DPP – 5 (EMI)

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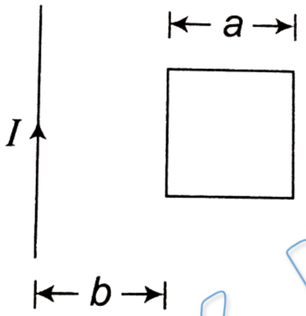
Q 1. The coefficient of mutual inductance



(a) $\frac{\mu_0 a}{2\pi}\ln\left(1+\frac{a}{2b}\right)$ (b) $\frac{\mu_0 a}{\pi}\ln\left(1+\frac{b}{2a}\right)$

(c) $\frac{\mu_0 a}{2\pi}\ln\left(1+\frac{a}{b}\right)$ (d) $\frac{\mu_0 a}{2\pi}\ln\left(1+\frac{b}{a}\right)$

Q 2. Coefficient of mutual inductance of two coils is 1 H. Current in one of the coils is increased from 4A to 5 A in 1 ms. What is the magnitude of average emf induced in the other coil ?

(a) 1000 V (b) 2000 V

(c) 100 V (d) 200 V

Q 3. The coefficient of mutual induction between two coils is 4 H. If the current in the primary reduces from 5A to zero in 10^{-3} sec then the induced emf in the secondary coil will be

(a) 10^4 V (b) 25×10^3 V

(c) 2×10^4 V (d) 15×10^3 V

Q 4. When a current of 5 A flows in the primary coil then the flux linked with the secondary coil is 200 weber. The value of coefficient of mutual induction will be

(a) 1000 H (b) 40 H

(c) 195 H (d) 205 H

Q 5. The coefficient of mutual inductance of two circuits A and B is 3 mH and their respective resistances are 10Ω and 4Ω. How much current should change in 0.02 s in circuit A, so that the induced current in B should be 0.0060A?

(a) 0.24A (b) 1.6 A

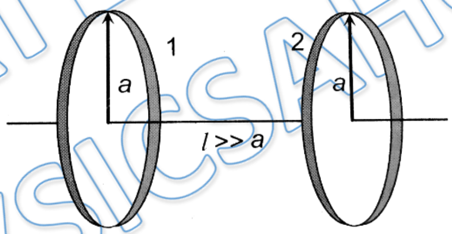
(c) 0.18 A (d) 0.16 A

Q 6. Two coil A and B have coefficient of mutual inductance M=2H. The magnetic flux passing through coil A changes by 4 Weber in 10 seconds due to the change in current in B. Then
(a) change in current in B in this time interval is 0.5A
(b) change in current in B in this time interval is 2A
(c) change in current in B in this time interval is 8A
(d) a change in current of 1A in coil A will produce a change in flux passing through B by 4 weber.

Q 7. Two coils X and Y are placed in a circuit such that when the current changes by 2 A in coil X. The magnetic flux changes by 0.4 Wb in Y. The value of mutual inductance of the coils is
(a) 0.2 H (b) 5 H
(c) 0.8 H (d) 4 H

Q 8. The mutual inductance between a primary and secondary circuits is 0.5 H. The resistances of the primary and the secondary circuits are 20 ohms and 5 ohms respectively. To generate a current of 0.4 A in the secondary, current in the primary must be changed at the rate of
(a) 4.0 A/s (b) 16.0 A/s
(c) 1.6 A/s (d) 8.0 A/s

Q 9. What is the mutual inductance of a two-loop system as shown with center separation l?

