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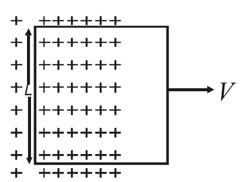
CHAPTER 20

Electromagnetic Induction

1. A conducting square loop of side L and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic induction B constant in time and space, pointing perpendicular and into the plane at the loop exists everywhere with half the loop outside the field, as shown in figure. The induced emf is **[2002]**



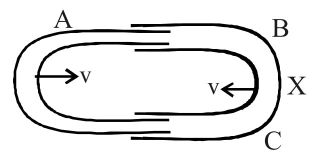
(a) zero (b) RvB
(c) vBL/R (d) vBL

2. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon **[2003]**
(a) the rates at which currents are changing in the two coils
(b) relative position and orientation of the two coils
(c) the materials of the wires of the coils
(d) the currents in the two coils

3. When the current changes from +2 A to –2A in 0.05 second, an e.m.f. of 8 V is induced in a coil. The coefficient of self -induction of the coil is **[2003]**
(a) 0.2 H (b) 0.4 H
(c) 0.8 H (d) 0.1 H

4. A metal conductor of length 1 m rotates vertically about one of its ends at angular velocity 5 radians per second. If the horizontal component of earth's magnetic field is 0.2×10^{-4}T, then the e.m.f. developed between the two ends of the conductor is **[2004]**
(a) 5mV (b) 50 μV
(c) 5 μV (d) 50mV

5. One conducting U tube can slide inside another as shown in figure, maintaining electrical contacts between the tubes. The magnetic field B is perpendicular to the plane of the figure . If each tube moves towards the other at a constant speed v, then the emf induced in the circuit in terms of B, l and v where l is the width of each tube, will be **[2005]**



(a) $-Blv$ (b) Blv
(c) 2 Blv (d) zero

6. The self inductance of the motor of an electric fan is 10 H. In order to impart maximum power at 50 Hz, it should be connected to a capacitance of **[2005]**
(a) 8 μF (b) 4 μF
(c) 2 μF (d) 1 μF

7. In an AC generator, a coil with N turns, all of the same area A and total resistance R, rotates with frequency ω in a magnetic field B. The maximum value of emf generated in the coil is **[2006]**
(a) N.A.B.R.ω (b) N.A.B
(c) N.A.B.R. (d) N.A.B.ω

8. The flux linked with a coil at any instant 't' is given by $\phi = 10t^2 - 50t + 250$. The induced emf at $t = 3s$ is **[2006]**
(a) –190 V (b) –10 V
(c) 10 V (d) 190 V

9. Two coaxial solenoids are made by winding thin insulated wire over a pipe of cross-sectional area A = 10 cm^2 and length = 20 cm. If one of the solenoid has 300 turns and the other 400 turns, their mutual inductance is **[2008]**
($\mu_0 = 4\pi \times 10^{-7}$ Tm A^{-1})
(a) $2.4\pi \times 10^{-5}$ H (b) $4.8\pi \times 10^{-4}$ H
(c) $4.8\pi \times 10^{-5}$ H (d) $2.4\pi \times 10^{-4}$ H

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10. A boat is moving due east in a region where the earth's magnetic field is 5.0×10^{-5} NA^{-1} m^{-1} due north and horizontal. The boat carries a vertical aerial 2 m long. If the speed of the boat is 1.50 ms^{-1}, the magnitude of the induced emf in the wire of aerial is: **[2011]**

(a) 0.75 mV (b) 0.50 mV
(c) 0.15 mV (d) 1 mV

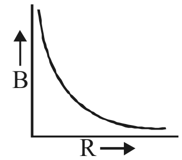
11. A horizontal straight wire 20 m long extending from east to west falling with a speed of 5.0 m/s, at right angles to the horizontal component of the earth's magnetic field 0.30×10^{-4} Wb/m^2. The instantaneous value of the e.m.f. induced in the wire will be **[2011 RS]**

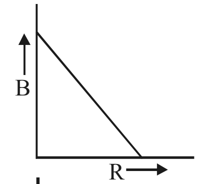
(a) 3mV (b) 4.5 mV
(c) 1.5 mV (d) 6.0 mV

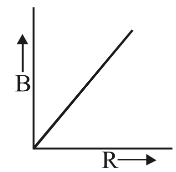
12. A coil is suspended in a uniform magnetic field, with the plane of the coil parallel to the magnetic lines of force. When a current is passed through the coil it starts oscillating; It is very difficult to stop. But if an aluminium plate is placed near to the coil, it stops. This is due to : **[2012]**

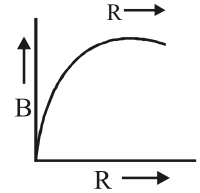
(a) developement of air current when the plate is placed
(b) induction of electrical charge on the plate
(c) shielding of magnetic lines of force as aluminium is a paramagnetic material.
(d) electromagnetic induction in the aluminium plate giving rise to electromagnetic damping.

