Solution

CET25P6 ELECTROMAGNETIC INDUCTION

Class 12 - Physics

1. **(a)** 80 V

   Explanation: The induced e.m.f. acts in opposite direction to the applied voltage V (Lenz's law) and in known as back or counter e.m.f.
   $i=\frac{V}{R}$
   $R=\frac{V}{i}=\frac{200}{5}=40\Omega$
   When motor is at its maximum speed it operates at
   $V=iR=3\times 40=120V$
   i.e. back emf or oppose to applied voltage = 200 - 120 = 80V

2. **(b)** $0\cdot 1\ H$

   Explanation: Here, dI = (-2) -2 = -4 A,
   dt = $0\cdot 5\ s$ and e = 8 V
   Now, $e=-L\frac{dI}{dt}$
   or $L=-\frac{e}{dI/dt}=-\frac{8}{-4/0\cdot 05}$ = $0\cdot 1\ H$

3. **(b)** 0.1 H

   Explanation: $L=-\frac{e}{\frac{\Delta i}{\Delta t}}$
   $\frac{\Delta i}{\Delta t}=-\frac{4}{0.05}=-80$
   e = 8 volt
   L $=-\frac{8}{-80}=0.1$H

4. **(c)** Zero

   Explanation: Induced EMF is zero because flux linked with it remains constant.

5. **(c)** $\frac{r^2}{R}$

   Explanation: Magnetic field at the centre of a large coil, $B=\frac{\mu_0 I}{2R}$ as, r << R
   Magnetic flux linkage, $\phi=\frac{\mu_0 I}{2R}\times\pi r^2$
   Thus, $M=\frac{\phi}{I}=\frac{\mu_0\pi r^2}{2R}$
   $\therefore M\propto\frac{r^2}{R}$

6. **(b)** become double

   Explanation: Induced emf $\propto$ speed of rotation of the dynamo.

7. **(c)** 0.5 A

   Explanation: $\varepsilon=-\frac{d\phi}{dt}=-100t$
   I(at = 2s) $=\frac{|\varepsilon|}{R}$
   $=\frac{100\times 2}{400}$ = 0.5 A

8. **(c)** no current flows through the ammeter A.

   Explanation: no current flows through the ammeter A.

9. **(c)** $[ML^2T^{-2}Q^{-1}]$

Explanation: $\varepsilon = \frac{[W]}{[q]} = \frac{[ML^2T^{-2}]}{[Q]}$

= $[ML^2T^{-2}Q^{-1}]$

10.

(b) 4H

Explanation: $L = -\frac{e}{\frac{di}{dt}} = -\frac{200}{\frac{-5}{0.1}} = 4H$

11.

(d) $\left(\frac{1}{2}\right)$ revolution

Explanation: Flux of the magnetic field through the loop

ϕ = B.Acosωt

Emf = $\frac{-\mathrm{d}\phi}{\mathrm{dt}}$ = B.Aωsinωt

ωt = 0 to π, sinωt = +ve

ωt = π to 2π, sinωt = −ve

Hence, the direction of induced e.m.f. changes once in $\left(\frac{1}{2}\right)$ revolution.

12.

(c) Electric motor

Explanation: Electric motor

13.

(c) doubled

Explanation: $L = \frac{\mu_0 N^2 A}{l}$

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

14.

(b) 4×10^{-4} Wb

Explanation: $\phi = LI = 50 \times 10^{-3} \times 8 \times 10^{-3}$ Wb

$= 4 \times 10^{-4}$ Wb

15.

(b) less than g

Explanation: As the magnet falls, the magnetic flux linked with the ring increases. This induces emf in the ring which opposes the motion of the falling magnet. Hence a < g.

16. **(a)** constant current clockwise.

Explanation: constant current clockwise.

17.

(d) equal to that due to gravity

Explanation: equal to that due to gravity

18.

(b) looking from above, the induced current in the coil will be anti-clockwise.

