\right)^2}$$

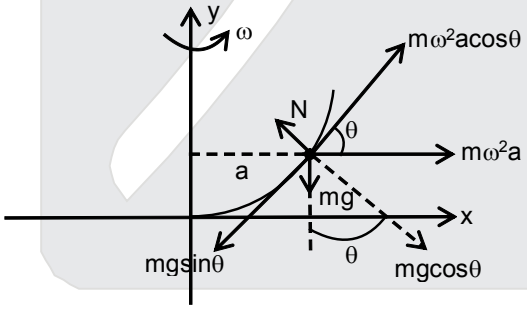
11. A bead of mass m stays at point P (a, b) on a wire bent in the shape of a parabola $y = Cx^2$ and rotating with angular speed ω (see figure). The value of ω is (neglect friction)



(1) $\sqrt{2gC}$ (2) $\sqrt{\frac{2gC}{ab}}$ (3) $\sqrt{\frac{2g}{C}}$ (4) $2\sqrt{2gC}$

Ans. (4)

Sol.



$m\omega^2 a\cos\theta = mg\sin\theta$

$$\omega = \sqrt{\frac{g\tan\theta}{a}}$$

$y = 4cx^2$

$$\tan\theta = \frac{dy}{dx} = 8xC$$

$(\tan\theta)_{a,b} = 8aC$

$$\omega = \sqrt{\frac{g\times 8ac}{a}} = 2\sqrt{2gc}$$

12. If speed V, area A and force F are chosen as fundamental units, then the dimension of Young's modulus will be :

(1) FA^2V^{-3} (2) FA^2V^{-1} (3) FA^2V^{-2} (4) $FA^{-1}V^0$

Ans. **(4)**

Sol. $Y \propto F^aV^bA^c$ $Y = \left(\frac{F}{A}\right)$

$$\frac{MLT^{-2}}{L^2} \propto (M^1L^1T^{-2})^a(L^1T^{-1})^b(L^2)^c$$

$M^1L^{-1}T^{-2} \propto M^a L^{a+b+2c} T^{-2a-b}$

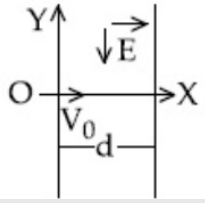
$a + b + 2c = -1$

$-2a + b = -2$

$a = 1, b = 0, c = -1$

$Y = F^1v^0A^{-1}$

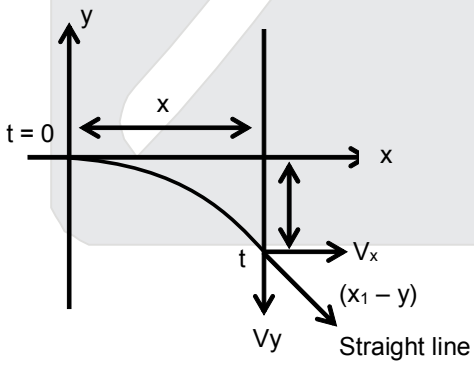
13. A charged particle (mass m and charge q) moves along X axis with velocity V_0. When it passes through the origin it enters a region having uniform electric field $\vec{E} = -E\hat{j}$ which extends upto x = d. Equation of path of electron in the region x > d is :



(1) $y = \frac{qEd}{mV_0^2}x$ (2) $y = \frac{qEd}{mV_0^2}(x-d)$ (3) $y = \frac{qEd}{mV_0^2}\left(\frac{d}{2}-x\right)$ (4) $y = \frac{qEd^2}{mV_0^2}x$

Ans. **(3)**

Sol.



