TOPIC : ELECTROMAGNETIC INDUCTION
EXERCISE # 1

SECTION (A)

1. $B_H = 3 \times 10^{-5}$ wb/m^2
$\phi = NBA \cos\theta = NBA \cos 0$
$3 \times 10^{-5} \times 5 \times 1m^2 = 15 \times 10^{-5}$ wb

5. $\phi = BA \cos\theta = 2.0 \times 0.5 \times \cos 60° = 2.0 \times 0.5 \times \frac{1}{2} = 0.5$ wb

6. $\phi = 0.02 \cos 100\pi t$
N = 50
$v = -\frac{d\phi}{dt} = -0.02 \times 50 \times 100\pi \times \sin 100\pi t = 1 \times 100 \times \pi = 100 \times 3.14 = 314$ volt

7. $\phi = 3t^2 + 4t + 9$
$|v| = \left|-\frac{d\phi}{dt}\right| = 6t + 4 = 6 \times 2 + 4 = 12 + 4 = 16$ volt

8. Since $\Delta\phi = 0$ hence EMF induced is zero.

9. Since magnetic field lines around the wire AB are circular, therefore magnetic flux through the circular loop will be zero, hence induced emf in the loop will be zero.

SECTION (B)

8. The direction of current in the loop such that it opposes the the change in magnetic flux in it.

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10. Since the magnetic flux in the loop is zero hence the current induced in it is zero.

11. By moving away from solenoid the ring will resist the changing flux in it.

12. The repulsion is to resist the increasing magnetic flux in coil B.

13. Q will move towards P to resist the increasing magnetic flux in the loop formed due to rails R,S and conductors P,Q.

14. When the magnet goes away from the ring the flux in the ring decreases hence the induced current will be such that it opposes the decreasing flux in it hence ring will behave like a magnet having face A as north pole and face B as south pole.

SECTION (C)

1. $l = 2m$, $v = 1m/s$, $B = 0.5$ wb/m^2
$v = Bvl = 2 \times 1 \times 0.5 = 1.0$ volt

2. $V = B\, v \times l$
$= 2 \times 10^{-4} \times 720 \times \frac{5}{18} \times 50$
$= 2 \times 10^{-4} \times 200 \times 50 = 2 \times 5 \times 2 \times 10^{-1}$
$= 2 \times 10 \times 10^{-1} = 2$ volt

3. $V = Bvl = 0.9 \times 7 \times 0.4 = 2.52$ V

4. $V = B \times v \times l = 4 \times 10^{-5} \times (30 \times \frac{5}{18}) \times 3$
$= 1 \times 10^{-3}$ volt

in horizontal case $V = 0$ $\quad \vec{\ell} \parallel \vec{B}$

6. If $\vec{\upsilon} \parallel \vec{\ell}$ or $\vec{\upsilon} \parallel \vec{B}$ or $\vec{\ell} \parallel \vec{B}$ then $\frac{d\phi}{dt}$ is zero. Hence potential difference is zero.

7. $\varepsilon = \vec{B}.(\vec{V} \times \vec{\ell})$

$= (3\hat{i} + 4\hat{j} + 5\hat{k}).[1\hat{i} \times 5\hat{j}]$

$\varepsilon = 25$ volt.

8. This is in accordance with Lenz law.

9. $e = Bvl$
Here : $B = 10T$, $v = 200$ km/sec
$= 2 \times 10^5$ m/sec, $l = 5$m
Putting given values is eq. (i)
$\therefore \quad e = 10 \times 2 \times 10^5 \times 5$
$= 1 \times 10^7$ volt

10. Induced emf is given by
$e = Bvl \sin\theta = 0.1 \times 10 \times 4 \sin 30°$
$e = 2$ volt

11. Induced emf = workdone in taking a charge
$$\frac{\text{Q once along the loop}}{\text{charge Q}}$$

i.e., $\quad V = \frac{W}{Q}$
$\Rightarrow \quad W = VQ$

SECTION (D)

1. It the magnitude of I_A is very large such that force due to magnetic field on PQ exceeds its weight then it will move upwards otherwise it will move downwards.

2. $V = Bvl = 0.15 \times 2 \times 0.5 = 0.15 \times 1 = 0.15$ volt

$F = Bil = 0.15 \times \frac{.15}{3} \times .5 = 75 \times 10^{-4} \times .5 = 375 \times 10^{-5} = 3.75 \times 10^{-3}$ N.

4. $W = (0.5)F$
$= 0.5 \times ILB \quad$ or $\quad H = I^2 RT$

$= 0.5 \times \frac{L^2B^2V}{R} = \frac{0.5 \times (0.5)^2 \times (1)^2 \times \left(\frac{0.5}{2}\right)}{10} = 3.125 \times 10^{-3}$ J.

