ELECTROMAGNETIC INDUCTION
PREVIOUS EAMCET BITS
[ENGINEERING PAPER]

1. A conductor rod of length L rotates with angular speed ω in a uniform magnetic field of induction B which is perpendicular to its motion. The induced e.m.f developed between the two ends of the rod is **[EAMCET 2002 E]**

1) $\frac{BL^2\omega}{4}$ 2) $\frac{BL^2\omega}{2}$ 3) $BL^2\omega$ 4) $2BL^2\omega$

Ans: 2

Sol. **Its Method** :

dE = Bvdx = $B\omega xdx$

$$E = \int_o^L B\omega dx = B\omega\int_0^L xdx = \frac{B\omega L^2}{2}$$

2nd Method :

Induced emf $e = \frac{-d}{dt}(BA) = \frac{-BA}{\in} = \frac{-B(\pi L^2)}{\left(\frac{2\pi}{\omega}\right)}$

$$= \left|-\frac{BL^2\omega}{2}\right| = \frac{BL^2\omega}{2}$$

2. If a change in current of 0.01 A in one coil produces a change in magnetic flux of 2×10^{-2} in the other coil, then the mutual inductance of the two coils in Henries is **[EAMCET 2002 E]**

1) 0 2) 0.5 3) 2 4) 3

Ans: 3

Sol. From laws of electromagnetic induction

$$\frac{d\phi}{dt} = E = M\frac{di}{dt} \Rightarrow M = \frac{2\times10^{-2}}{0.01} = 2$$

3. A coil has 1, 000 turns and 500 cm² as its area. The plane of the coil is placed at right angles to a magnetic induction field of 2×10^{-5} web/m². The coil is rotated through 180° in 0.2 seconds. The average emf induced in the coil, in milli volts, is: **[EAMCET 2003 E]**

1) 5 2) 10 3) 15 4) 20

Ans: 2

Sol. Induced emf = $\frac{d\phi}{dt} = \frac{\phi_2 - \phi_1}{t} = \frac{2NAB}{t} = 10mV$

4. Two ions having masses in the ratio 1 : 1 and charges 1 : 2 are projected into uniform magnetic field perpendicular to the field with speeds in the ratio 2 : 3. The ratio of the radii of circular paths along which the two particles move is: **[EAM CET 2003 E]**

1) 4 : 3 2) 2 : 3 3) 3 : 1 4) 1 : 4

Ans: 1

Sol. Magnetic force = Centripetal force

$$Bq\ v = \frac{mv^2}{r}$$

$\therefore \frac{r_1}{r_2} = \frac{v_1}{v_2} \times \frac{q_2}{q_1} = \frac{2}{3} \times \frac{2}{1} = \frac{4}{3}$

$\Rightarrow r_1 : r_2 = 4:3$

5. Magnetic induction at the center of a circular loop of area π square meter is 0.1 tesla. The magnetic moment of the loop is : (μ_o = permeability of air) **[EAMCET 2004 E]**

1) $\frac{0.1\pi}{\mu_o}$ 2) $\frac{0.2\pi}{\mu_o}$ 3) $\frac{0.3\pi}{\mu_o}$ 4) $\frac{0.4\pi}{\mu_o}$

Ans: 2

Sol. Magnetic induction at the centre of circular loop $B = \frac{\mu_0}{2}.\frac{ni}{r}$ [where r is the radius of loop]

$A = \pi r^2 \Rightarrow \pi = \pi r^2 \Rightarrow r = 1$

$\therefore$ Magnetic moment of the loop

$$M = niA = \frac{2BrA}{\mu_0} = \frac{(0.2)\pi}{\mu_0}$$

6. A wire of length '*l*' is bent in to a circular coil of one turn of radius R_1. Another wire of the same material and same area of cross section and same length is bent in to a circular coil of two turns of radius R_2. When the same current flows through the two coils, the ratio of magnetic induction at the centers of the two coils is : **[EAMCET 2004 E]**

1) 1 : 2 2) 1 : 1 3) 1 : 4 4) 3 : 1

Ans: 3

Sol. Magnetic induction at the centre of a circular coil $B = \frac{\mu_0}{2}.\frac{ni}{r} \Rightarrow B\alpha\frac{n}{r}$