x > d path is straight line

$$\frac{-y = \frac{1}{2}at^2}{x-d} = \frac{at}{V_0}$$

$$\frac{-y-\frac{1}{2}at^2}{at} = \frac{x-d}{V_0}$$

$$\frac{-y}{at} - \frac{1}{2}\frac{d}{V_0} = \frac{x}{V_0} - \frac{d}{V_0}$$

$$\frac{-myV_0}{qEd} = \frac{x}{V_0} - \frac{d}{2V_0}$$

$$y = \frac{-qEd}{mV_0}\left(\frac{x}{V_0} - \frac{d}{2V_0}\right)$$

$$y- = \frac{qEd}{mV_0^2}\left(\frac{d}{2} - x\right)$$

14. In a reactor, 2 kg of $_{92}U^{235}$ fuel is fully used up in 30 days. The energy released per fission is 200 Mev. given that the Avogadro number, N = 6.023×10^{26} per kilo mole and 1 eV = 1.6×10^{-19} J. The power output of the reactor is close to :

(1) 54 MW (2) 60 MW (3) 125 MW (4) 35 MW

Ans. **(2)**

Sol. $P = \frac{E}{t}$

$$= \frac{2}{235} \times \frac{6.023 \times 10^{26} \times 200 \times 1.6 \times 10^{-19}}{30 \times 24 \times 60 \times 60} = 60W$$

15. A plane electromagnetic wave, has frequency of 2.0×10^{10} Hz and its energy density is 1.02×10^{-8} J/m^3 in vacuum. The amplitude of the magnetic field of the wave is close to ($\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \frac{Nm^2}{C^2}$ and speed of light = 3×10^8 ms^{-1}) :

(1) 160 nT (2) 180 nT (3) 190 nT (4) 150 nT

Ans. **(1)**

Sol. Energy Density = $\frac{1}{2}\frac{B^2}{\mu_0}$

$$B = \sqrt{2 \times \mu_0 \times \text{Energy density}}$$

$$B = \sqrt{2 \times 4\pi \times 10^{-7} \times 1.02 \times 10^{-8}} = 160 \times 10^{-9} = 160 \text{ nT}$$

16. Train A and train B are running on parallel tracks in the opposite directions with speed of 36 km/hour and 72 km/hour, respectively. A person is walking in train A in the direction opposite to its motion with a speed of 1.8 km/hour. Speed (in ms^{-1}) of this person as observed from train B will be close to : (take the distance between the tracks as negligible)

(1) 30.5 ms^{-1} (2) 29.5 ms^{-1} (3) 31.5 ms^{-1} (4) 28.5 ms^{-1}

Ans. **(2)**

Sol.

V_A = 36 km/hr = 10 m/s

V_B = –72 km/hr = –20 m/s

$V_{MA} = -1.8$ km/hr $= -0.5$ m/s

$V_{man,\,B} = V_{man,\,A} + V_{A,\,B}$

$= V_{man,\,A} + V_A - V_B$

$= -0.5 + 10 - (-20)$

$= -0.5 + 30$

$= 29.5$ m/s

17. Magnetic materials used for making permanent magnets (P) and magnets in a transformer (T) have different properties of the following, which property best matches for the type of magnet required ?

(1) T : Large retentivity, large coercivity

(2) P : Large retentivity, large coercivity

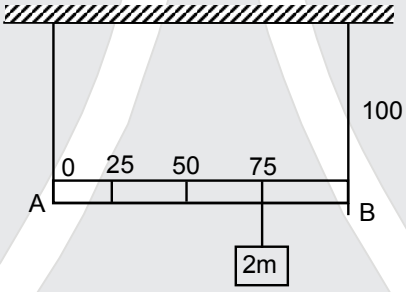
(3) T : Large retentivity, small coercivity

(4) T : Small retentivity, large coercivity

Ans. **(2)**

Sol. **Based on theory**

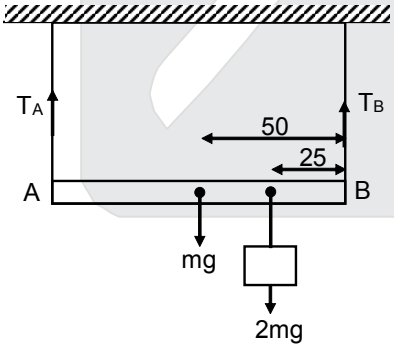
18. Shown in the figure is rigid and uniform one meter long rod AB held in horizontal position by two strings tied to its ends and attached to the ceiling. The rod is of mass 'm' and has another weight of mass 2m hung at a distance of 75 cm from A. The tension in the string at A is :