13. A charge Q is uniformly distributed over the surface of non-conducting disc of radius R. The disc rotates about an axis perpendicular to its plane and passing through its centre with an angular velocity ω. As a result of this rotation a magnetic field of induction B is obtained at the centre of the disc. If we keep both the amount of charge placed on the disc and its angular velocity to be constant and vary the radius of the disc then the variation of the magnetic induction at the centre of the disc will be represented by the figure : **[2012]**

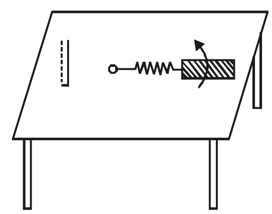
(a)


(b)


(c)


(d)


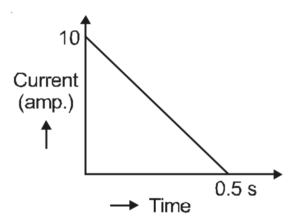
14. A metallic rod of length 'ℓ' is tied to a string of length 2ℓ and made to rotate with angular speed w on a horizontal table with one end of the string fixed. If there is a vertical magnetic field 'B' in the region, the e.m.f. induced across the ends of the rod is **[2013]**



(a) $\frac{2B\omega\ell^2}{2}$ (b) $\frac{3B\omega\ell^2}{2}$

(c) $\frac{4B\omega\ell^2}{2}$ (d) $\frac{5B\omega\ell^2}{2}$

15. In a coil of resistance 100Ω, a current is induced by changing the magnetic flux through it as shown in the figure. The magnitude of change in flux through the coil is **[2017]**



(a) 250 Wb (b) 275 Wb
(c) 200 Wb (d) 225 Wb

Answer Key

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(d)	(b)	(d)	(b)	(c)	(d)	(d)	(b)	(d)	(c)	(a)	(d)	(a)	(d)	(a)

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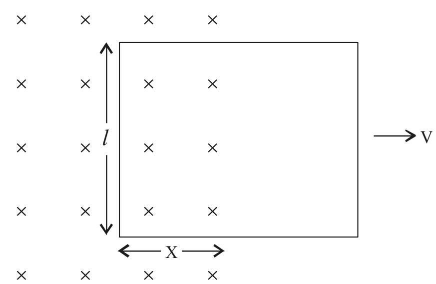
SOLUTIONS

1. **(d)** The induced emf is

$$e = \frac{-d\phi}{dt} = -\frac{d(\vec{B}.\vec{A})}{dt} = \frac{-d(BA\cos 0^{\circ})}{dt}$$



$$\therefore \mathbf{e} = -B\frac{dA}{dt} = -B\frac{d(\ell \times x)}{dt}$$

$$\therefore e = -B\ell\frac{dx}{dt} = -B\ell v$$

2. **(b)** Mutual inductance depends on the relative position and orientation of the two coils.

3. **(d)** $e = -\frac{\Delta\phi}{\Delta t} = \frac{-\Delta(LI)}{\Delta t} = -L\frac{\Delta I}{\Delta t}$

$$\therefore |e| = L\frac{\Delta I}{\Delta t} \Rightarrow 8 = L \times \frac{4}{0.05}$$

$$\Rightarrow L = \frac{8 \times 0.05}{4} = 0.1\text{H}$$

4. **(b)** $\ell = 1\text{m}, \omega = 5$ rad/s, $B = 0.2 \times 10^{-4}T$

$$\varepsilon = \frac{B\omega\ell}{2} = \frac{0.2 \times 10^{-4} \times 5 \times 1}{2} = 50\mu V$$

5. **(c)** Relative velocity $= v + v = 2v$

$\therefore$ emf. $= B.l\,(2v)$

6. **(d)** For maximum power, $X_L = X_C$, which yields

$$C = \frac{1}{(2\pi n)^2 L} = \frac{1}{4\pi^2 \times 50 \times 50 \times 10}$$

$$\therefore C = 0.1 \times 10^{-5} F = 1\mu F$$

7. **(d)** $e = -\frac{d\phi}{dt} = -\frac{d(N\vec{B}.\vec{A})}{dt}$

$$= -N\frac{d}{dt}(BA\cos\omega t) = NBA\omega\sin\omega t$$

$$\Rightarrow e_{max} = NBA\omega$$

8. **(b)** $\phi = 10t^2 - 50t + 250$

$$e = -\frac{d\phi}{dt} = -(20t - 50)$$

$$e_{t=3} = -10\ V$$

9. **(d)** $M = \frac{\mu_0 N_1 N_2 A}{\ell}$

$$= \frac{4\pi \times 10^{-7} \times 300 \times 400 \times 100 \times 10^{-4}}{0.2}$$

$$M = \frac{\mu_0 N_1 N_2 A}{\ell}$$

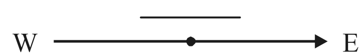
$$= 2.4\pi \times 10^{-4}\text{ H}$$

10. **(c)** Induced emf $= vB_H l = 1.5 \times 5 \times 10^{-5} \times 2$

$= 15 \times 10^{-5}$

$= 0.15$ mV

11. **(a)**



$\varepsilon_{ind} = Bv\ell$

$= 0.3 \times 10^{-4} \times 5 \times 20$

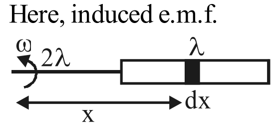
$= 3 \times 10^{-3}$ V $= 3$ mV.

12. **(d)** Because of the Lenz's law of conservation of energy.

13. **(a)** The magnetic field due to a disc is given as

$$B = \frac{\mu_0 \omega Q}{2\pi R} \quad \text{i.e.,} \quad B \propto \frac{1}{R}$$

14. **(d)** Here, induced e.m.f.



$$e = \int_{2\ell}^{3\ell} (\omega x)B\,dx = B\omega\frac{[(3\ell)^2 - (2\ell)^2]}{2}$$

$$= \frac{5B\ell^2\omega}{2}$$

15. **(a)** According to Faraday's law of electromagnetic induction, $\varepsilon = \frac{d\phi}{dt}$

Also, $\varepsilon = iR$

$\therefore \quad iR = \frac{d\phi}{dt} \quad \Rightarrow \quad \int d\phi = R\int i\,dt$

Magnitude of change in flux $(d\phi) = R \times$ area under current vs time graph

or, $\quad d\phi = 100 \times \frac{1}{2} \times \frac{1}{2} \times 10 = 250$ Wb