## Solution

## Class 12 - Physics

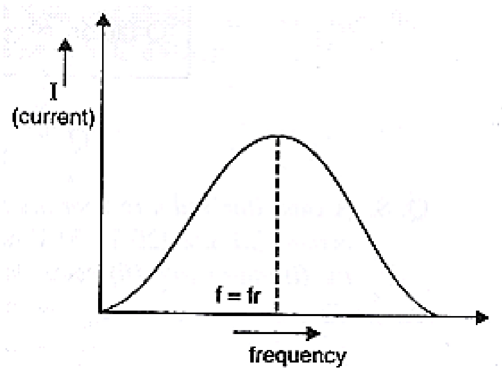
## 2020-21 paper 4

### Section A

1. Two factors for energy losses are
   i. The resistance of winding causes loss of energy.
   ii. The eddy current causes heat loss.
2. A transformer that increases voltage from primary to secondary having more secondary winding turns than primary winding turns is called a step-up transformer.
3. Bar magnet
4. The angle of dip will be greater than 18° in Britain. The angle of dip increases from equator towards pole. Britain is farther from equator as compared to India.

   OR

   Resonance occurs in a series of LCR circuit when
   $X_L = X_C$
   The graph showing the variation of current with frequency of a.c. source in a series LCR circuit is given below:


5. There will be no induced emf, because the angle between rod and magnetic field is zero.

   OR

   When a block of metal is kept in a varying magnetic field then Eddy current is produced.
6. The impedance of an LR circuit is given by the expression
   Z = $\sqrt{R^2 + (X_L - X_c)^2}$ and I = $\frac{V}{Z}$
   Addition of capacitor decreases impedance in the circuit, therefore, there is an increase in current through the circuit.
7. Yes, in any A.C. circuit, the applied instantaneous voltage is equal to the algebraic sum of the instantaneous voltages across the series elements of the circuit but is not true for root mean square voltage because the voltages are not in the same phase across different elements.
8. P = 100 W, $V_{rms}$ = 220 V, f = 50 Hz, R = ?, $I_{rms}$ = ?
   i. R = $\frac{V_{rms}^2}{P}$ = $\frac{(220)^2}{100}$ = 484 $\Omega$
   ii. $I_{rms}$ = $\frac{V_{rms}}{R}$ = $\frac{(220)}{484}$ = 0.45 A
9. When two coils (or solenoids) are mutually coupled, then change in current of one coil causes a change in magnetic flux in the other coil and as a result an emf is induced in the other coil. This process is called mutual induction.
   SI unit of mutual inductance = Henry (H)
10. When we insert the dielectric slab in the coil, then permeability of the material increases hence its self inductance increases.
11. **(a)** Both A and R are true and R is the correct explanation of A
    **Explanation:** Torque due to magnetic field is given by:

$\tau = MB\sin\theta$

When $\theta$ = $90^0$, $\tau$ is maximum.

12. **(b)** Both A and R are true but R is NOT the correct explanation of A
**Explanation:** Both A and R are true but R is NOT the correct explanation of A

13. **(a)** Both A and R are true and R is the correct explanation of A
**Explanation:** Both A and R are true and R is the correct explanation of A

14. **(b)** Both A and R are true but R is NOT the correct explanation of A
**Explanation:** Both A and R are true but R is NOT the correct explanation of A

**Section B**

15. **(d)** L/2
**Explanation:** The resonance frequency is given by
$f_0 = \frac{1}{2\pi\sqrt{L\,C}}$
When C is changed to 2C, $f_0$ will remain unchanged, if L is changed to L/2.

16. **(a)** 66 V, 210 V
**Explanation:** $R = 100\Omega$
$C = 10\mu F$
V = 220 volt
f = 50Hz
$Z = \sqrt{R^2 + {X_C}^2}$
$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} = \frac{1}{2\times3.14\times50\times10\times10^{-6}} = 318.5\Omega$
$Z = \sqrt{(100)^2 + (318.5)^2} = 333.8\Omega$
Current in circuit,
$i = \frac{V}{Z} = \frac{220}{333.8} = 0.66A$
Voltage across the resistor, $V_R = iR = 0.66 \times 100 = 66V$
Voltage across the capacitor, $V_C = iX_C = 0.66 \times 318.5 = 210V$