(1) 0.75 mg (2) 1 mg (3) 0.5 mg (4) 2mg

Ans. **(2)**

Sol. τ_{net} about B is zero at equilibrium



$T_A\ 100 - mg \times 50 - 2\,mg \times 25 = 0$

$T_A\ 100 = 100\,mg$

$T_A = 1$ mg

19. Consider four conducting materials copper, tungsten, mercury and aluminum with resistivity ρ_C, ρ_T, ρ_M and ρ_A respectively. Then :

(1) $\rho_C > \rho_A > \rho_T$ (2) $\rho_A > \rho_T > \rho_C$ (3) $\rho_A > \rho_M > \rho_C$ (4) $\rho_M > \rho_A > \rho_C$

Ans. **(4)**

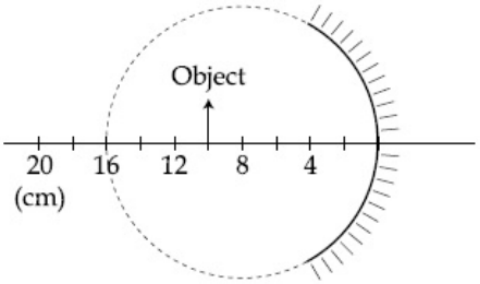
Sol. $\rho_m = 98 \times 10^{-8}$

$\rho_A = 2.65 \times 10^{-8}$

$\rho_C = 1.724 \times 10^{-8}$

$\rho_T = 5.65 \times 10^{-8}$

20. A spherical mirror is obtained as shown in the figure from a hollow glass sphere. if an object is positioned infront of the mirror, what will be the nature and magnification of the image of the object? (Figure drawn as schematic and not to scale)

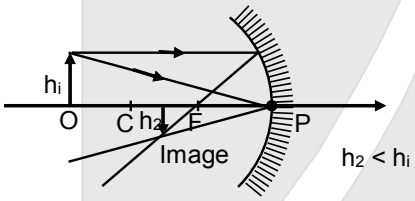


(1) Inverted, real and magnified (2) Erect, virtual and unmagnified

(3) Inverted, real and unmagnified (4) Erect, virtual and magnified

Ans. **NTA answer is (1) but reso answer is (3)**

Sol.



Numerical Value Type (संख्यात्मक प्रकार)

This section contains **5 Numerical value type questions.**

इस खण्ड में **5 सख्यात्मक प्रकार के प्रश्न** हैं।

21. A 5μF capacitor is charged fully by a 220 V supply. It is then disconnected from the supply and is connected in series to another uncharged 2.5 μF capacitor. If the energy change during the charge redistribution is $\frac{X}{100}$ J then value of X to the nearest integer is :

Ans. **NTA answer is 36 but Reso answer is 4**

Sol. $C_1 = 5\mu F$ $V_1 = 220$ Volt

$C_2 = 2.5\ \mu F$ $V_2 = 0$

Heat loss; $\Delta H = U_i - U_f = \frac{1}{2}\frac{c_1c_2}{c_1+c_2}(v_1 - v_2)^2$

$= \frac{1}{2} \times \frac{5 \times 2.5}{(5+2.5)}(220-0)^2 \mu J$

$= \frac{5}{2 \times 3} \times 22 \times 22 \times 100 \times 10^{-6} J$

$= \frac{5\times11\times22}{3}\times10^{-4}\text{J} = \frac{55\times22}{3}\times10^{-4}\text{ J}$

$= \frac{1210}{3}\times10^{-4}\text{ J} = \frac{1210}{3}\times10^{-3}\text{J} = 4\times10^{-2}$