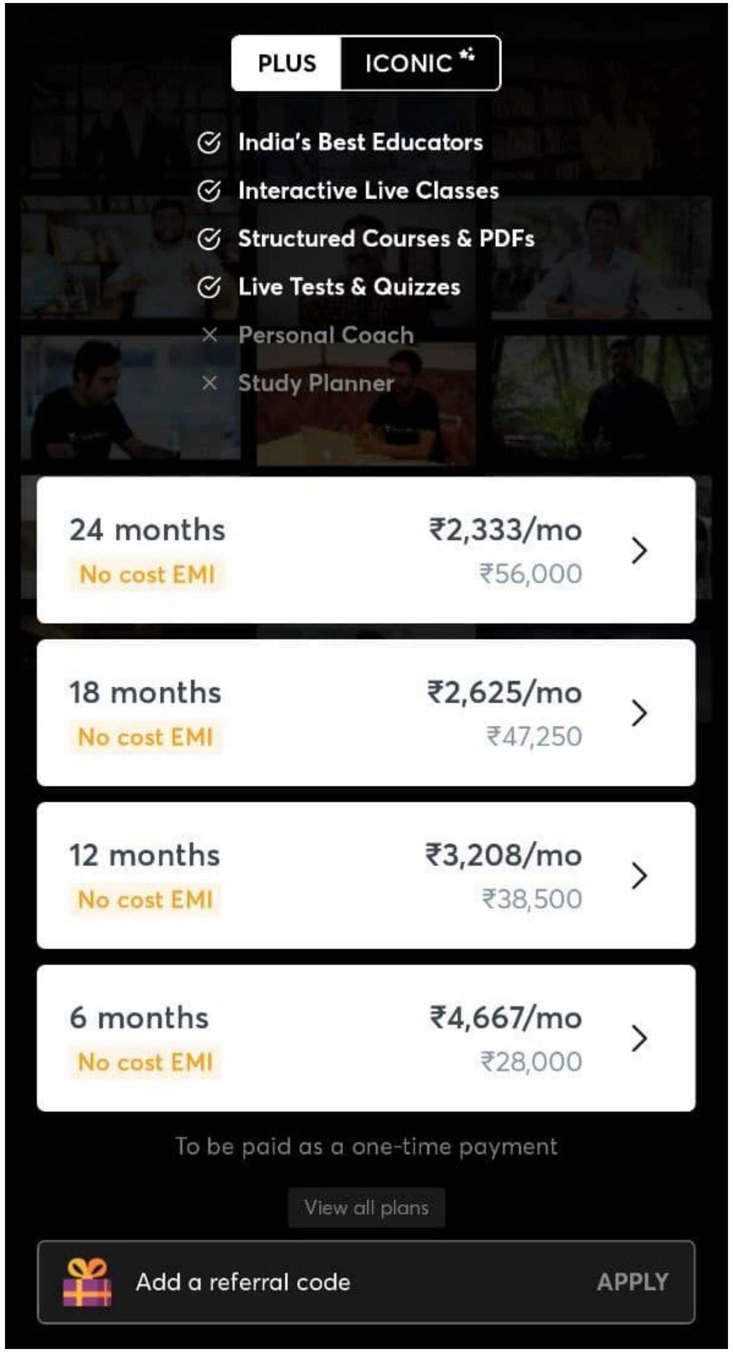


(a) $\frac{\mu_o \pi a^4}{8l^3}$ (b) $\frac{\mu_o \pi a^4}{4l^3}$
(c) $\frac{\mu_o \pi a^4}{6l^3}$ (d) $\frac{\mu_o \pi a^4}{2l^3}$

Q 10. Two coils have a mutual inductance 0.005H. The current changes in the first coil according to equation $I = I_o \sin(\omega t)$, where $I_o = 10A$ and $\omega = 100\pi$ rad/sec. The max. value of e.m.f. in second coil is
(a) 2π (b) 5π
(c) π (d) 4π

Answer Key

Q.1 c	**Q.2 a**	**Q.3 c**	**Q.4 b**	**Q.5 d**
Q.6 b	**Q.7 a**	**Q.8 a**	**Q.9 d**	**Q.10 b**