17. **(a)** 5 mH
**Explanation:** We know that emf, $E = -L\frac{di}{dt}$
So, $L = \frac{-E}{\frac{di}{dt}}$
Put given values, we get
$\Rightarrow L = \frac{-5\times10^{-3}}{(2-3)} = \frac{-5\times10^{-3}}{-1}$
$\Rightarrow L = 5 \times 10^{-3}H = 5\ mH$

18. **(d)** zero
**Explanation:** Here, the phase difference between current and e.m.f.,
$\phi = \pi/2$
$\therefore$ $P_{av}$ = $E_V I_V$ $cos\phi$ = $E_V I_V$ cosπ/2 = 0

19. **(c)** Electric motor
**Explanation:** Electric motor

20. **(c)** Power
**Explanation:** Energy losses be zero in transformers hence power remains constant in step down and step up transformer also.

21. **(a)** Magnetic dipole
**Explanation:** Magnetic dipole

22. **(a)** $\vec{M} \times \vec{B}$
**Explanation:** Since torque is cross product of magnetic moment vector and magnetic field, hence it is given by $\vec{M} \times \vec{B}$

## Section C

23. The impedance of an LR circuit is given by the expression Z = $\sqrt{R^2+X_L^2}$ and the impedance of a series LCR circuit is given by the expression, Z = $\sqrt{R^2+(X_L-X_C)^2}$.
    Now current flowing through the two circuits is given by I = $\frac{V}{Z}$.
    Since Z decreases when a capacitor is connected to an LR circuit, therefore, there is an increase in current through the circuit. This increases the brightness of the bulb.
24. The induced emf will be same in both the loops because it does not depend on the nature of the material of the loops.
    The induced current will be more in copper loop because its resistance is less than aluminium loop.
25. i. Power factor, $\cos\phi=\frac{R}{Z}$ or Z = R [For power factor unity, $\cos\phi=1$]
    $\therefore X_C=X_L$ or $\frac{1}{2\pi fC}=2\pi fL$
    or $C=\frac{1}{4\pi^2f^2L}=\frac{1}{4\times9.87\times(50)^2\times200\times10^{-3}}$
    $=5\times10^{-5}F$
    or $C=50\mu F$
    ii. Q-factor $=\frac{1}{R}\sqrt{\frac{L}{C}}$
    $Q=\frac{1}{10}\sqrt{\frac{200\times10^{-3}}{5\times10^{-5}}}=6.32$

OR

i. V = 140 sin 314 t
Comparing it with V = $V_0$ sin $\omega t$,
Here, $\omega=314\text{rad/s}$
i.e. $2\pi f=314$
$\Rightarrow\quad f=314/2\pi$
$f=\frac{314}{2\times3.14}$ = 50 Hz
ii. We know, $I_{\text{rms}}=\frac{V_{\text{rms}}}{R}$ and $V_{\text{rms}}=\frac{V_0}{\sqrt{2}}$
Here, $V_0=140\text{V}$
$V_{\text{rms}}=\frac{140}{\sqrt{2}}=70\sqrt{2}\text{V}$
$\therefore\quad I_{\text{rms}}=\frac{70\sqrt{2}}{R}=\frac{70\sqrt{2}}{50}=1.9\text{A}$

26. Magnetic Moment of the bar magnet is given by , $M$ = $0.32JT^{-1}$
    External magnetic field is given by, $B$ = 0.15 T
    a. For the system to be in stable equilibrium the angle $\theta$, between the bar magnet and the magnetic field is taken as 0°.
    Potential energy of the system = $-MB\cos\theta$
    $=-0.32\times0.15\cos0^\circ$
    $=-4.8\times10^{-2}J$
    b. For unstable equilibrium, the bar magnet is oriented at 180°to the magnetic field.
    θ = 180°
    Potential energy = – $MB$ cos $\theta$
    $=-0.32\times0.15\cos180^\circ$
    $=4.8\times10^{-2}J$

OR

Angle of dip, $\delta=60^\circ=\frac{\pi}{3}$
Horizontal component of the earth's magnetic field is, $B_H$ = 0.4 G = 0.4 $\times$ $10^{-4}$ T
Magnetic field of earth (B) =?
Horizontal component of the earth's magnetic field,

