Speed Test-20

1. **(b)** Induced emf produced between the centre and a point on the disc is given by

$$e = \frac{1}{2}\omega BR^2$$

Putting the values,

$\omega = 60$ rad/s, B=0.05 Wb/m^2
and R = 100 cm = 1m

We get $e = \frac{1}{2} \times 60 \times 0.05 \times (1)^2 = 1.5V$

2. **(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 × area under current vs time graph

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

3. **(a)** If a wire, ℓ meter in length, moves perpendicular to a magnetic field of B weber/meter^2 with a velocity of v meter/second, then the e.m.f. induced in the wire is given by

V = B vℓ volt.
Here, B = 0.30 × 10^{-4} weber/meter^2,
v = 5.0 meter/second and ℓ = 10 meter.
$\therefore$ B = 0.30 × 10^{-4} × 5.0 × 10 = 0.0015 volt.

4. **(d)** The magnetic field is increasing in the downward direction. Therefore, according to Lenz's law, the current I_1 will flow in the direction ab and I_2 in the direction dc.

5. **(a)** Self inductance of a solenoid,

$$L = \frac{\mu_0 N^2 A}{l} = \frac{\mu_0 N^2 \pi r^2}{l}$$

$$\therefore \quad \frac{L_1}{L_2} = \left(\frac{r_1}{r_2}\right)^2 \left(\frac{l_2}{l_1}\right) \qquad [\because N_1 = N_2]$$

Here, $\frac{l_1}{l_2} = \frac{1}{2}, \frac{r_1}{r_2} = \frac{1}{2}$

$$\therefore \quad \frac{L_1}{L_2} = \left(\frac{1}{2}\right)^2 \left(\frac{2}{1}\right) = \frac{1}{2}$$

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

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

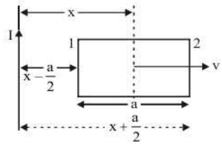
7. **(c)**

8. **(c)** Emf induced in side 1 of frame $e_1 = B_1 V\ell$

$$B_1 = \frac{\mu_o I}{2\pi(x - a/2)}$$

Emf induced in side 2 of frame $e_2 = B_2 V\ell$

$$B_2 = \frac{\mu_o I}{2\pi(x + a/2)}$$



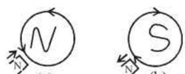
Emf induced in square frame

$e = B_1 V\ell - B_2 V\ell$

$$= \frac{\mu_0 I}{2\pi(x - a/2)}\ell v - \frac{\mu_0 I}{2\pi(x + a/2)}\ell v$$

or, $e \propto \frac{1}{(2x - a)(2x + a)}$

9. **(a)** When a north pole of a bar magnet moves towards the coil, the induced current in the coil flows in a direction such that the coil presents its north pole to the bar magnet as shown in figure (a). Therefore, the induced current flows in the coil in the anticlockwise direction. When a north pole of a bar magnet moves away from the coil, the induced current in the coil flows in a direction such that the coil presents its south pole to the bar magnet as shown in figure (b).



(a) (b)

Therefore induced current flows in the coil in the clockwise direction.

10. **(d)** Given: $\phi = 4t^2 + 2t + 1$ wb

$$\therefore \quad \frac{d\phi}{dt} = \frac{d}{dt}(4t^2 + 2t + 1) = 8t + 2 = |\varepsilon|$$

Induced current, $I = \frac{|\varepsilon|}{R} = \frac{8t+2}{10\Omega} = \frac{8t+2}{10}$A

At t = 1 s,

$$I = \frac{8 \times 1 + 2}{10}A = 1A$$

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

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

$$M = \frac{\mu_0 N_1 N_2 A}{\ell}$$
$$= 2.4\pi \times 10^{-4} \text{ H}$$

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

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

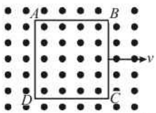
$\Rightarrow L = \frac{8 \times 0.05}{4} = 0.1\text{H}$

13. (c) Total number of turns in the solenoid, N = 500
Current, I = 2A.
Magnetic flux linked with each turn
$= 4 \times 10^{-3}$ Wb

As, $\phi = \text{LI}$ or $\text{N}\phi = \text{LI} \Rightarrow \text{L} = \frac{\text{N}\phi}{\text{I}}$

$= \frac{500 \times 4 \times 10^{-3}}{2}$ henry = 1 H.

14. (d) Electric field will be induced, as ABCD moves, in both *AD* and *BC*. The metallic square loop moves in its own plane with velocity *v*. A uniform magnetic field is imposed perpendicular to the plane of the square loop. *AD* and *BC* are perpendicular to the velocity as well as perpendicular to applied field so an emf is induced in both, this will cause electric fields in both.



15. (d) E.M.F. generated, $e = -\frac{d\phi}{dt} = -\frac{d(N\vec{B}.\vec{A})}{dt}$

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

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

16. (c) $L = 2\text{mH}, i = t^2e^{-t}$

$E = -L\frac{di}{dt} = -L[-t^2e^{-t} + 2te^{-t}]$

when $E = 0$,
$-e^{-t}t^2 + 2te^{-t} = 0$
or, $2te^{-t} = e^{-t}t^2$
$\Rightarrow t = 2$ sec.

17. (b)

18. (b) $\frac{d\phi}{dt} = \frac{(W_2 - W_1)}{t}$ $R_{tot} = (R + 4R)\Omega = 5R\ \Omega$

$i = \frac{nd\varphi}{R_{tot}dt} = \frac{-n(W_2 - W_1)}{5Rt}$.