5. Relative velocity $= \upsilon - (-\upsilon) = 2\upsilon = \frac{dl}{dt}$

Now, $\quad e = \frac{d\phi}{dt}$

$e = \frac{Bld l}{dt}$ $\left(\frac{dl}{dt} = 2\upsilon\right)$

Induced emf

$e = 2\,Bl\upsilon$

SECTION (E)

1. $V = \frac{1}{2} B\omega l^2$

$\omega = 2\pi f$

3. $\Delta q = \frac{\Delta\phi}{R}$ independent to time

4. $l = 1m$, $B = 0.2 \times 10^{-4}$ T, $W = 5$ radi/sec

$$V = \frac{1}{2} Bwl^2$$

5. $w = 2\pi \times f = 60\pi$ rad/s

$V = V_0 \sin wt$

$V = NABw \sin wt$

$V_{max} = NABW = 60 \times 200 \times 10^{-4} \times 0.5 \times 60\,\pi = 6 \times 2 \times 0.5 \times 6\,\pi = 36\,\pi = 36 \times 3.14 = 113$ v

6. $R = 5\,\Omega$, $i = 0.2A$,

$V = -\frac{d\phi}{dt} = i \times R = 5 \times 0.2 = 1$volt

Rate of chage of magnetic flux = 1volt = $\frac{1wb}{second}$

7. Since there is no magnetic flux change due to roation of rod hence the potential difference between two ends of the rod is zero.

8. Here effective length is 2R

$\varepsilon = \frac{1}{2} B\omega(2R)^2 = 2B\omega R^2$

9. The rate of change of flux or emf induced in the coil is

$\varepsilon = \frac{-\Delta\phi}{\Delta t}$

∴ Induced current

$i = \frac{\varepsilon}{R_{eq}} = -\frac{1}{R}\frac{\Delta\phi}{\Delta t}$ ...(i)

Given: $R_{eq.} = R + 4R = 5R$, $\Delta\phi = n(w_2 - w_1)$ A, $\Delta t = t$. (Here W_1 and W_2 are associated with one turn.)

Putting the given values in eq. (i), we get

∴ $i = -\frac{n}{5R}\frac{(W_2 - W_1)A}{t}$

10. The emf induced between ends of conductor

$e = \frac{1}{2} B\omega L^2$

$= \frac{1}{2} \times 0.2 \times 10^{-4} \times 5 \times (1)^2 = 0.5 \times 10^{-4}\,V = 5 \times 10^{-5}\,V = 50\,\mu V$

SECTION (F)

1. $N = 100$, $A = 100 \times 10^{-4}\,M^2$,

$B = 50$ gans.

$y = \frac{d(N\phi)}{dt} = \frac{N.\Delta\phi}{\Delta t} = \frac{100 \times 100 \times 10^{-4} \times 50 \times 10^{-4}}{0.01}$
$= 50 \times 100 \times 10^{-4} = 0.5$ volt

2. $|V| = \frac{d\phi}{dt} = B.\frac{da}{dt}$ $V = B.\frac{d}{dt}(\pi r^2)$ $V = B.\ \pi.2r.\frac{dr}{dt}$
$= 0.02 \times 3.14 \times 2 \times 4 \times 10^{-2} \times 1 \times 10^{-3}$
$= 5 \times 10^{-6}$ V = 5μv

3. $a = \frac{qE}{m} = \frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$.

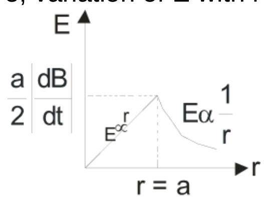
4. $\oint \vec{E}.\vec{dl} = \left|\frac{d\phi}{dt}\right| = S\left|\frac{dB}{dt}\right|$

or $E(2\pi r) = \pi a^2 \times \frac{dB}{dt}$ for $r \geq a$

∴ Induced electric field $\propto \frac{1}{r}$ for $r \leq a$

$E = (2\pi r) = \pi r^2 \left|\frac{dB}{dt}\right|$ or $E = \frac{r}{2}\left|\frac{dB}{dt}\right|$ or $E \alpha r$

At r = a, $E = \frac{a}{2}\left|\frac{dB}{dt}\right|$
Therefore, variation of E with r (distance from centre) will be as follows :



5. According to faraday's second law of electromagnetic induction the induced emf is given by rate4 of change of magnectic flux linked with the circuit.

Here, B = 0.04 T and $\frac{-dr}{dt} = 2mms^{-1}$

induced emf, $e = \frac{-d\phi}{dt} = \frac{-BdA}{dt} = -B\frac{d(\pi r^2)}{dt}$

$= -B\pi 2r\frac{dr}{dt}$

Now , if r = 2 cm
$e = -0.04 \times \pi \times 2 \times 2 \times 10^{-2} \times (-2 \times 10^{-3}) = 3.2\ \pi\mu V$

6. The flux associated with coil of area A and magnetic induction B is

$\phi = BA\cos\theta = \frac{1}{2}B\pi r^2\cos\omega t$ $\left[\because A = \frac{1}{2}\pi r^2\right]$

∴ $e_{induced} = -\frac{d\phi}{dt} = -\frac{d}{dt}\left(\frac{1}{2}B\pi r^2\cos\omega t\right)$