$B_H = B cos\delta$

$B = \frac{B_H}{\cos\delta}$

$B = \frac{0.4 \times 10^{-4}\,T}{\cos 60^\circ}$

$B = \frac{0.4 \times 10^{-4}\,T}{1/2}$

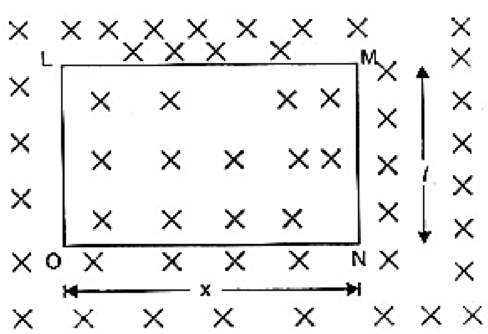
$B = 0.8 \times 10^{-4}\,T$

$\therefore B = 8 \times 10^{-5}\,T$

27. i. Torque, $\tau = mB\sin\theta$ where m is the magnetic moment of the magnet, B is the external magnetic field and $\theta$ is the angle with which a short bar magnet placed with its axis.
    Here, $\theta = 60^\circ$
    $\tau = 0.063 Nm$
    $m = 0.9 J/T$
    $\Rightarrow B = \frac{\tau}{m\sin\theta} = \frac{0.063}{0.9 \times \sin 60^\circ}$
    $\Rightarrow B = 0.081\ T$
    ii. The magnet will be in stable equilibrium in the magnetic field if torque, $\tau = 0$
    $\Rightarrow mB\sin\theta = 0 \Rightarrow \theta = 0^\circ$
    i.e when bar magnet aligns itself parallel to the field.
28. i. Outside the magnet, the magnetic lines starts from North pole and enter into the South pole whereas inside the magnet, the field lines travel from South pole to North pole. As monopoles do not exist, so, north and south pole always occur together. So, magnetic lines of force always form a closed loop.
    ii. Due to different rotations of electrons, the diamagnetic materials is magnetized in the direction opposite to the external field, therefore lines of force are repelled by a diamagnetic material.
29. Energy W = $\frac{1}{2}LI^2$
    A solenoid having magnetic field B, area A, & length l and having n numbers of turns per unit length. L Self-inductance of the solenoid is given by:
    L = $\mu_0 n^2 l A$
    $\therefore$ W = $\frac{1}{2}\mu_0 n^2 l A I^2$ ... (i)
    But, B = $\mu_0 n I$ and I=current flowing
    $\therefore$ $B^2$ = $\mu_0^2 n^2 I^2$ ...(ii)
    V = AI (volume) ...(iii)
    From equation (i), (ii), (iii), we have
    $\Rightarrow$ W = $\frac{1}{2\mu_0}B^2V$
    Energy density = $\frac{W}{V}$ = $\frac{B^2}{2\mu_0}$

OR

No, the acceleration of the magnet will not be equal to g. It will be less than ‘g'. This is because as the magnet falls, the amount of magnetic flux linked with the ring changes. An induced current is developed in the ring which opposes the downward motion of the magnet. After the magnet has crossed the metal ring, the amount of magnetic flux linked with the ring goes on decreasing. An induced current develops in the ring and opposes the fall of the magnet. Therefore, the downward acceleration of the magnet continues to be less than ‘g'.
30. Let us assume a rectangular loop LMNO is placed in a uniform magnetic field B.




Suppose at any instant, length ON = x

Flux through the loop $\phi = Blx$ $[\because \max. flux,\ \phi = BA]$
Induced emf, $E = -\frac{d\phi}{dt} = -\frac{d}{dt}Blx$
or $E = -Bl\frac{dx}{dt} = -Bl\ v$
where $\frac{dx}{dt} = v$, is the velocity of conductor MN.
Thus, |E| = Blv

31. Mutual inductance of a pair of could, $\mu$ =1.5 H
Initial current $I_1$ = 0A

Final current $I_2$ = 20A

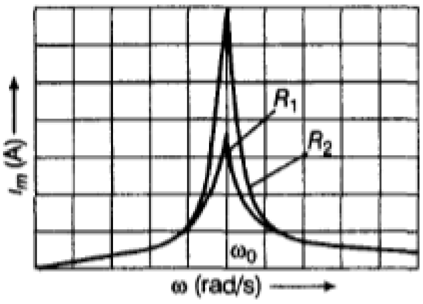
Change in current in the circuit is given by , dI = $I_2$ - $I_1$ = 20 - 0 = 20 A