Explanation: looking from above, the induced current in the coil will be anti-clockwise.

19.

(d) Zero

Explanation: Induced EMF is zero because flux linked with it remains constant.

20.

(d) Faraday's law

Explanation: According to Faraday's laws,

$|\varepsilon| = \frac{d\phi}{dt}$

21. **(a)** $\frac{1}{2}$Li^2

Explanation: If current I flows through a coil of self-inductance L, then magnetic field energy stored in it is $\frac{1}{2}$Li^2.

22.

(b) 100 V

Explanation: $\varepsilon = L\frac{dI}{dt}$
$= 40 \times 10^{-3}\frac{11-1}{4\times10^{-3}}$ V = 100 V

23.

(d) 136 V

Explanation: $e = NBA\omega = NBA2\pi n = 8 \times 0.5 \times 0.09 \times 2 \times 3.14 \times 60 = 136\text{V}$

24.

(c) become double

Explanation: $\varepsilon_{ind} = \frac{-d(NAB\cos\theta)}{dt} = NAB\sin\theta\frac{d\theta}{dt} = NAB\omega\sin\theta$

25.

(c) 1.9×10^{-3}A

Explanation: 1.9×10^{-3}A

26.

(b) the resistance of the coil

Explanation: Because induced e.m.f. is given by $E = -N\frac{d\varphi}{dt}$

27.

(d) Crooke's dark space

Explanation: At 0.02 mm, the entire discharge tube is filled up with Crooke's dark space.

28.

(d) zero.

Explanation: zero.

29.

(d) 75 mH

Explanation: $L = \frac{\mu_0 N^2 A}{l}$
So, $L \propto N^2$
$\therefore \frac{L_1}{L_2} = \frac{N_1^2}{N_2^2}$
Or, $\frac{108}{L_2} = \frac{600^2}{500^2}$
$\therefore L_2 = 108 \times \frac{25}{36}$ = 75 mH

30.

(b) -10 V

Explanation: The induced e.m.f.
$= -L(\frac{dl}{dt}) = -5 \times 2$ = -10V

31. **(a)** 1 H

Explanation: N = 100, I = 4A, $\phi = 4 \times 10^{-3}$ Wb
$\phi N = LI$
$\therefore L = \frac{\phi N}{I}$
$= \frac{4\times10^{-3}\times1000}{4}$H = 1 H

32.

(b) l decreases and A increases

Explanation: L= self-inductance, A = area of cross-section.
As we know, $L = \mu_r\mu_0\frac{N^2}{ll}Al$
$L = \mu_r\mu_0\frac{N^2A}{l}$
as L is constant for a coil
$L \propto A$ and $L \propto \frac{1}{l}$
As, μ_r and N are constant here so, to increase L for a coil, area A must be increased and l must be decreased.

33.

(d) N^2

Explanation: Self-inductance,
$L=\frac{\mu_0 N^2 A}{l}$
i.e., $L \propto N^2$

34. **(a)** $(\frac{10}{5}) amp$
Explanation: Just after switch is closed, inductor will act as an infinite resistance
$\therefore$ I_2 = 0 and I_1 = I_3
I_1 = $\frac{V}{R_1+R_2}$
I_1 = $\frac{10}{2+3}$
I_1 = $\frac{10}{5}$ amp

35.
(b) $\pi\mu$V
Explanation: $\phi=B\pi r^2\cos 0^{\circ}=B\pi r^2$
$|\varepsilon|=\frac{d\phi}{dt}=\frac{d}{dt}\left(\pi r^2 B\right)=2\pi rB\frac{dr}{dt}$
When r = 2cm $=2\times 10^{-2}$ m
$\frac{dr}{dt}=1\ \mathrm{mm\ s^{-1}}$ = 10^{-3}ms^{-1}
$|\varepsilon|=0.025\times\pi\times 2\times 2\times 10^{-2}\times 10^{-3}$
$=0.100\times\pi\times 10^{-5}=\pi\mu$V