$= \frac{1}{2}B\pi r^2\omega\sin\omega t$ ∴ Power $P = \frac{e^2_{induced}}{R} = \frac{B^2\pi^2r^4\omega^2\sin^2\omega t}{4R}$
Hence, $P_{mean} = $ < P >

$= \frac{B^2\pi^2r^4\omega^2}{4R} \cdot \frac{1}{2}$ $\left[\because <\sin\omega t> = \frac{1}{2}\right]$

$= \frac{\left(B\pi r^2\omega\right)^2}{8R}$

SECTION (G)

1. L α n^2

4. $L = -\frac{V}{\frac{\Delta i}{\Delta t}} = +\frac{5}{10^3} = +5\times10^{-3}H$ = 5 mH

5. $\frac{L_1L_2}{L_1+L_2} = 2.4$

$L_1 + L_2 = 10$ ⇒ $L_1 - L_2 = \sqrt{(L_1+L_2)^2 - 4\ell_1\ell_2} = \sqrt{10^2 - 4\times24} = \sqrt{100-96} = \sqrt{4} = 2$

6. U = $\frac{1}{2}$ × Li^2 $\frac{1}{2}$ = × 2 × $\left(\frac{10}{2}\right)^2$ = 1 × 5^2 = 25 J

7. $V = \left|L.\frac{di}{dt}\right|$ ⇒ 5 × $\frac{1}{5}$ = 1 volt

9. B = $\frac{\mu_0 Ni}{L}$ = 4 π×10^{-7}× $\frac{200}{10^{-2}}$ × 2.5

12. ∵ $L.\frac{di}{dt} = V$

L = $\frac{v}{\frac{di}{dt}}$ = $\frac{45}{1.5} = 30H$

13. U = $\frac{1}{2}$ LI^2

P = I^2R or $\frac{2U}{P} = \frac{L}{R}$ = τ.

14. R has dimensions $ML^2T^{-3}I^{-2}$, C has dimensions $M^{-1}L^{-2}T^4I^2$, L has dimensions $ML^2T^{-2}I^{-2}$, frequency has dimensions T^{-1}.

15. $L_1\frac{di_1}{dt}$ = $L_2\frac{di_2}{dt}$ or $L_1di_1 = L_2di_2$ or $L_1i_1 = L_2i_2$ ∴ $\frac{i_1}{i_2} = \frac{L_2}{L_1}$

16. EMF induced = –L $\frac{di}{dt}$.

17. $V_{ab} = L\frac{dI}{dt} + IR$

8 = L × 1 + 2 × R

4 = – L × 1 + 2 × R

Solving the above equations

we get R = 3Ω

L = 2H.

18. $e = -L\frac{di}{dt} = -L\frac{(-2-2)}{0.05}$

$8 = L\frac{(4)}{0.05}$ $\quad\therefore\quad$ $L = \frac{8\times 0.05}{4} = 0.1H$

19. For a DC source inductance plays no role.

$\therefore$ Current in the circuit (I) = $\frac{E}{R}$

20. When current flows in any of the coils, the flux linked with the other coil will be maximum in the first case. Therefore, mutual inductance will be maximum in case (1) .

21. Energy density in magnetic field is directly proportional to B^2.

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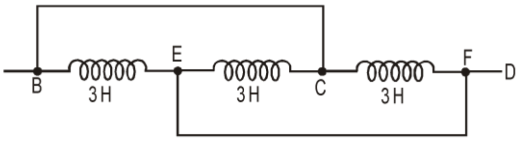
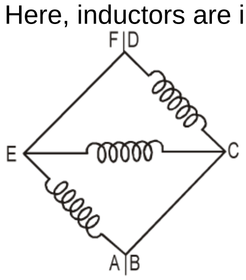
23. Initially the inductor offers infinite resistance hence i_1 is 1A. Finally, at steady state inductor offers zero resistance and current i_2 is 1.25 A in the battery.

24.



Here, inductors are in parallel



$\therefore$ $\frac{1}{L} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$

L = 1

25. $\frac{1}{2}Li^2 = \frac{1}{2}\frac{q^2}{C}$

$\Rightarrow$ $q^2 = Li^2C$ .....(i)

and $U_{E(max)} = U_{B(max)}$ (given) .....(ii)

Since, $U_B = \frac{1}{2}Li^2$ where $i = \frac{\varepsilon}{R}(1-e^{Rt/L})$ at t = ∞ ; = $i_\infty = \frac{\varepsilon}{R}$

$U_{B(max)} = \frac{1}{2}Li_\infty^2$ .....(iii)

and $U_{E(max)} = \frac{Q^2}{2C}$ .....(iv)

Where Q is maximum charge on capacitor. The energy is equally divided between electric and magnetic fields. Therefore $\therefore$ $U_B = \frac{U_{B(max)}}{2}$ $\Rightarrow$ $\frac{1}{2}Li^2 = \frac{1}{2}\left(\frac{1}{2}Li_\infty^2\right)$