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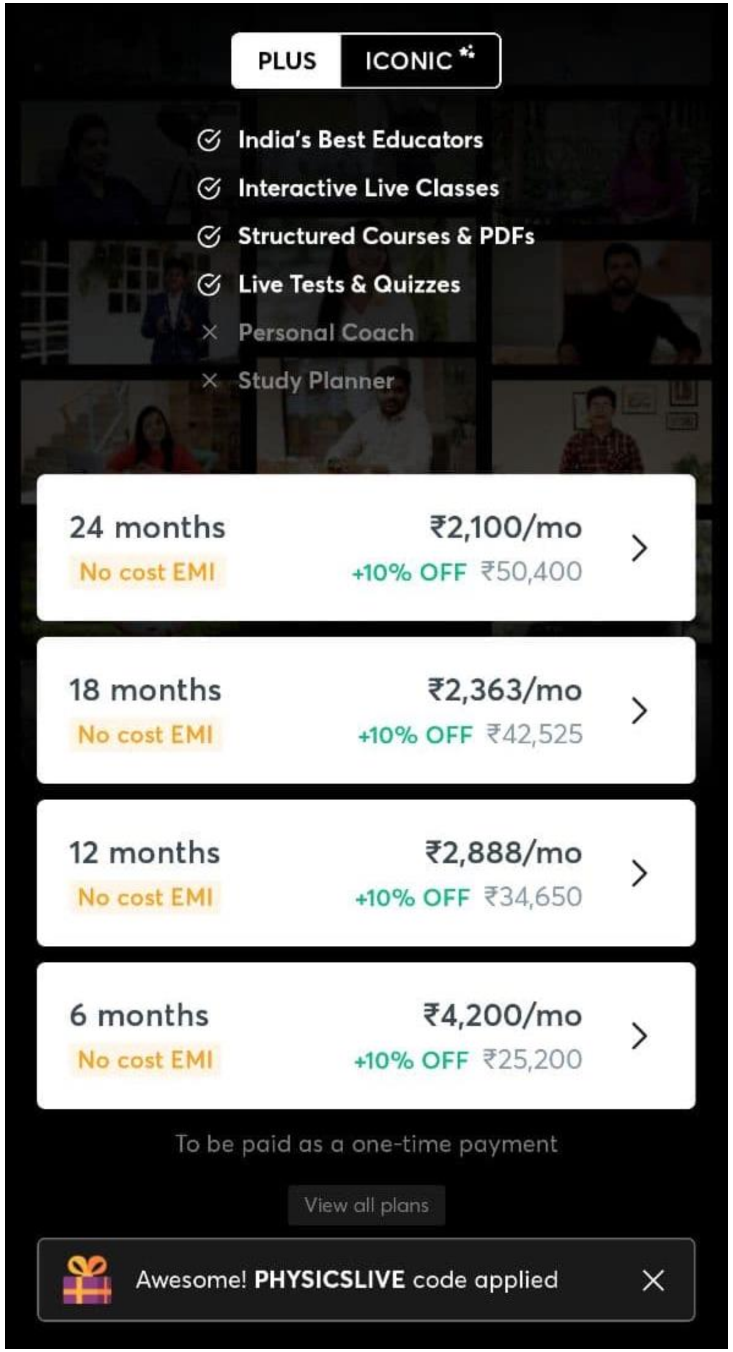