36.
(b) $8.04\times 10^{-4} T$
Explanation: The magnetic induction at the end of the solenoid on its axis
$B=\frac{1}{2}\mu_0 Ni$
$\mu_0=4\pi\times 10^{-7}$ N/A^2
N = 800 turns/meter
i = 1.6 amp
$B=\frac{1}{2}\times 4\pi\times 10^{-7}\times 800\times 1.6=8.04\times 10^{-4}$T

37.
(d) 6.3 C
Explanation: $q=\frac{\text{Net change in magnetic flux}}{R}$
$=\frac{BA(\cos 0^{\circ}-\cos 90^{\circ})}{R}=\frac{B\times\pi r^2(1-0)}{R}=\frac{B\pi r^2}{R}$
$=\frac{2\times 3.14\times(0.1)^2}{0.01}$C = 6.28C = 6.3 C

38.
(d) $Q=\frac{\Delta\phi}{R}$
Explanation: $Q=i\Delta t=\frac{e}{R}\Delta t=\frac{\Delta\phi}{\Delta tR}\Delta t$
Thus, $Q=\frac{\Delta\phi}{R}$

39.
(c) $0\cdot 05\ J$
Explanation: Here, L = 100 mH = $0\cdot 1$ H and I = 1 A
The energy stored is given by
$U=\frac{1}{2}L\ I^2=\frac{1}{2}\times 0\cdot\times 1^2$ $=0\cdot 05\ J$

40.
(b) Weber
Explanation: Weber

41.
(c) Energy
Explanation: Energy

42.
(b) as long as the magnetic flux in the circuit changes.

Explanation: as long as the magnetic flux in the circuit changes.

43.

(b) 375 mH

Explanation: $L \propto N^2$

$\therefore L_2 = \left(\frac{N_2}{N_1}\right)^2 L_1$

$= \left(\frac{500}{100}\right)^2 \times 15\text{mH}$ = 375 mH

44. **(a)** its magnetic field

Explanation: The energy is stored inside an inductor in the form of magnetic field.

45.

(c) $\frac{1}{2\mu_0} B^2 Al$

Explanation: $U = \frac{1}{2} Li^2$

For a solenoid,

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

$B = \mu_0 \frac{N}{l} i$

$i = \frac{Bl}{\mu_0 N}$

Thus, $U = \frac{1}{2}\left(\frac{\mu_0 N^2 A}{l}\right)\left(\frac{Bl}{\mu_0 N}\right)^2$

$U = \frac{1}{2\mu_0} B^2 Al$

46.

(d) be four times

Explanation: $L = \mu_0 n^2$ Al i.e., $\mu \propto n^2$

When n is doubled, L becomes four times its initial value.

47.

(b) $32\mu C$

Explanation: $q = \frac{\Delta\phi}{R} = \frac{\Delta(NBA)}{R} \equiv \frac{NA\Delta B}{R}$

$= \frac{NA\Delta(\mu_0 nI)}{R}$

or $q = \frac{N \times \pi r^2 \times \mu_0 n \Delta I}{R}$

$= \frac{100 \times \pi (0.01)^2 \times 4\pi \times 10^{-7} \times 2 \times 10^4 \times (4-0)}{10\pi^2}$

$= 32 \times 10^{-6}\text{C} = 32\mu\text{C}$

48.

(b) along abc if I increases

Explanation: In accordance with Lenz law.

49. **(a)** resistance (r)

Explanation: current depends on resistance (r), but emf doesn't.

50.

(b) Lenz's law

Explanation: According to Lenz's law, the direction of an induced e.m.f always opposes the change in magnetic flux that causes the e.m.f.

51.

(d) decreases in both A and B.

Explanation: decreases in both A and B.

52.

(c) 2.52 V

Explanation: $\varepsilon = Blv$

$= 0.9 \times 0.4 \times 7$ V

= 2.52 V

53.