$\Rightarrow$ $i_\infty^2 = 2i^2$ ......(v)

From equation (ii), (iii), (iv) and (v), we get

$\therefore$ $\frac{1}{2}L.\,2i^2 = \frac{1}{2}\frac{Q^2}{C}$ $\Rightarrow$ $LCi^2 = \frac{Q^2}{2}$

$\therefore$ $q^2 = \frac{Q^2}{2}$ [from equation (i)] $q = \frac{Q}{\sqrt{2}}$

Method II

$\frac{q^2}{2C} = \frac{1}{2}\left(\frac{Q^2}{2C}\right) \Rightarrow q = \frac{Q}{\sqrt{2}}$ **Ans.**

26. $I = I_0 e^{-Rt/L} = \frac{1}{e}$ A.

SECTION (H)

2. $\therefore M = \sqrt{L_1.L_2}$ $\Rightarrow$ $M = 0.5$ H

3. $\phi = NAB$

$\frac{\mu_0 Ni}{2R_1}\pi R_2^2 = Mi$

$M \propto \frac{R_2^2}{R_1}$

4. $M = 0.5$ H

$R_p = 20\Omega$, $R_s = 5\Omega$

$\frac{M.di_p}{dt} = V_s = R_s \times i_s$

$0.5 \times \frac{di_p}{dt} = 0.4 \times 5$ $\Rightarrow$ $.5.\frac{di_p}{dt} = 5 \times 0.4$ $\Rightarrow$ $\frac{di_p}{dt} = 4$ A/s

5. $N_A = 300$ $N_B = 600$

$i_A = 3A$ $i_B = ?$

$\phi_A = 1.2 \times 10^{-4}$ wb $\phi_B = 9.0 \times 10^{-5}$ wb $\because = M \times i_A = \phi_B$

$M = \frac{\phi_B}{i_A} = \frac{9.0 \times 10^{-5}}{3} = 3 \times 10^{-5}$ H

6. $M = \frac{M = m \times \ell}{M' = m \times 2 \times \frac{\ell}{\pi}}$ $\Rightarrow$ $M' = \frac{2M}{\pi}$

7. Mutual inductance of the pair of coils depends on distance between two coils and geometry of two coils.

8. L_{eq} in parallel, is given by $L = \frac{L_1 L_2}{L_1 + L_2}$

9. (1) When current flows in any of the coils, the flux linked with the other coil will be maximum in the first case. Therefore, mutual inductance will be maximum in case (1) .

10. $L_1 = 2$ mH, $L_2 = 8$mH

$M = \sqrt{L_1.L_2} = \sqrt{2 \times 8} \times 10^{-3} = 4$ mH

11. **Key Idea:** Inductance of a coil is numerically equal to the emf induced in the coil when the current in the coil changes at the rate of 1 As^{-1}. If I is the current flowing in the circuit, then flux linked with the circuit is observed to be proportional to I, ie,

$\phi \propto I$

or $\phi = LI$ ....(i)

where L is called the self-inductance or coefficient of self-inductance or simply inductance of the coil.
Net flux through solenoid,

$$\phi = 500 \times 4 \times 10^{-3} = 2 \text{ Wb}$$

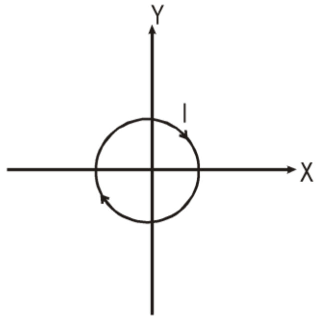
or $2 = L \times 2$ [after putting values in Eq. (i)]

or $L = 1$ H

12. $M = \mu_0 n_1 A N_2 = \left(4\pi \times 10^{-7}\right)\left(\frac{300}{0.20}\right)(10 \times 10^{-4})(400)$
$= 2.4\,\pi \times 10^{-4}$ H

EXERCISE # 2

1. Total magnetic flux passing through whole of the X-Y plane will be zero, because magnetic lines from a closed loop. So as many lines will move in -Z direction same will return to + Z direction from the X-Y plane.



2. When the coil is entering and coming out of the field the magnetic flux in it is changing but when it is within the field the magnetic flux in it is constant.

3. Since the magnitude flux in the ring due to motion of charge particle is zero hence the induced emf will be zero.

4. Since the tube is very long the force on magnet due to induced current will continue to oppose its motion till it acquires a constant speed.

5. When the loop enters the magnetic field the magnetic flux in it changes till it covers a distance 'a'. Hence the EMF induced in the surface afer that flux in it remains constant till its back portion has not entered in magnetic field. No emf is induced during this time.when it is out of magnetic field the magnetic flux in it decreases. EMF is again induced in the circuit hence total time for which emf is induced is $\frac{2a}{v}$.

6. Electric field will be induced in both AD and BC.

7. Force acting on the rod because of the induced current due to change in magnetic flux will try to oppose the motion of rod. Hence the accelereation of the rod will decrease with time $\frac{dp}{dt} = F\frac{dv}{dt}$ = F × a. Thus, rate of power delivered by external force will be decreasing continuously.

