Explanations

1. (a) Given, $A = 100\,\text{cm}^2 = 100 \times 10^{-4}\,\text{m}^2$

$$\theta = 30°,\ B_1 = 10^{-1}\ \text{T},\ B_2 = 0$$

$$\Delta t = 10^{-4}\,\text{s}$$

As, magnetic flux, $\phi = BA\cos\theta$

$$\Rightarrow \quad \Delta\phi = \Delta BA\cos\theta = (B_2 - B_1)A\cos 30°$$

$$= -10^{-1} \times 100 \times 10^{-4} \times \frac{\sqrt{3}}{2}$$

$$= -\frac{\sqrt{3}}{2} \times 10^{-3}\ \text{Wb}$$

$\therefore$ Induced emf, $e = \left| -N\frac{\Delta\phi}{\Delta t} \right|$

$$= \left| -1 \times \left(\frac{-\sqrt{3}}{2}\right) \times 10^{-3} \times \frac{1}{10^{-4}} \right| = 5\sqrt{3}\ \text{V}$$

2. (d) Given, $L_1 = 108\,\text{mH}$

$$N_1 = 600$$
$$N_2 = 500$$

As, self-inductance of solenoid, $L = \dfrac{\mu_0 N^2 \pi r}{2}$

$$\Rightarrow \quad L \propto N^2 \quad \therefore \quad \frac{L_1}{L_2} = \frac{N_1^2}{N_2^2}$$

$$\Rightarrow \quad L_2 = L_1\left(\frac{N_2}{N_1}\right)^2 = 108\left(\frac{500}{600}\right)^2$$

$$= 75\,\text{mH}$$

3. (b) According to Lenz's law of electromagnetic induction, the relative motion between the coil and magnet produces the change in magnetic flux.

4. (c) According to Faraday's law, the induced emf in a closed loop equals the time rate of change of magnetic flux through the loop.

i.e. $$e = -\frac{d\phi_B}{dt}$$

Hence, induced emf in a coil depends on the rate of change of flux.

5. (c) When a magnet is dropped between current carrying coils, then magnetic flux in coil changes due to which induced current is produced in the coil, the direction of induced current will be such that it opposes the motion of magnet, so acceleration of magnet will be less than g.

6. (d) When a wire of length l moves with a velocity v perpendicular to a magnetic field B, an induced emf is produced in the wire given by $e = Blv$

Given, $l = 50\text{ cm} = 0.5\text{ m}$

$$\Rightarrow \quad v = 300\text{ m min}^{-1} = \frac{300}{60} = 5\text{ ms}^{-1}$$

and $e = 2\text{V}$

Magnetic field, $B = \dfrac{e}{lv} = \dfrac{2}{0.5 \times 5} = 0.8\text{ T}$

7. (b) When coil is open, there is no current in it, hence no flux is associated with it, i.e. $\phi = 0$.

Also, we know that flux linked with the coil is directly proportional to the current in the coil

i.e. $\phi \propto i \Rightarrow \phi = Li$

where, L is proportionality constant known as self- inductance.

$$\therefore \quad L = \frac{\phi}{i} = 0$$

Again, since $i = 0$, hence, $R = \infty$. $\left[\because i = \dfrac{e}{R}\right]$

8. (d) Induced emf, $e = -L\dfrac{di}{dt} = -L\dfrac{(-2-2)}{0.05}$

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

9. (d) From the relation, $L = \mu_0 n^2 lA$

$$\Rightarrow \quad L = \mu_0 \frac{N^2}{l} A \qquad \left(\because n = \frac{N}{l}\right)$$

$$\Rightarrow \quad L \propto N^2$$

10. (d) For a solenoid of length l, area of cross-section A, having N closely wound turns, the self- inductance of the solenoid is $L = \dfrac{\mu_0 N^2 A}{l}$

When $N' = 2N$

$$\Rightarrow \quad L' = \frac{\mu_0 (2N)^2 A}{l} = \frac{4\mu_0 N^2 A}{l} = 4L$$

Hence, when number of turns is doubled, then self-inductance becomes quadruple.