(c) 10

Explanation: 10

54.

(b) $\frac{\pi}{2}$

Explanation: $\phi = BA\cos\omega t$

$\varepsilon = -\frac{d\phi}{dt} = BA\omega\sin\omega t$

$= BA\omega\cos\left(\frac{\pi}{2} - \omega t\right)$

$= BA\omega\cos(\omega t - \frac{\pi}{2})$

Phase difference between ϕ and $\varepsilon = \frac{\pi}{2}$

55.

(d) 12 A, 5 A

Explanation: When motor is turned on

$i = \frac{V}{R} = \frac{120}{10} = 12A$

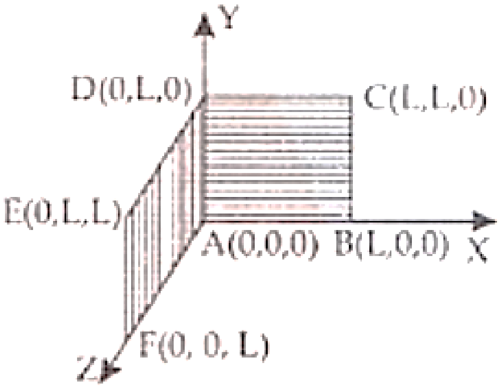
When it has reached maximum speed, the back emf is 70 V, then current will be

$i = \frac{V}{R} = \frac{120-70}{10} = 5A$

56. **(a)** 2 B_0L^2Wb

Explanation:

The loop can be considered in two planes:



i. Plane of ABCDA is in X-Y plane So its vector $\vec{A}$ is in Z-direction so
$A_1 = |A|\hat{k} = L^2\hat{k}$

ii. Plane of DEFAD is in Y-Z plane
So $\mathrm{A_2 = |A|i = L^2 i}$
$\therefore A = A_1 + A_2 = L^2(\hat{i} + \hat{k})$
B = B_0 (i + k)
the magnetic flux linked with uniform surface of area A in uniform magnetic field is given by,
$\phi = B \cdot A = B_0(i+k) \cdot L^2(i+k)\ = \mathrm{B_0L^2[i.\,i + i.\,k + k.\,i + k.\,k]}$
= B_0L^2[1 + 0 + 0 + 1] $\because \cos 90^\circ = 0$
= 2 B_0L^2Wb

57. **(a)** two times

Explanation: $\varepsilon = NBA\omega\sin\omega t$ i.e., $\varepsilon \propto \omega$

$\frac{\varepsilon_2}{\varepsilon_1} = \frac{2\omega}{\omega} = 2$

58.

(c) $\frac{AB}{R}$

Explanation: $\frac{AB}{R}$

59. **(a)** 30^o

Explanation: $\varepsilon = -\frac{\phi_2 - \phi_1}{t}$

$125 \times 10^{-3} = -\frac{0 - 1\times 0.5\times 0.5\times\cos(90^\circ - \theta)}{0.1}$

$125 \times 10^{-3} = 0.50 \times 0.50 \times \sin\theta$
$\sin\theta = \frac{125\times10^{-3}}{0.50\times0.50} = \frac{1}{2}$
$\theta = 30^\circ$

60.

(b) 226 V

Explanation: $\varepsilon_0 = NBA\omega = 30 \times 1 \times 400 \times 10^{-4} \times \left(1800 \times \frac{2\pi}{60}\right)$

= 226 V

61.

(c) 2 L

Explanation: $e = e_1 + e_2$
$L_f \frac{di}{dt} = L_1 \frac{di}{dt} + L_2 \frac{di}{dt}$
$L_f = L_1 + L_2$ = L + L = 2L

62.

(d) $\frac{\mu_0 \pi r_1^2}{2r_2}$

Explanation: Let a time varying current I_2 flow through the outer circular coil.