8. $I = -\frac{1}{R}\frac{d\phi}{dt}$

$I = \frac{BA}{RT} = \frac{1}{3}$ A.

9. The induced current in upper semicircular and lower semicircular will cancel each other in diameter (AB).

10. Since $P_1 = P_2$ or $i_1v_1 = i_2v_2$ & $\frac{L_1\frac{di_1}{dt}}{L_2\frac{di_2}{dt}} = \frac{v_1}{v_2}$ or $\frac{v_1}{v_2} = 4$ & $\frac{i_1}{i_2} = \frac{1}{4}$ $\frac{w_2}{w_1} = \frac{\frac{1}{2}L_2I_2^2}{\frac{1}{2}L_1I_1^2} = 4$.

11. $i = i_0\left(e^{\frac{-t}{\tau}}\right)$ or $t = \frac{2}{\ln\left(\frac{10}{9}\right)}$.

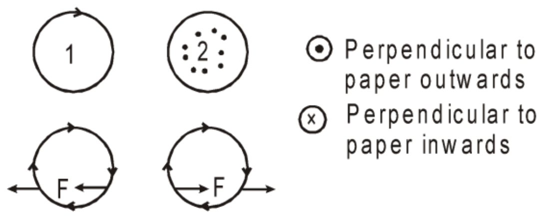
12. Initially inductor will offer infinite resistance and capacitors zero resistor and finally capacitor will offer infinite resistance and inductor will offer zero resistance.

13. $I = I_1 + I_2$
$I_1 = E/R$
$\frac{dI}{dt} = E.$
$I_2 = \frac{Et}{L}$
$I = E/R + \frac{Et}{L}$
$I = 12A.$

14. EMF = $\left|-M\frac{dI}{dt}\right|$ $25 \times 10^{-3} = L \times 15$ or $L = \frac{5}{3} \times 10^{-3}$ H
$\phi = LI = \frac{5}{3} \times 10^{-3} \times 3.6 = 6.00$ mWb.

15. As the flux in the ring due to wire will be zero hence mutual inductance will be zero.

16. For understanding, let us assume that the two loops are lying in the plane of paper as shown. The current in loop 1 will produce ⊙ magnetic field in loop 2. Therefore, increase in current in loop 1 will produces ⊗ magnetic field passing through it i.e. induced current in loop 2 will also be clockwise as shown alongside.

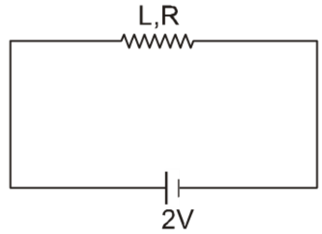


The loops will now repel each other as the currents at the nearest and farthest points of the two loops flow in the opposite directions.

17. When two coils are brought near to each other then flux changes to both the coils, due to which induce current produces, so the current in both decrease, because induce current oppose the main current.

19. Magneticfield is produced by moving charges, (current carrying loop) and changing electric field.

20. The current at any instant is given by
$I = I_0(1 - e^{Rt/L})$
$\frac{I_0}{2} = I_0(1 - e^{Rt/L})$
$\frac{1}{2} = (1 - e^{-Rt/L})$



$e^{-Rt/L} = 1/2$

$\frac{Rt}{L} = \ln 2$

$\therefore \quad t = \frac{L}{R}\ln 2 = \frac{300\times10^{-3}}{2}\times 0.693 = 150 \times 0.693 \times 10^{-3} = 0.10395$ s $= 0.1$ s

21. If a bar magnet is dropping through the copper ring than due to change in magnetic flux an induced current is produced in it, which opposes the motion of the magnet. Therefore, velocity of the magnet decreases.

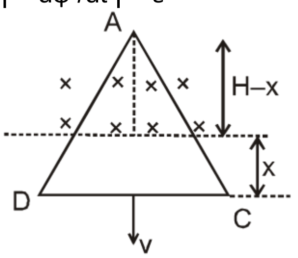
22. According to Lenz's law " the direction induced current is always in such a direction that it opposes the cause, due to which it is produced.

23. $\phi = Mi \Rightarrow \quad M = \frac{\phi}{i} \Rightarrow$ weber/sec

24. EMF is induced in the ring if there is change in flux which occurs either due to rotation about a diameter or due to its deformation.

25. $\phi = -\frac{1}{2}(2)\frac{H-X}{\sqrt{3}}(H-X)$

$|-d\phi/dt| = \varepsilon = \frac{2(H-x)}{\sqrt{3}}$



$i = \frac{2}{\sqrt{3}R}(H-x)$

Hence answer is (2)

26. $I = \frac{\frac{1}{2}B\omega L^2}{R} = \frac{\frac{1}{2}\times0.10\times40\times(5\times10^{-2})^2}{1} = 5$ mA

27. $\phi = M \times I$

$\frac{\int_{d}^{d+b} B.ds}{I} = M \quad \Rightarrow \quad M = \frac{\mu_0 a}{2\pi}\ell n\frac{b+d}{d}$ Hence $M \propto a$.