Time taken for the change, t = 0.5 S

Induced emf, $e = \frac{d\phi}{dt}$ ..... (i)
Where $d\phi$ is the change in the flux linkage with the coil.
Emf is related with mutual inductance as:
$e = \mu\frac{dI}{dt}$ ..... (ii)
Equating equations (i) and (ii), we get
$\frac{d\phi}{dt} = \mu\frac{dI}{dt}$
$d\phi = 1.5 \times (20)$
= 30 Wb
Hence, the change in the flux linkage is 30 Wb.

**Section D**

32. Figure shows the variation of $I_m$ with $\omega$ in an L-C-R series circuit for two values of resistance $R_1$ and $R_2\,(R_1 > R_2)$.




The condition for resonance in the L-C-R circuit is,
$X_L = X_C \Rightarrow \omega_0 L = \frac{1}{\omega_0 C} \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$....(i)
where $\omega_0, X_C,\ and\ X_L$ are resonant angular frequency, capacitive reactance and inductive reactance respectively of the series LCR circuit.
We see that the current amplitude is maximum at the resonant frequency. Since $I_m = V_m / R$ at resonance, the current amplitude for case $R_2$ is sharper to that for case $R_1$.

Quality factor or simply the Q-factor of a resonant L-C-R circuit is defined as the ratio of voltage drops across the inductor and resistance at resonance.
$Q = V_L/V_R = \omega_0 L/R$
Finally, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$, putting the value of resonant frequency, $\omega_0$ from equation (i).
The Q-factor determines the sharpness at resonance as for higher value of Q-factor the tuning of the circuit and its sensitivity to accept resonating frequency signals will be much higher.

33. Let an alternating voltage, V = $V_0$ sin $\omega t$

$V_0$ being peak value of the AC voltage is applied across pure inductor of inductance L. The magnitude of induced emf is given by
$e = LdI/dt$
where L and dI/dt are the inductance of the inductor and time rate of change of the current respectively.
For the circuit,
Magnitude of induced emf = Applied voltage

i.e. $L\frac{dI}{dt} = V_0 \sin\omega t$ or $dI = \frac{V_0}{L}\sin\omega t dt$

On integrating both sides, we get

$I = \frac{V_0}{L}\int \sin\omega t dt$

$= \frac{V_0}{L}\left(\frac{-\cos\omega t}{\omega}\right)$

or $I = -\frac{V_0}{\omega L}\cos\omega t$

$= -\frac{V_0}{\omega L}\sin\left(\frac{\pi}{2} - \omega t\right)$

$\therefore \quad I = \frac{V_0}{X_L}\sin\left(\omega t - \frac{\pi}{2}\right)$

$\therefore \quad I = I_o \sin\left(\omega t - \frac{\pi}{2}\right)$

where, $I_0$ = peak value of current of AC

i. Considering equation, $I = \frac{V_0}{X_L}\sin\left(\omega t - \frac{\pi}{2}\right)$
   $X_L = \omega L$ = inductive reactance of the given circuit.
ii. Now, $V = V_0 \sin\omega t$ and $I = I_o \sin\left(\omega t - \frac{\pi}{2}\right)$
   Thus, AC current lags behind the voltage by phase $\pi/2$.

34. Applied voltage = $V_0$ sin $\omega t$

Current in the circuit = $I_0$ sin $(\omega t - \phi)$

Where $\phi$ is the phase lag of the current with respect to the voltage applied

Hence instantaneous power dissipation

= $V_0$ sin $\omega t \times I_0$ sin $(\omega t - \phi)$

$= V_0 \sin\omega t \times I_0 \sin(\omega t - \phi)$

$= \frac{V_0 I_0}{2}$ [2sin $\omega t$.sin $(\omega t - \phi)$]

$= \frac{V_0 I_0}{2}$ [cos $\phi$ - cos (2$\omega t - \phi$)]

Therefore, average power for one complete cycle = average of $\left[\frac{V_0 I_0}{2}\{\cos\phi - \cos(2\omega t - \phi)\}\right]$

The average of the second term over a complete cycle is zero.