$\therefore$ Magnetic field at the centre of this coil is
$B_2 = \frac{\mu_0 I_2}{2r_2}$
Since the inner coil placed co-axially has very small radius, B_2 may be considered constant over its cross-sectional area.

$\therefore$ Magnetic flux associated with inner coil is
$\phi_1 = B_2 \times \pi r_1^2 = \left(\frac{\mu_0 I_2}{2r_2}\right) \pi r_1^2 = \pi r_1^2 \frac{\mu_0 I_2}{2r_2}$
or $\phi_1 = \left(\frac{\mu_0 \pi r_1^2}{2r_2}\right) I_2 = M_{12} I_2$
$\therefore M_{12} = \frac{\mu_0 \pi r_1^2}{2r_2}$
Now, $M_{12} = M_{21} = \frac{\mu_0 \pi r_1^2}{2r_2}$

63.

(d) 16V

Explanation: ϕ = $3t^2$ + 4t + 9
$\frac{d\phi}{dt} = 6t + 4$
At t = 2s, $|\varepsilon| = 6 \times 2 + 4$ = 16V

64.

(d) $\sqrt{\mathrm{L_1 L_2}}$
Explanation: $M = k\sqrt{L_1 L_2}$
here k is coefficient of coupling. Its maximum value is 1 for tight coupling.

65.

(b) $\frac{L}{R}$
Explanation: $L_1 = \left(\frac{\eta}{\eta+1}\right) L, R_1 = \left(\frac{\eta}{\eta+1}\right) R$
$L_2 = \left(\frac{1}{\eta+1}\right) L, R_2 = \left(\frac{1}{\eta+1}\right) R$
$L_{net} = \frac{L_1 L_2}{L_1 + L_2} = \frac{\eta LL}{(\eta+1)(\eta L + L)}$
Similarly, $R_{net} = \frac{R_1 R_2}{R_1 + R_2} = \frac{\eta RR}{(\eta+1)(\eta R + R)}$
$\tau_L = \frac{L_{net}}{R_{net}} = \frac{L}{R}$

66.

(d) $\frac{L}{2}$

Explanation: If M is negligible, then for parallel combination of two inductors,
$L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$
$= \frac{L \times L}{L + L} = \frac{L}{2}$

67.

(c) Electromagnetic induction

Explanation: Electromagnetic induction, the electric dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current through Faraday's law of induction.

68. **(a)** 32 units

Explanation: Induced e.m.f = $\frac{d\phi}{dt}$

= -($5t^2$ + 2t + 3)

= -(10t + 2) = -32

69.

(b) 0.2 H

Explanation: $\varepsilon = L\frac{dI}{dt}$

or $8 = L\frac{2-0}{0.05}$

or L = 0.2 H

70.

(b) 1 mH

Explanation: $M = -\frac{e_2}{\frac{\Delta i}{\Delta t}} = \frac{100\times10^{-3}}{\frac{10}{0.1}} = 10^{-3}H$

= 1 mH

71. **(a)** inertia

Explanation: inertia

72. **(a)** there is a constant current in the counterclockwise direction in A.

Explanation: there is a constant current in the counterclockwise direction in A.

73.

(d) $5\sqrt{3}$ V

Explanation: Flux through the coil ϕ = BA cos θ

or, $\phi = 10^{-1} \times (100 \times 10^{-4}) \times \cos 30^{o}$

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

Induced emf = $\varepsilon = \frac{-d\phi}{dt} = \frac{-(\phi_f - \phi_i)}{\Delta t}$

$= \frac{-\left(0-10^{-3}\times\frac{\sqrt{3}}{2}\right)}{10^{-4}}$

$= 5\sqrt{3}$ V

74.

(d) is tripled

Explanation: ϕ = $NBA\cos\theta$

i.e., $\phi \propto N$

75.

(b) 2 L

Explanation: When the two inductors are joined in series,

$L_{eq} = L_1 + L_2 = L + L$

= 2L