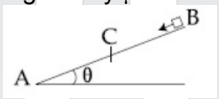
According to questions

$\frac{x}{100} = 4\times10^{-2}$

So, x = 4

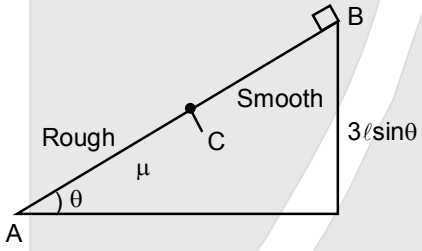
Note : But given answer by JEE Main x = 36

22. A small block starts slipping down from a point B on an inclined plane AB, which is making an angle θ with the horizontal section BC is smooth and the remaining section CA is rough with a coefficient of friction μ. It is found that the block comes to rest as it reaches the bottom (point A) of the inclined plane. If BC = 2AC, the coefficient of friction is given by $\mu = k\tan\theta$. The value of k is …….



Ans. **3**

Sol. Let AC = ℓ $\therefore$ BC = 2ℓ $\therefore$ AB = 3ℓ



Apply work – Energy theorem

$W_f + W_{mg} = \Delta KE$

$mg(3\ell)\sin\theta - \mu mg\cos\theta(\ell) = 0 + 0$

$\mu mg\cos\theta\ell = 3mg\ell\sin\theta$

$\mu = 3\tan\theta = k\tan\theta$

$\therefore$ k = 3

23. An engine takes in 5 moles of air at 20°C and 1 atm, and compresses it adiabatically to 1/10th of the original volume. Assuming air to be a diatomic ideal gas made up of rigid molecules, the change in its internal energy during this process comes out to be XkJ. The value of X to the nearest integer is :

Ans. **46**

Sol. $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$

$= T_1(10)^{\frac{7}{5}-1}$

$T_2 = T_1(10)^{2/5}$

$\Delta V = \frac{5}{2}nR\,;\ \frac{5}{2}\times5\times3[10^{2/5}-1](293)$

$\frac{625}{6}\times1.5\times293 = 461440$

$\approx 46\text{ks}$

24. When radiation of wavelength A is used to illuminate a metallic surface, the stopping potential is V. When the same surface is illuminated with radiation of wavelength 3A, the stopping potential is $\frac{V}{4}$. If the threshold wavelength for the metallic surface is $n\lambda$ then value of n will be :

Ans. **9**

Sol. $\frac{hc}{\lambda} = \phi + eV$ ...(1)

$\frac{hc}{3\lambda} = \phi + \frac{eV}{4}$ ....(2)

from (1) & (2)

$\frac{hc}{\lambda}\left(1-\frac{1}{3}\right) = \frac{3}{4}eV$

$\frac{hc}{\lambda}\frac{2}{3} = \frac{3}{4}eV$

$eV = \frac{8}{9}\frac{hc}{\lambda}$

$\frac{hc}{\lambda} = \phi + \frac{8}{9}\frac{hc}{\lambda}$

$\phi = \frac{hc}{9\lambda} = \frac{hc}{\lambda_{th}}$

$\lambda_{th} = 9\lambda$

$\therefore$ k = 9

25. A circular coil of radius 10 cm is placed in a uniform magnetic field of 3.0×10^{-5} T with its plane perpendicular to the field initially. It is rotated at constant angular speed about an axis along the diameter of coil and perpendicular to magnetic field so that it undergoes half of rotation in 0.2 s. The maximum value of EMF induced (in μV) in the coil will be close to the integer...

Ans. **15**

Sol. Flux as a function of time $\phi = \vec{B}.\vec{A} = AB\cos(\omega t)$

Emf induced,

$e = \frac{-d\phi}{dt} = AB\omega\sin(\omega t)$

Max. value of Emf = $AB\omega$

= $\pi R^2 B\omega$

= $3.14 \times 0.1 \times 0.1 \times 3 \times 10^{-5} \times \frac{\pi}{0.2}$ = 15

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