Hence, average power dissipated over one complete cycle = $\frac{V_0 I_0}{2}\cos\phi$

Conditions:

i. No power is dissipated when R = 0 (or $\phi$ = $90^0$)
ii. Maximum power is dissipated when $X_L = X_C$
   Or $\omega L = \frac{1}{\omega C}$ (or $\phi$ = 0)

OR

Here current , I = 2.5 amp

earth's magnetic field is B = 0.33 G $= 0.33 \times 10^{-4} T$

$\delta = 0^\circ$

Horizontal component of earth's field,

$H = B\cos\delta = 0.33 \times 10^{-4}\cos 0^\circ$

$= 0.33 \times 10^{-4}$ tesla

Let the neutral points lie at a distance r from the cable.

Strength of magnetic field on this line due to current in the cable $= \frac{\mu_0 I}{2\pi r}$

At neutral point,

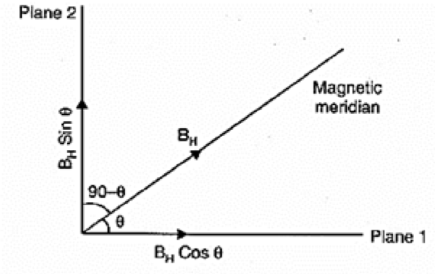
$\frac{\mu_0 I}{2\pi r} = H$

$r = \frac{\mu_0 I}{2\pi H} = \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}} = 1.5 \times 10^{-2} m = 1.5 cm$

Hence neutral points lie on a straight line parallel to the cable at a perpendicular distance of 1.5 cm above the plane of the paper.

35. It horizontal and vertical components of earth's magnetic field are represented by $B_H$ and $B_V$ respectively, then

$\tan\delta = \frac{B_V}{B_H}$




Let $\delta_1$ be the (apparent) dip in a plane which makes angle $\theta$ with the magnetic meridian. In this plane, the vertical component will be $B_V$ only but the effective horizontal component will be $B_H \cos\theta$.

$\tan\delta_1 = \frac{B_V}{B_H \cos\theta}$

or $\tan\delta_1 = \frac{\tan\delta}{\cos\theta} \because B_V = B_H \tan\delta$

or $\cos\theta = \frac{\tan\delta}{\tan\delta_1} = \tan\delta \cot\delta_1$....(i)

Let $\delta_2$ be the (apparent) dip in the second plane. The angle made by this plane with the magnetic meridian will be $(90^\circ - \theta)$

Effective horizontal component in this plane is $B_H \cos(90^\circ - \theta)$ i.e. $B_H \sin\theta$. The vertical component will be $B_V$ only.

$\tan\delta_2 = \frac{B_V}{B_H \sin\theta} = \frac{\tan\delta}{\sin\theta}$

Or $\sin\theta = \frac{\tan\delta}{\tan\delta_2} = \tan\delta \cot\delta_2$ ....(ii)

Squaring and adding equation (i) and (ii) we get,

$\cos^2\theta + \sin^2\theta = \tan^2\delta \cot^2\delta_1 + \tan^2\delta \cot^2\delta_2$

or $1 = \tan^2\delta(\cot^2\delta_1 + \cot^2\delta_2)$

$\Rightarrow \cot^2\delta = (\cot^2\delta_1 + \cot^2\delta_2)$

OR

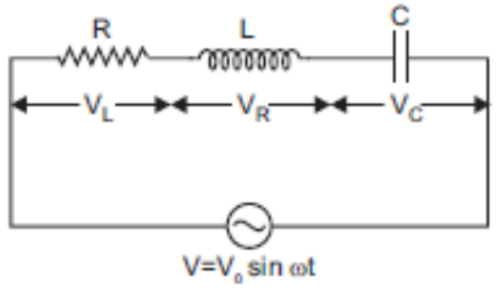
i. The direction of induced current will be such that it tends to maintain the original flux. So induced current flows anticlockwise in loop 1 and clockwise in loop 2.
ii. No, the emf's induced in the two loops will not be equal.
Since, the rate of change of flux is more in the second coil, emf induced in the second coil is more than that in the first coil.
Emf in the first coil, $E_1$ = Bav
Emf in the school coil, $E_2$ = Bbv
Since, b > a therefore, $E_2 > E_1$