$\therefore \frac{B_1}{B_2} = \frac{n_1}{n_2} \times \frac{r_2}{r_1} = \frac{1}{2} \times \frac{(r/2)}{r} = \frac{1}{4}$

$\Rightarrow B_1 : B_2 = 1:4$

7. An inductance 1 H is connected in series with an A.C source of 220V and 50Hz. The inductive reactance (in ohms) is **[EAMCET 2005 E]**

1) 2π 2) 50π 3) 100π 4) 1000π

Ans: 3

Sol. Inductive reactance $X_L = \omega L = 2\pi nL$

$= 2\pi \times 50 \times 1 = 100\pi$

8. Two parallel rails of a railway track insulated from each other and with the ground are connected to a millivoltmeter. The distance between the rails is one metre. A train is traveling with a velocity of 72 kmph along the track. The reading of the millivoltmeter (in m V) is : (Vertical component of the earth's magnetic induction is 2×10^{-5}T) **[EAMCET 2005 E]**

(1) 144 (2) 0.72 (3) 0.4 (4) 0.2

Ans: 3

Sol. Induced emf = $Blv = 2\times10^{-5}\times1\times72\times\frac{5}{18}$

$= 0.4\times10^{-3}V = 0.4mV$

9. A rectangular loop of length ‘f’ and breadth ‘b’ is placed at a distance of x from an infinitely long wire carrying current ‘i’ such that the direction of current is parallel to breadth. If the loop moves away from the current wire in a direction perpendicular to it with a velocity ‘v’, the magnitude of the e.m.f. in the loop is : (permeability of free space) **(EAMCET 2006 E)**

1) $\frac{m_0 iv}{2\pi x}\left(\frac{l+b}{b}\right)$ 2) $\frac{m_0 i^2 v}{4\pi^2 x}\log\left(\frac{b}{l}\right)$ 3) $\frac{\mu_0 ilbv}{2\pi x(l+x)}$ 4) $\frac{\mu_0 ilbv}{2\pi}\log\left(\frac{x+l}{x}\right)$

Ans: 3

Sol. Net emf = $e_1 - e_2$

$\therefore$ Net emf $= B_1bv - B_2bv$

$= bv[B_1 - B_2]$

$= bv\left[\frac{\mu_0 i}{2\pi x} - \frac{\mu_0 i}{2\pi(L+x)}\right] = \frac{bv\mu_0 i}{2\pi}\left[\frac{1}{x} - \frac{1}{L+x}\right]$

$= \frac{\mu_0 ibv}{2\pi}\left[\frac{L+x-x}{x(L+x)}\right] = \frac{\mu_0 iLbv}{2\pi x(L+x)}$

Hence (3) is the correct choice.

10. A small square loop of wire of side ‘l’ is placed inside a large square loop of side ‘L’ (L>>l). If the loops are coplanar and their centres coincide, the mutual induction of the system is directly proportional to : **(EAMCET 2006 E)**

1) $\frac{L}{l}$ 2) $\frac{l}{L}$ 3) $\frac{L^2}{l}$ 4) $\frac{l^2}{L}$

Ans: 4

Sol. Magnetic induction at the centre = B = $\frac{\mu_0 i}{4\pi r}[\sin\alpha + \sin\beta]$

$B = \frac{\mu_0 i}{4\pi\frac{L}{2}}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right)$

Flux linked with the smaller loop

$\phi = Mi = BA = B\ell^2 = \frac{2\sqrt{2}\mu_0 i.\ell^2}{\pi L}$

$\Rightarrow M \propto \frac{\ell^2}{L}$

Hence (4) is the correct choice.