28. $L_{eff} = 2H$

Energy stored in inductor = $\frac{1}{2}LI^2$

$= \frac{1}{2} \times (2) \times (1)^2 = 1J.$

Energy developed in resistance = $I^2RT = 1^2 \times 10 \times 10 = 100$ J

Hence the required ratio is $\frac{1}{100}$.

29. In the loop containing wire AB the flow of current will be from B to A because emf generated in that loop is less than the emf generated in the loop containing CD.

30. $f = \frac{1}{2\pi}\frac{1}{\sqrt{L_{eff} \times C_{eff}}} = \frac{1}{2\pi\sqrt{3L \times 3C}} = \frac{1}{6\pi\sqrt{LC}}$.

31. Power $P = \frac{e^2}{R}$

here e = induced emf $= -\left(\frac{d\phi}{dt}\right)$ Where $\phi = NBA$

$\therefore$ $e = -NA\left(\frac{dB}{dt}\right)$ also $R \propto \frac{1}{r^2}$ where R = resistance, r = radius, ℓ = length

$\therefore$ $P \propto \frac{N^2r^2}{\ell}$ $\therefore$ $\frac{P_1}{P_2} = 1$

EXERCISE # 3

PART - I

1. Area coming out per second from the magnetic field is not constant for elliptical and circular loops, so induced emf, during the passage of these loops, out of the field resion will not remain constant for the circular and the elliptical loops.

2. In case of oscillatory discharge of a capacitor through an inductor, charge at instant t is given by

$q = q_0\cos\omega t$ where $\omega = \frac{1}{\sqrt{LC}}$

$\therefore$ $\cos\omega t = \frac{q}{q_0} = \frac{CV_2}{CV_1} = \frac{V_2}{V_1}$ $(\because q = CV)$ ...(i)

Current through the inductor

$I = \frac{dq}{dt} = \frac{d(q_0\cos\omega t)}{dt} = -q_0\omega\sin\omega t$

$|I| = CV_1\frac{1}{\sqrt{LC}}[1-\cos^2\omega t]^{1/2} = V_1\sqrt{\frac{C}{L}}\left[1-\left(\frac{V_2}{V_1}\right)^2\right]^{1/2} = \left[\frac{C(V_1^2-V_2^2)}{L}\right]^{1/2}$ (using (i))

3. $e = -L\frac{di}{dt}$

during 0 to T/4 $\frac{di}{dt}$ = const.$(e \Rightarrow -ve)$

T/4 to T/2 $\frac{di}{dt} = 0$ $(e \Rightarrow 0)$

T/2 to 3T/4 $\frac{di}{dt}$ = const. $(e \Rightarrow +ve)$

4. Induced e.m.f. $\varepsilon = -\frac{d\phi}{dt} = -(100t)$

induced current i at t = 2 sec. $= \left|\frac{\varepsilon}{R}\right| = +\frac{100 \times 2}{400} = +0.5$ Amp

Ans. (1)

5. $V = -L\frac{di}{dt}$

Here $\frac{di}{dt}$ +ve for $\frac{T}{2}$ time and

$\frac{di}{dt}$ is – ve for next $\frac{T}{2}$ time so Ans. (4)

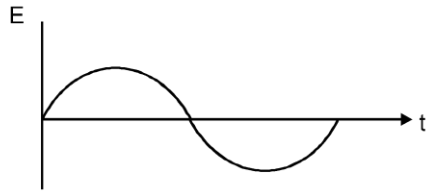
6. Area of i – t graph = q = $\frac{1}{2} \times 0.1 \times 4$

q = 0.2 C

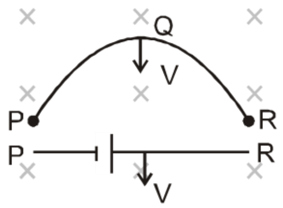
q = $\frac{\Delta\phi}{R}$

q = 0.2 = $\frac{\Delta\phi}{10}$

$\Delta\phi$ = 2 weber

7. 

From graph it is clear that direction is changing twice in a cycle.

8. 

emf = $VB\ell_{eq}$ = VB(2R) where R is at higher potential and P is at lower potential

9. Current in primary coil = $\frac{P}{V} = \frac{3000}{200}$ = 15A

P_{out} = η % of P_{in}

$V_2\ i_2 = \frac{90}{100} \times (3000)$

(v_2) (6) = 2700

V_2 = 450 volt

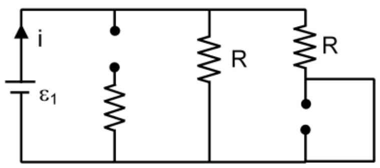
10. EMF induced = $B_1 V\ell - B_2 V\ell$

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

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

11. $W_{ext} = U_f - V_i$
$= -MB\cos 60° - (-MB)$
$= MB(1 - \cos 60°) = MB/2 = W$
$r = MB \sin 60° = MB\,\frac{\sqrt{3}}{2} = \sqrt{3}W$

12. $e = -\frac{d\phi}{dt} = -\frac{d}{dt}\{\pi r^2 B\} = -\pi r^2 \frac{dB}{dt}$ in loop 1 & zero in loop 2.