Written Solution

DPP- 5 : EMI - Mutual Induction

By Physicsaholics Team

Solution: 1

$\phi_2 = M I_1$

at a distance 'x' from wire

$B = \frac{\mu_0 I}{2\pi x}$

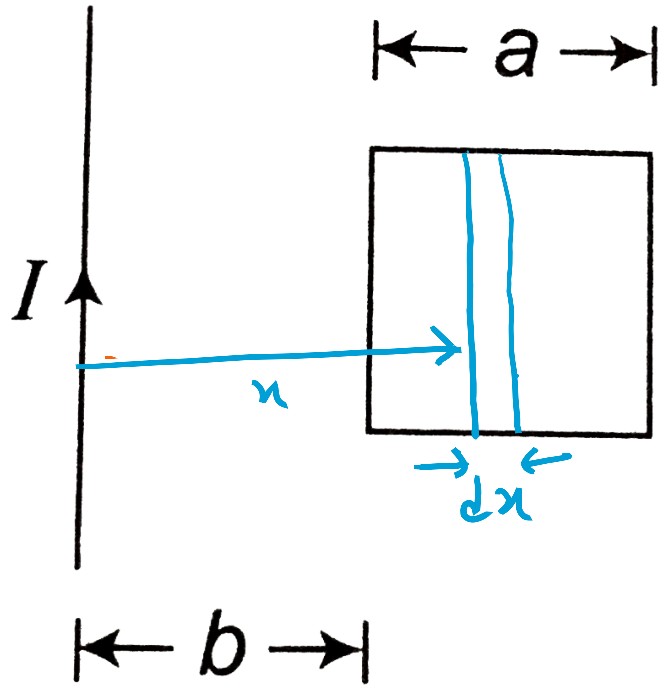
flux passing through element

$d\phi = B \cdot dA = \frac{\mu_0 I}{2\pi x} \times (a \times dx)$

$\int d\phi = \frac{\mu_0 I a}{2\pi} \int_b^{a+b} \frac{dx}{x}$

$\phi = \frac{\mu_0 I a}{2\pi} [\ln(x)]_b^{a+b}$

$\phi = \frac{\mu_0 I a}{2\pi} \ln(a+b) - \ln(b)$



$\Rightarrow \phi = \frac{\mu_0 I a}{2\pi} \ln \frac{a+b}{b}$

$\phi = \frac{\mu_0 I a}{2\pi} \ln\left(1 + \frac{a}{b}\right)$

$\phi = M I$

$\Rightarrow \boxed{M = \frac{\mu_0 a}{2\pi} \ln\left(1 + \frac{a}{b}\right)}$ Ans.

Ans. c

Solution: 2

$$\phi_2 = M I_1$$

$$\varepsilon_2 = -\frac{d\phi_2}{dt} = -M\frac{dI_1}{dt}$$

$$\varepsilon_2 = -M\frac{dI_1}{dt}$$

$$\varepsilon_2 = -1 \times \frac{5-4}{1 \times 10^{-3}}$$

$$\varepsilon_2 = -1 \times \frac{1}{10^{-3}} = -1 \times 10^{3}$$

$$\varepsilon_2 = -1000 \text{ Volt}$$

$$|\varepsilon_2| = 1000 \text{ Volt} \quad \text{Ans.}$$

Ans. a

Solution: 3

$$\varepsilon_2 = -M\frac{dI_1}{dt}$$

$$\varepsilon_2 = -4 \times \frac{0-5}{10^{-3}}$$

$$\varepsilon_2 = -4 \times -5 \times 10^{3}$$

$$\varepsilon_2 = 20 \times 10^{3}$$

$$\boxed{\varepsilon_2 = 2 \times 10^{4} \text{ Volt}}$$ Ans.

Ans. c

Solution: 4

$\phi_2 = M I_1$

$200 = M \times 5$

$M = 40\,H$ Ans.

Ans. b

Solution: 5

$\phi_2 = M I_1$

$\varepsilon_2 = -\frac{d\phi_2}{dt} = -M \frac{dI_1}{dt}$

$I_2 = \frac{\varepsilon_2}{R_2}$

$I_2 = -\frac{M}{R_2}\frac{dI_1}{dt}$

given; $I_2 = 0.0060$ A

$R_2 = 4\,\Omega$

$M = 3$ mH

$dt = 0.02$ s

$dI_1 = ?$

$\Rightarrow 0.0060 = -\frac{3\times10^{-3}}{4} \times \frac{dI_1}{0.02}$

$2 \cancel{6\times10^{-3}} = \frac{-\cancel{3\times10^{-3}}}{4\times2\times10^{-2}} \times dI_1$

$2\times4\times2\times10^{-2} = -dI_1$

$dI_1 = -16\times10^{-2}$

$dI_1 = -0.16$ Amp

$|dI_1| = 0.16$ Amp Ans.

Ans. d

Solution: 6

$$\phi_A = M I_B$$

$$\frac{\Delta\phi_A}{\Delta t} = M \frac{\Delta I_B}{\Delta t}$$

$$\Delta\phi_A = M \Delta I_B$$

$$4 = 2 \times \Delta I_B$$

$$\Rightarrow \boxed{\Delta I_B = 2 \text{ Amp}}$$ Ans.

if $\Delta I_A = 1$ Amp

$$\Rightarrow \Delta\phi_B = M \Delta I_A$$

$$= 2 \times 1$$

$$\boxed{\Delta\phi_B = 2 \text{ weber}}$$

Ans. b

Solution: 7

$$\phi_y = M I_x$$

$$\Delta\phi_y = M \Delta I_x$$

$$M = \frac{\Delta\phi_y}{\Delta I_x}$$

$$M = \frac{0.4}{2}$$

$$\boxed{M = 0.2 \text{ H}}$$ Ans.

