CHAPTER - 15

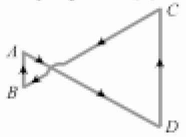
ELECTROMAGNETIC INDUCTION & AC

1. 4

2. 3

3. 4 When switch S is closed magnetic field lines passing through Q increases in the direction from right to left. So, according to Lenz's law induced current in Q i.e. I_{Q_1} will flow in such a direction so that the magnetic field lines due to I_{Q_2} passes from left to right through Q. This is possible when I_{Q_1} flows in anticlockwise direction as seen by E. Opposite is the case when switch S is opened i.e. I_{Q_2} will be clockwise as seen by E.

4. 1 Inward magnetic field (×) increasing. Therefore, induced current in both the loops should be anticlockwise. But as the area of loop on right side is more, induced emf in this will be more compared to the left side loop $\left(e = -\frac{d\phi}{dt} = -A.\frac{dB}{dt}\right)$. Therefore net current in the complete loop will be in a direction shown below. Hence only option (1) is correct.



5. 1 Current in the inner coil $i = \frac{e}{R} = \frac{A_1}{R_1}\frac{dB}{dt}$

length of the inner coil $= 2\pi a$

so it's resistance $R_1 = 50 \times 10^{-3} \times 2\pi\,(a)$

$$\therefore i_1 = \frac{\pi a^2}{50 \times 10^{-3} \times 2\pi\,(a)} \times 0.1 \times 10^{-3} = 10^{-4}\,A$$

According to lenz's law direction of i_1 is clockwise.

Induced current in outer coil $i_2 = \frac{e_2}{R_2} = \frac{A_2}{R_2}\frac{dB}{dt}$

$$\Rightarrow i_2 = \frac{\pi b^2}{50 \times 10^{-3} \times (2\pi b)} \times 0.1 \times 10^{-3} = 2 \times 10^{-4}\,A\,(CW)$$

6. 2

7. 3 By using $e = \frac{1}{2}Bl^2\omega$

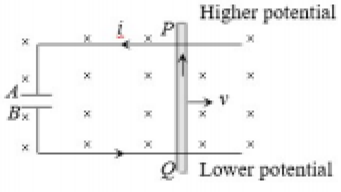
For part AO ; $e_{OA} = e_O - e_A = \frac{1}{2}Bl^2\omega$

For part OC; $e_{OC} = e_O - e_C = \frac{1}{2}B(3l)^2\omega$

$\therefore e_A - e_C = 4\ Bl^2\omega$

8. 1

9. 1 Q = CV = C (Bvl) = $10 \times 10^{-6} \times 4 \times 2 \times 1 = 80\ \mu C$. According to Fleming's right hand rule induced current flows from Q to P. Hence P is at higher potential and Q is at lower potential. Therefore A is positively charged and B is negatively charged.



10. 2 Due to magnetic field, wire will experience an upward force

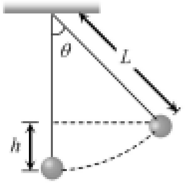
$F = Bil = B\left(\frac{Bvl}{R}\right)l \Rightarrow F = \frac{B^2vl^2}{R}$

If wire slides down with constant velocity then

$$F = mg \Rightarrow \frac{B^2vl^2}{R} = mg \Rightarrow v = \frac{mgR}{B^2l^2}$$

11. 1 $\Rightarrow h = L(1 - \cos\theta)$ ....(i)

Maximum velocity at equilibrium is given by



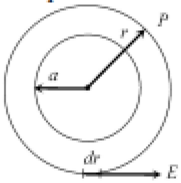
$\therefore\ v^2 = 2gh = 2g\ L(1 - \cos\theta) = 2g\ L\left(2\sin^2\frac{\theta}{2}\right)$

$\Rightarrow v = 2\sqrt{gL}\sin\frac{\theta}{2}$

Thus, max. potential difference

$$V_{max} = BvL = B \times 2\sqrt{gL}\sin\frac{\theta}{2}L = 2BL\sin\frac{\theta}{2}(gL)^{1/2}.$$

12. 2 Construct a concentric circle of radius r. The induced electric field (E) at any point on the circle is equal to that at P. For this circle



$$\oint \vec{E}.d\vec{l} = \left|\frac{d\phi}{dt}\right| = A\left|\frac{dB}{dt}\right| \text{ or } E \times (2\pi r) = \pi a^2 . \left|\frac{dB}{dt}\right|$$

$$\Rightarrow E = \frac{a^2}{2r}\left|\frac{dB}{dt}\right| \Rightarrow E \propto \frac{1}{r}$$