13.


equivalent circuit just after closing use swith is
$i = \frac{\varepsilon_1}{R_{eq}} = \frac{\varepsilon_2}{(R/2)} = \frac{2\varepsilon_1}{R} = \frac{2\times 18}{9}$ = 4A

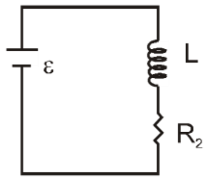
14. $q = \frac{\Delta\phi}{R} = \frac{\mu_0 n(i-0)NA}{R}$
N = Number of loops in coil
A = Area of coil
N = Number of turns per unit length of solenoid
$Q = \frac{4\pi\times 10^{-7}\times 2\times 10^4 \times 4\times 100\times \pi\times 10^{-4}}{10\pi^2}$ = 32μC

15. $U = \frac{1}{2}Li^2$
$25\times 10^{-3} = \frac{1}{2}L(60\times 10^{-3})^2 \Rightarrow L = \frac{500}{36} = 13.89H$

16. Electric heater

17. $e_{induced} = \frac{-d\phi}{dt} = \frac{-\Delta\phi}{dt}$
$\phi_i = N(\vec{B}\cdot\vec{A})$ $\phi_f = 0$
$\phi_i = 800 \times 5 \times 10^{-5} \times 5 \times 10^{-2}$
$\Delta t = 0.15$
$E_{induced} = -\frac{(0 - 800\times 5\times 10^{-5}\times 5\times 10^{-2})}{0.1}$
$e_{induced} = 0.02$ V

PART - II

1. 

$V_L = \varepsilon\, e^{-\frac{R_2 t}{L}} = 12.\, e^{-\frac{2t}{400\times10^{-3}}} = 12\, e^{-5t}$.

2. At t = 0, current does not flow through inductor.

$\therefore i = \frac{V}{R_2}$

At $t = \infty$ inductor behaves as wire $\Rightarrow$ $R_{eq} = \frac{R_1R_2}{R_1+R_2}$ $\therefore i = \frac{V(R_1+R_2)}{R_1R_2}$

3. $\tan 30^o = \frac{X_L}{R}$ $\Rightarrow$ $X_L = \frac{R}{\sqrt{3}} = \frac{200}{\sqrt{3}}$

$\tan 30^o = \frac{X_C}{R}$ $\Rightarrow$ $X_c = \frac{200}{\sqrt{3}}$

$Z = \sqrt{R+(X_L-X_C)^2} = 200\ \Omega$

$i_{rms} = \frac{220}{200} = 1.1$

$P = (i_{rms})^2 \times R = (1.1)^2 \times 200$

P = 242 W

4. In LC oscillation energy is transfered C toL

or L to C maximum energy in L is = $\frac{1}{2} LI^2_{max}$

Maximum energy in C is = $\frac{q^2_{max}}{2C}$

Equal energy will be when

$\frac{1}{2} LI^2 = \frac{1}{2}\,\frac{1}{2}\, LI^2_{max}$

$I = \frac{1}{\sqrt{2}} I_{max}$

$I = I_{max} \sin\omega t = \frac{1}{\sqrt{2}} I_{max}$

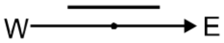
$\omega t = \frac{\pi}{4}$

or $\frac{2\pi}{T} t = \frac{\pi}{4}$ or $t = \frac{T}{8}$

$t = \frac{1}{8} 2\pi\sqrt{LC} = \frac{\pi}{4}\sqrt{LC}$ **Ans.**

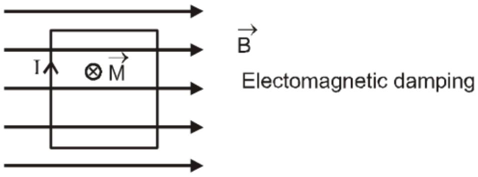
5. $E_{ind} = B \times v \times \ell$

$= 5.0 \times 10^{-5} \times 1.50 \times 2 = 10.0 \times 10^{-5} \times 1.5 = 15 \times 10^{-5}$ vot. = 0.15 mv

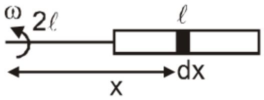
6. 

$\varepsilon_{ind} = Bv\ell$

$= 0.3 \times 10^{-4} \times 5 \times 20 = 3 \times 10^{-3}$ v = 3 mv.

7. 