Ans. a

Solution: 8

$M = 0.5\,H$

$\delta I_1 = ?$

$\phi_2 = M I_1$

$\varepsilon_2 = M \frac{dI_1}{dt}$

$I_2 R_2 = M \frac{dI_1}{dt}$

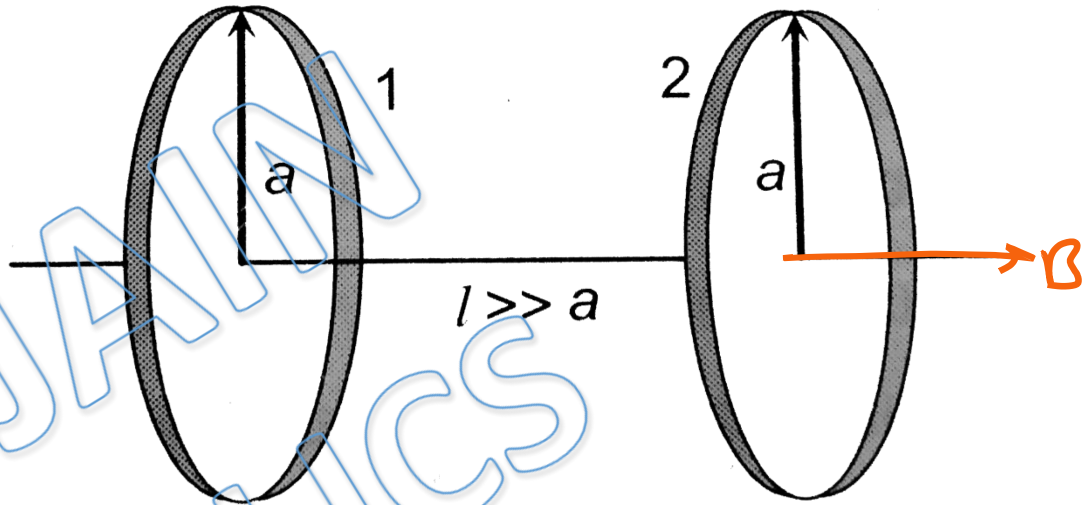
$0.4 \times 5 = 0.5 \frac{dI_1}{dt}$

$4 \times 5 = 5 \frac{dI_1}{dt}$

$\boxed{\frac{dI_1}{dt} = 4 \text{ Amp/sec}}$ Ans.

Ans. a

Solution: 9



B = magnetic field due to coil-1 at centre of coil-2

if $l >> a$

⇒ magnetic field can be assumed inside coil-2

$$B = \frac{\mu_0 I a^2}{2(l^2+a^2)^{3/2}} = \frac{\mu_0 I a^2}{2 l^3} \quad [\because a << l]$$

$$\phi_2 = B A_2 = \frac{\mu_0 I a^2}{2 l^3} \times \pi a^2 \Rightarrow \phi_2 = \frac{\mu_0 I \pi a^4}{2 l^3}$$

$$\phi_2 = M I \Rightarrow \frac{\mu_0 I \pi a^4}{2 l^3} = M I \Rightarrow \boxed{M = \frac{\mu_0 \pi a^4}{2 l^3}} \text{ Ans.}$$

Ans. d

Solution: 10

$$\phi_2 = M I_1$$

$$\frac{d\phi_2}{dt} = M \frac{dI_1}{dt}$$

$$I_1 = 10 \sin \omega t$$

$$\frac{dI_1}{dt} = 10\omega \cos \omega t$$

$$\varepsilon_2 = -M \frac{dI_1}{dt}$$

$$\varepsilon_2 = -0.005 \times 10\omega \cos \omega t$$

$$|\varepsilon_2| = 0.005 \times 10 \times 100\pi \cos \omega t$$

$$|\varepsilon_2| = 5\pi \cos \omega t$$

Max ε_2

$$(\varepsilon_2)_{max} = 5\pi \text{ Volt} \quad \text{Ans.}$$

Ans. b

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