13. 1

14. 3

15. 2 $i = i_0(1 - e^{-Rt/L})$

$i_0 = \frac{E}{R}$ (Steady current) when $t = \infty$

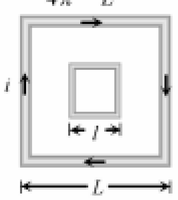
$$i_\infty = \frac{E}{R}(1 - e^{-\infty}) = \frac{15}{10} = 1.5$$

$$i_1 = 1.5(1 - e^{-R/L}) = 1.5(1 - e^{-2})$$

$$\Rightarrow \frac{i_\infty}{i_1} = \frac{1}{1 - e^{-2}} = \frac{e^2}{e^2 - 1}$$

16. 2 Magnetic field produced due to large loop

$$B = \frac{\mu_0}{4\pi}\frac{8\sqrt{2}i}{L}$$



Flux linked with smaller loop

$$\phi = B(l^2) = \frac{\mu_0}{4\pi}\frac{8\pi i l^2}{L}$$

$$\therefore \phi = Mi \Rightarrow M = \frac{\phi}{i} = \frac{\mu_0}{4\pi}.\frac{8\sqrt{2}l^2}{L} \Rightarrow M \propto \frac{l^2}{L}$$

17. 1

18. 1

19. 1

20. 4 The voltage V_L and V_C are equal and opposite so voltmeter reading will be zero.
Also $R = 30\,\Omega,\ X_L = X_C = 25\Omega$
So $i = \dfrac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \dfrac{V}{R} = \dfrac{240}{30} = 8\ A$

SECTION - II

Numerical Type Questions

21. 6
22. 2
23. 8
24. 7

25. 400 $\tan\phi = \dfrac{X_L}{R} = \dfrac{X_C}{R} \Rightarrow \tan 60^o = \dfrac{X_L}{R} = \dfrac{X_C}{R}$
$\Rightarrow X_L = X_C = \sqrt{3}\ R$
i.e. $Z = \sqrt{R^2 + (X_L - X_C)^2} = R$
So average power $P = \dfrac{V^2}{R} = \dfrac{200 \times 200}{100} = 400$ W

PART - II (JEE ADVANCED LEVEL)

26. D
27. B
28. A
29. C
30. D
31. B,C,D
32. A,D
33. A,B,D

34. A,B $L\dfrac{di}{dt} = Bu\ell \Rightarrow \int di = \dfrac{B\ell}{L}\int udt \Rightarrow i = \dfrac{B\ell}{L}x$ ----- (i)
$F = ma \Rightarrow -iB\ell = mu\dfrac{du}{dx}$

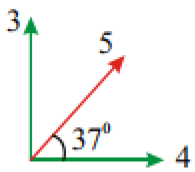
$$\Rightarrow -\frac{B^2\ell^2 x}{L} = mu\frac{du}{dx} \quad \Rightarrow \quad -\frac{B^2\ell^2}{mL}\int_0^d x\,dx = \int_{u_0}^{u_0/2} u\,du$$

$$\Rightarrow -\frac{B^2\ell^2 d^2}{2mL} = \frac{-3u_0^2}{8}, u_0 = \frac{J}{m} \quad \Rightarrow d = \sqrt{\frac{3J^2L}{4B^2\ell^2 m}}$$

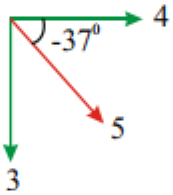
Put $x = d$ in (i), $i = \frac{B\ell}{L}\sqrt{\frac{3J^2L}{4B^2\ell^2 m}} = \sqrt{\frac{3J^2}{4Lm}}$

35. A,C,D
36. B,D
37. A,B,C
38. A,B,C,D
39. A,B,C,D
40. 4
41. 2.3
42. 3
43. -40
44. -4.8

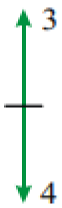
45. A-PS; B-PT; C-QT; D-RS

(A) 

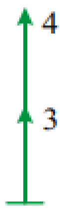
$V_3 = 5V$ current is lagging

(B) 

$V_3 = 5V$ Voltage is lagging

(C) 

$V_3 = 1V$ Voltage is lagging

(D) 

$V_3 = 7V$ Current is lagging