($\because$ W_2 & W_1 are magnetic flux)

19. (b) The individual emf produced in the coil $e = \frac{-d\phi}{dt}$

$\therefore$ The current induced will be $i = \frac{|e|}{R} \Rightarrow i = \frac{1}{R}\frac{d\phi}{dt}$

But $i = \frac{dq}{dt} \Rightarrow \frac{dq}{dt} = \frac{1}{R}\frac{d\phi}{dt} \Rightarrow \int dq = \frac{1}{R}\int d\phi \Rightarrow q = \frac{BA}{R}$

20. (c) Induced emf $= vB_H l = 1.5 \times 5 \times 10^{-5} \times 2$
$= 15 \times 10^{-5}$
$= 0.15$mV

21. (b) $\varepsilon = \frac{d\phi}{dt} = nA\frac{dB}{dt}$

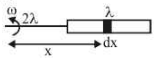
$\therefore$ $\varepsilon = 10 \times (10 \times 10^{-4})(10^4)$ $[10^8 \text{ Gauss/sec} = 10^4 \text{ T/s}]$
$= 100$ V.
$I = (\varepsilon/R) = (100/20) = 5$ amp.

22. (a)

$\varepsilon_{ind} = Bv\ell$
$= 0.3 \times 10^{-4} \times 5 \times 20$
$= 3 \times 10^{-3}$ V = 3 mV.

23. (d) The self inductance of a long solenoid is given by
$L = \mu_r\mu_0 n^2 Al$
Self inductance of a long solenoid is independent of the current flowing through it.

24. (d) Here, induced e.m.f.



$e = \int_{2\ell}^{3\ell}(\omega x)B dx$

$= B\omega\frac{[(3\ell)^2 - (2\ell)^2]}{2} = \frac{5B\ell^2\omega}{2}$

25. (b)

26. (b) Induced e.m.f. in the ring opposes the motion of the magnet.

27. (a)

28. (b)

29. (d) Magnetic flux, $\phi_B = BA\cos\theta$
Induced emf, $\varepsilon = BA\sin\theta$
Here, $\theta = 0°$
$\therefore$ Magnetic flux is maximum and induced emf is zero.

30. (c) e.m.f. induced $= \frac{1}{2}BR^2\omega = \frac{1}{2}BR^2(2\pi n)$

$= \frac{1}{2} \times (0.1) \times (0.1)^2 \times 2\pi \times 10 = (0.1)^2\ \pi$ volts

31. (a) $E = \frac{d}{dt}(NMI) \Rightarrow E = NM\frac{dI}{dt} \Rightarrow E = \frac{NMI}{t}$

emf induced per unit turn $= \frac{E}{N} = \frac{MI}{t}$

32. **(d)** According to Lenz's law, when switch is closed, the flux in the loop increases out of plane of paper, so induced current will be clockwise.

33. **(a)** Since $\varepsilon = -\frac{Nd\phi}{dt}$ if $\frac{d\phi}{dt}$ is fast, so ε is large.

34. **(d)** The e.m.f. is induced when there is change of flux. As in this case there is no change of flux, hence no e.m.f. will be induced in the wire.

35. **(b)** Given, $B = 0.01\ T, A = \pi R^2 = \pi \times (1\ \text{m})^2 = \pi \text{m}^2$
$\omega = 100\ \text{rads}^{-1}$

$\therefore$ The maximum induced emf $\varepsilon_{max} = BA\omega$
$= 0.01 \times \pi \times 100\ \text{V} = \pi \text{V}$

36. **(b)** $e = \frac{-(\phi_2 - \phi_1)}{t} = \frac{-(0 - NBA)}{t} = \frac{NBA}{t}$

$$t = \frac{NBA}{e} = \frac{50 \times 2 \times 10^{-2} \times 10^{-2}}{0.1} = 0.1\ \text{s}$$

37. **(c)** $\frac{\Delta\phi}{\Delta t} = \varepsilon = iR \Rightarrow \Delta\phi = (i\Delta t)R = QR$

$$\Rightarrow Q = \frac{\Delta\phi}{R}$$

38. **(d)** $\phi = BA\cos\theta = 2.0 \times 0.5 \times \cos 60^\circ$

$$= \frac{2.0 \times 0.5}{2} = 0.5 \text{ weber.}$$

39. **(a)** $\xi = \frac{W}{Q} \Rightarrow V = \frac{W}{Q} \Rightarrow W = QV$

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

41. **(c)**

42. **(a)** As the magnetic field increases, its flux also increases into the page and so induced current in bigger loop will be anticlockwise. i.e., from D to C in bigger loop and then from B to A in smaller loop.

43. **(c)** As I increases, ϕ increases
$\therefore I_i$ is such that it opposes the increases in ϕ.
Hence, ϕ decreases (By Right Hand Rule). The induced current will be counterclockwise.

44. **(d)** According to Faraday's law of electromagnetic induction,

Induced emf, $e = \frac{Ldi}{dt}$

$$50 = L\left(\frac{5-2}{0.1\text{sec}}\right)$$

$$\Rightarrow L = \frac{50 \times 0.1}{3} = \frac{5}{3} = 1.67\ \text{H}$$

45. **(d)** Mutual inductance between two coil in the same plane with their centers coinciding is given by

$$M = \frac{\mu_0}{4\pi}\left(\frac{2\pi^2 R_2^2 N_1 N_2}{R_1}\right) henry.$$