8. $e = \int_{2\ell}^{3\ell} (\omega x)B\,dx = B\omega \frac{[(3\ell)^2 - (2\ell)^2]}{2}$

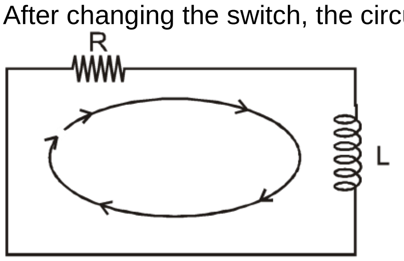


$= \frac{5B\ell^2\omega}{2}$

9. $\frac{\mu_0(2)(20\times10^{-2})^2}{2\left[(0.2)^2+(0.15)^2\right]} \times \pi\,(0.3\times10^{-2})^2$

on solving $= 9.216 \times 10^{-11} \approx 9.2 \times 10^{-11}$ weber

10. After changing the switch, the circuit will act like an L–R discharging circuit.



Applying Kirchoff loop eqation.

$V_R + V_L = 0$

$\Rightarrow V_R = -V_L$

So $\frac{V_R}{V_L} = -1$

11. Current at t = 0 $I_0 = \frac{E_0}{R}$

For decay circuit $I = I_0\, e^{-\frac{tR}{L}}$

$I = \frac{E_0}{R} e^{-\frac{tR}{L}} \quad \Rightarrow \quad I = 0.67$ mA

12. $\Delta Q = \frac{\Delta\phi}{r} =$ Area under $i - t$ graph

$= \frac{\Delta\phi}{100} = \frac{1}{2} \times 10 \times .5$

$\Rightarrow \Delta\phi = 2.5 \times 100 = 250$

13. $Q = \frac{\Delta\phi}{R}$, $\Delta\phi = \int_0^{t=10ms} BAdt$

$\Delta\phi = \int_0^{t=10ms} 0.4\sin(50\pi t)\times 3.5\times 10^{-3}dt$ $= 1.4 \times 10^{-3}$

$Q = \frac{1.4\times 10^{-3}}{10}$ $= 140\mu C$

No option matches so it should be bonus.

14. $e = Bv\ell = 0.1\ (2 \times 10^{-2}) \times 6 = 12 \times 10^{-3} = 12$ mV

15. $|\varepsilon| = \frac{Ldi}{dt}$

$25 = L\times \frac{(25-10)}{1}$

$L = \frac{5}{3}$ H

energy of inductor $E = \frac{1}{2}Li^2$ $\Rightarrow$ $\Delta E = \frac{1}{2}\times\frac{5}{3}$ [625 – 100] J

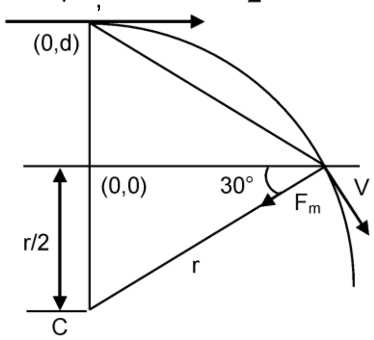
$\Delta E = 437.5$ J

16. Self inductance $L \propto \ell$

17. In question, entry point of particle is not given

Assuming particle enters from (0, d)

$r = \frac{mv}{qB}$, $d = \frac{r}{2}$



$a = \frac{qVB}{m}\left[\frac{-\sqrt{3}\,\hat{i}-\hat{j}}{2}\right]$ this option is not given in the all above four choices

18. $r = \frac{\sqrt{2meV}}{eB}$

$= \sqrt{\frac{2meV_{ac}}{e^2B^2}}$ $= \sqrt{\frac{2\times 9\times 10^{-31}\times 500}{1.6\times 10^{-19}\times(100\times 10^{-3})^2}}$ $= \sqrt{\frac{2\times 9.1\times 10^{-31}\times 500}{1.6\times 10^{-19}\times 10^{-2}}}$

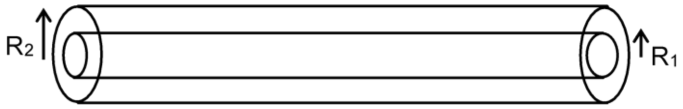
$= \sqrt{\frac{2\times 9.1\times 5\times 10^{-31+23}}{1.6}}$ $= \sqrt{\frac{9.1}{1.6}\times 10^{-7}}$ $= \sqrt{\frac{91}{16}\times 10^{-7}}$ $= \sqrt{\frac{910}{16}\times 10^{-8}}$

$= \sqrt{56.875}\times 10^{-4} = 7.54 \times 10^{-4}$ m

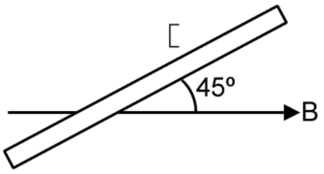
19. Mutual inductance $= \mu_0 n_1 n_2\ R_2^2\ \ell$

Self inductance of inner solenoid = $\mu_0 n_1^2 R_2^2 \ell$

Ratio = $\frac{n_2}{n_1}$



20.



ε_{ind} = Bvl sin 45º

$= 0.3 \times 10^{-4} \times 5 \times 10 \times \frac{1}{\sqrt{2}}$

$= 1.060 \times 10^{-3}$V