11. Two concentric coils of 10 turns each are placed in the same plane. Their radii are 20cm and 40 cm and carry 0.2 and 0.3 amp. current respectively in opposite directions. The magnetic induction (in Tesla) at the centre is **[EAMCET 2008 E]**

1) $\frac{3}{4}\mu_0$ 2) $\frac{5}{4}\mu_0$ 3) $\frac{7}{4}\mu_0$ 4) $\frac{9}{4}\mu_0$

Ans: 2

Sol. The resultant magnetic induction at the centre is $B = B_1 - B_2$

$$B = B_1 \sim B_2 = \frac{\mu_0 i_1 n_1}{2r_1} \sim \frac{\mu_0 i_2 n_2}{2r_2}$$

$$= \mu_0\left[\frac{0.2\times 10}{2\times 20\times 10^{-1}} - \frac{0.3\times 10^{5}}{2\times 40\times 10^{-1}}\right]$$

$$= \mu_0\left[5 - \frac{1.5}{0.4}\right] = \frac{5}{4}\mu_0$$

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12. If the flux of magnetic induction through a coil of resistance R and having N turns changes from ϕ_1 to ϕ_2 then the magnitude of the charge that passes through this coil is **[EAMCET 2001 M]**

1) $\frac{\phi_2 - \phi_1}{R}$ 2) $\frac{N(\phi_2 - \phi_1)}{R}$ 3) $\frac{\phi_2 - \phi_1}{NR}$ 4) $\frac{NR}{\phi_2 - \phi_1}$

Ans: 3

Sol. $E = \frac{Nd\phi}{dt}$

$$\Rightarrow iR = \frac{N(\phi_2 - \phi_1)}{\Delta t} \Rightarrow i\Delta t = \frac{N(\phi_2 - \phi_1)}{R}$$

Where $i\Delta t$ is the charge that passes through the ocil

13. Two coils have self-inductance $L_1 = 4$ mH and $L_2 = 1$ mH respectively. The currents in the two coils are increased at the same rate. At a certain instant of time both coils are given the same power. If I_1 and I_2 are the currents in the two coils, at that instant of time respectively, then the value of (I_1/I_2) is: **[2003 MED]**

1) 1/8 2) 1/4 3) 1/2 4) 11

Ans: 2

Sol.. $E = \frac{LdI}{dt}$ L is the self inductance

P= EI, $P_1 = P_2$ [since power is same]

$$\Rightarrow L_1 \frac{dI_1}{dt}\times I_1 = L_2 \frac{dI_2}{dt}\times I_2$$

$$\Rightarrow \frac{I_1}{I_2} = \frac{I_2}{I_1}\left[\because \frac{dI_1}{dt} = \frac{dI_2}{dt}\right] \Rightarrow \frac{I_1}{I_2} = \frac{1}{4}$$

14. The electric current in a circular coil of two turns produced a magnetic induction of 0.2 T at its centre. The coil is unwound and is rewound into a circular coil of four turns. The magnetic induction at the centre of the coil now is, in tesla, (if same current flows in the coil): **[2003 MED]**

1) 0.2 2) 0.4 3) 0.6 4) 0.8

Ans: 4

Sol. Magnetic induction at the centre of coil $B = \frac{\mu_0 ni}{2r}$

$$\frac{B_1}{B_2} = \frac{n_1}{n_2} \times \frac{r_2}{r_1}$$

$$\frac{0.2}{B_2} = \frac{2}{4} \times \frac{r/2}{r} = \frac{1}{4}$$

$\therefore B_2 = 0.8$ T

15. Two ions having equal masses, but charges in the ratio 1 : 2 are projected perpendicular to a uniform magnetic field with speeds in the ratio 2 : 3. The ratio of the radii of the circular paths along which the two ions move is **[EAMCET 2003 MED]**

1) 4 : 3 2) 2 : 3 3) 3 : 2 4) 1 : 4

Ans: 1

Sol. Centripetal force = Magnetic force

$$Bq\ v = \frac{mv^2}{r}$$

$$\therefore \frac{r_1}{r_2} = \frac{v_1}{v_2} \times \frac{q_2}{q_1} = \frac{2}{3} \times \frac{2}{1} = \frac{4}{3}$$

$\Rightarrow r_1 : r_2 = 4 : 3$

16. A magnetic flux of 500 micro-webers passing through a 200 turns coil is reversed in 20×10^{-3} seconds. The average emf induced in the coil in volts, is : **[EAMCET 2004 M]**