11. (d) A dynamo converts mechanical energy into electrical energy.

12. (c) Quantity obtained by product of two vectors may be either vector or scalar. Scalar product (dot product) of two vectors gives scalar quantity whereas cross product of two vectors gives vector quantity.

Since, magnetic flux of a magnetic field $\mathbf{B}$ through an area $\mathbf{A}$ is equal to scalar product $\mathbf{B} \cdot \mathbf{A}$, therefore magnetic flux is a scalar quantity.

13. (c) According to Faraday's law, the conservation of mechanical energy into electrical energy is in accordance with the law of conservation of energy.

The earth's magnetic field also produces a flux through the loop. But it is a steady field and hence does not induce any emf.

14. (b) According to Lenz's law, induction effects always oppose the cause.

15. (d) In non-uniform magnetic field, magnetic flux will be obtained by integration, but it will not vary with time.

16. (a) If the inner solenoid is much shorter than (and placed well inside) the outer solenoid, then the flux linkage $N_1\phi_1$ can still be calculated.

It is because the inner solenoid is effectively immersed in a uniform magnetic field due to the outer solenoid.

17. (a) The self-induced emf is also called the back emf as it opposes any change in the current in a circuit. Physically, the self-inductance plays the role of inertia. It is the electromagnetic analogue of mass in mechanics.

18. (b) On moving from left to right, current is increasing, then battery $\left(\text{induced emf} = L \cdot \dfrac{dI}{dt}\right)$ will produce right to left current, i.e. its positive terminal is on left hand side or $V_A > V_B$.

Further $I = \text{constant} \Rightarrow \dfrac{dI}{dt} = 0$ or $V_L = 0$.

19. (i) (b) Current will be smaller, when the magnetic is pulled away from the magnet because change in magnetic flux associated with coil decreases.

(ii) (d) $\phi = t^3 + 3t - 5$

$$\therefore \text{ Induced emf, } e = -\frac{d\phi}{dt} = -(3t^2 + 3) = -3t^2 - 3$$

At $t = 0$, $e = -3\text{ V}$

Therefore, shape of graph will be a parabola not through the origin $(\because e \propto t^2)$.

(iii) (d) If a wire loop is rotated in a magnetic field, the frequency of change in the direction of the induced emf is twice per revolution, i.e. once per half revolution.

(iv) (b) Given, $\phi = 5t^3 - 100t + 20$

Emf induced,

$$e = -\frac{d\phi}{dt} = -\frac{d}{dt}(5t^3 - 100t + 20)$$

$$= -15t^2 + 100$$

$$= -15 \times 2^2 + 100$$

$$= 40 \text{ V}$$

(v) (d) From Faraday's law of electromagnetic induction,

$$e = -\frac{d\phi}{dt} = -BAN \qquad (\because dt = 1\text{ s})$$

Given, $B = 0.2$ T, $N = 20$, $A = \pi r^2 = \pi\,(0.1)^2$

$\therefore \quad e = 0.2 \times 20 \times \pi(0.1)^2 = 40\pi$ mV

20. (i) (a) Eddy currents are minimised by using laminations of metal to make a metal core.

(ii) (d) Induction meter, electromagnetic shielding and energy meter all are based on the use of eddy currents.

(iii) (b) Induction furnace can be used to produce high temperatures and can be utilised to prepare alloys, by melting the constituent metals. A high frequency alternating current is passed through a coil which surrounds the metals to be melted. The eddy currents generated in the metals produce high temperatures sufficient to melt it.

(iv) (a) Since, induction furnaces uses the concept of eddy currents. Thus, they are used to prepare alloys, by melting the constituent metals.

(v) (c) Eddy current generated in the metal produce high temperature sufficient to melt it.