36. The maximum back electromotive force (u) will be maximum when there is a maximum rate of change of magnetic flux which is directly proportional to the rate of change of current.
Maximum change or rate of current will be where (t - I) graph for the solenoid makes a maximum angle with time axis which is in part AB
So the maximum back e.m.f. will occur between 5 s to 10 s. As the back e.m.f. at t = 3 s it is e (given)
Rate of change of current at t = 3 s-slope of OA graph with time axis So the rate of change of current at 3s = $\frac{1}{5} A/s$
So back electromotive force at t = 3s $= L \times \frac{1}{5} = \frac{L}{5} = e$ (given)
$\because e = L \cdot \frac{dI}{dt}$ and L = constant for the solenoid.
Similarly back e.m.f. u between 5 to 10 sec.
$u_1 = L\left(\frac{-3}{5}\right) = -3\frac{L}{5} = -3e$
back e.m.f. between 10 to 30 sec
$u_2 = L\frac{[0-(-2)]}{(30-10)} = \frac{+2L}{20} = \frac{+1}{2}\frac{L}{5}$
$u_2 = +\frac{1}{2}e$
So back e.m.f. at 7 sec = -3 e
Back e.m.f. at 15 sec $= +\frac{1}{2}e$
At 40 sec graph is along the time axis, i.e. its slope with time axis is zero.

So, $\frac{dI}{dt} = 0$
Or back e.m.f. at 40 sec = 0

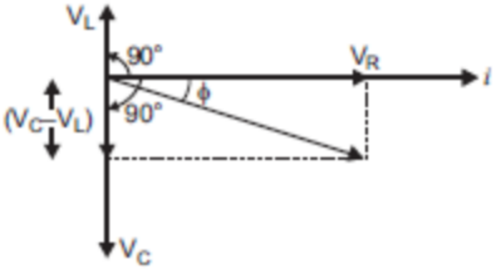
**Section E**

37. a. Suppose a resistance R, inductance L and capacitance C are connected to series and an alternating voltage V = $V = V_0 sinwt$ is applied across it.




Since L, C and R are connected in series, current flowing through them is the same. The voltage across R is $V_R$, inductance across L is $V_L$ and across capacitance is $V_C$.

The voltage $V_R$ and current i are in the same phase, the voltage $V_L$ will lead the current by angle $90^o$ while the voltage $V_C$ will lag behind the current by $90^o$.




Thus, $V_R$ and ($V_C$ - $V_L$) are mutually perpendicular and the phase difference between them is $90^o$. As seen in the fig, we can say that, as the applied voltage across the circuit is V, the resultant of $V_R$ and $V_C$ - $V_L$) will also be V.

So,

$V^2 = V_R^2 + (V_c - V_L)^2$

$\Rightarrow$ V = $\sqrt{V_R^2 + (V_c - V_L)^2}$

But, $V_R$ = Ri, $V_c$ = $X_c$i and $V_L$ = $X_L$i

where, $X_c$ = $\frac{1}{\omega C}$ and $X_L$ = $\omega$L

So, V = $\sqrt{(Ri)^2 + (X_c i - X_L i)^2}$,

Therefore, impendance of the circuit is given by,

Z = $\frac{V}{i}$ = $\sqrt{(R)^2 + (X_c - X_L)^2}$

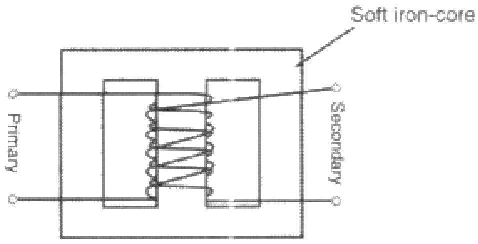
Z = $\sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$

This is the impedance of the LCR series circuit.

b. A radio or a TV set has an LC circuit capacitor of variable capacitance C. The circuit remains connected with an aerial coil through the phenomenon of mutual inductance. Suppose a radio or TV station has transmitted a program at frequency f, then waves produce an alternating voltage of frequency in area, due to which an emf of the same frequency is induced in LC circuit. When capacitor C is in circuit is varied then for a particular value of capacitance, C, f = $\frac{1}{2\pi\sqrt{LC}}$, the resonance occurs and maximum current flows in the circuit; so the radio or TV gets tuned.