1) 2.5 2) 5.0 3) 7.5 4) 10.0

Ans: 4

Sol. $\therefore$ Induced emf in the coil $= E = N\frac{d\phi}{dt}$

$$E = N\frac{\Delta\phi}{\Delta t} = \frac{200\times2\times500\times10^{-6}}{20\times10^{-3}}$$

= 10 volts

17. A current carrying circular coil, suspended freely in a uniform external magnetic field orients to a position of stable equilibrium. In this state [EAMCET 2005 M]

1) The plane of the coil is normal to the external magnetic field
2) The plane of the coil is parallel to the external magnetic field
3) Flux through the coil is minimum
4) Torque on the coil is maximum

Ans: 1

Sol. In the stable equilibrium the plane of the coil is normal to the external magnetic field.

18. A proton is projected with a velocity 10^7 ms^{-1}, at right angles to a uniform magnetic field of induction 100 mT. The time (in seconds) taken by the proton to traverse 90^o arc is
(Mass of proton = 1.65×10^{-27} kg and charge of proton = 1.6×10^{-19}C) **[EAMCET 2005 M]**

1) 0.81×10^{-7} 2) 1.62×10^{-7} 3) 2.43×10^{-7} 4) 3.24×10^{-7}

Ans: 2

Sol. Centripetal force = magnetic force $\frac{mv^2}{r} = Bqv \Rightarrow V = \frac{Bqr}{m}$

But $V = rw \;\; and \;\; T = \frac{2\pi}{w}$

Cyclotron time period $\mathrm{T} = \frac{2\pi m}{qB}$

Time required to complete a sector of angle 90° is

$\frac{T}{4} = \frac{\pi m}{2qB} = \frac{\pi \times 1.6 \times 10^{-27}}{2 \times 1.6 \times 10^{-19} \times 100 \times 10^{-3}} = 1.6 \times 10^{-7}$

20. A coil of 1200 turns and mean area of 500 cm^2 is held perpendicular to a uniform magnetic field of induction $4 \times 10^{-4} T$. The resistance of the coil is 20 ohms. When the coil is rotated through 180^0 in the magnetic field in 0.1 seconds the average electric current (in mA) induced is : **(EAMCET 2006 M)**

1) 12 2) 24 3) 36 4) 48

Ans: 2

Sol. From $e = N\frac{d\phi}{dt} = \frac{2BAN}{t}$

$e = N\frac{\phi_2 - \phi_1}{t}$; $i = \frac{e}{R} = \frac{2BAN}{Rt}$

$= \frac{2 \times \left(4 \times 10^{-4}\right)\left(5 \times 10^{-2}\right)(1200)}{20 \times 0.1}$

$= 24 \times 10^{-3}$

Hence (2) is the correct choice.

21. The e.m.f. induced in a secondary coil is 20000 V when the current breaks in the primary coil. The mutual inductance is 5H and the current reaches to zero in 10^{-4} sec in the primary. The maximum current in the primary before it breaks is **(EAMCET 2007 M)**

1) 0.1A 2) 0.4A 3) 0.6A 4) 0.8A

Ans: 2

Sol. $e_s = -\frac{MdiP}{dt}$

$20000 = -5\frac{\left(0 - I_p\right)}{10^{-5}}$

$\Rightarrow I_p = 0.44$; Hence (2) is the correct choice.

22. A coil of 40 H inductance is connected in series with a resistance of and this combination is connected to the terminals of a 2V battery. The inductive time constant of the circuit is (in seconds) **(EAMCET 2007 M)**

1) 40 2) 20 3) 5 4) 0.2

Ans: 3

Sol. Inductive time constant $t = \frac{L}{R}$

$\therefore\ t = \frac{L}{R} = \frac{40}{8} = 5\,\text{sec}.$

Hence (3) is the correct choice.

23. The north pole of a bar magnet is moved towards a coil along the axis passing through the centre of the coil when viewed in the direction of the motion of the magnet is **(EAMCET 2008 M)**

1) Clockwise
2) Anti - Clockwise
3) No current in the coil
4) Either clockwise or anti-clockwise

Ans: 2

Sol. The direction of the inducted current in the coil when viewed in the direction of the motion of the magnet is anti clock wise.[According to Flemings right hand rule]