OR

i.




ii. Principle of a transformer: When an alternating current flows through the primary coil, an emf is induced in the neighbouring (secondary) coil. Or When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it.

a. Let $\frac{d\varphi}{dt}$ be the rate of change of flux through each turn of the primary and the secondary coil

$\frac{\varepsilon_1}{\varepsilon_2} = \frac{-N_1\frac{d\phi}{dt}}{-N_2\frac{d\phi}{dt}} = \frac{N_1}{N_2}$ and $e_1 = v_1$ and $e_2 = v_2$

or $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ ...(i)

b. But for an ideal transformer,

$V_1 I_1 = V_2 I_2$

$\frac{V_1}{V_2} = \frac{I_2}{I_1}$ ...(ii)

From equation (i) and (ii)

$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$

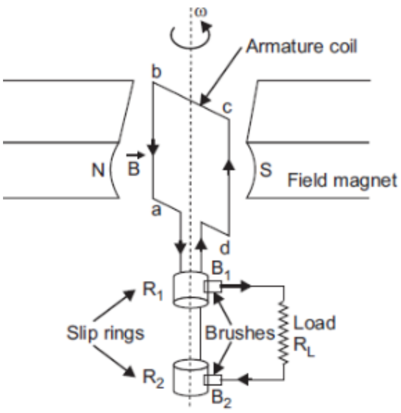
iii. Main assumptions:

a. The primary resistance and current are small.
b. The flux linked with the primary and secondary coils is the same/there is no leakage of flux from the core.
c. Secondary current is small.

iv. Reason due to which energy losses may occur: Flux leakage/Resistance of the coils and the Eddy currents/ Hysteresis.

38. i. **A.C. generator principle:** A dynamo or generator is a device which converts mechanical energy into electrical energy. It is based on the principle of electromagnetic induction.

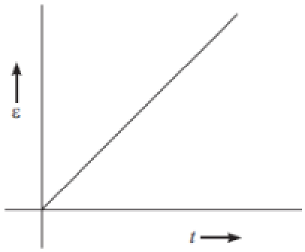
**Working:** When the armature coil is rotated in the strong magnetic field, the magnetic flux linked with the coil changes and the current is induced in the coil, its direction being given by Fleming's right hand rule. Considering the armature to be in vertical position and as it rotates in anticlockwise direction, the wire ab moves upward and cd downward, so that the direction of induced current is shown in fig. In the internal circuit, the current flows along $B_1R_LB_2$. The direction of current remains unchanged during the first half turn of armature. During the second half revolution, the wire ab moves downward and cd upward, so the direction of current is reversed and in external circuit it flows along $B_2R_LB_1$. Thus the direction of induced emf and current changes in the external circuit after each half revolution.




**Expression of induced emf:** If N is the number of turns in coil, f the frequency of rotation, A area of coil and B the magnetic induction, then induced emf

$e=-\frac{d\phi}{dt}=\frac{d}{dt}\{NBA(\cos 2\pi ft)\}$
$=2\pi NBAf\sin 2\pi ft$
Obviously, the emf produced is alternating and hence the current is also alternating. Current produced by an ac generator cannot be measured by moving coil ammeter because the average value of ac over full cycle is zero. The source of energy generation is the mechanical energy of rotation of armature coil.

ii. As the earth's magnetic field lines are cut by the falling rod, the change in magnetic flux takes place. This change in flux induces an emf across the ends of the rod.
Since the rod is falling under gravity,
v = gt (∵ u = 0)
$\varepsilon=Blv=Blgt$
$\therefore \quad \varepsilon\propto t$




OR

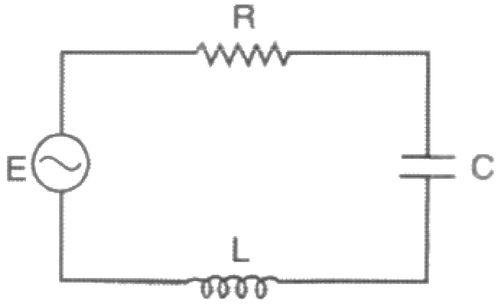
The self-inductance of a coil is equal to the induced emf set up in the coil when the current passing through it changes at the unit rate
The SI unit of self-inductance is henry. Consider a long solenoid of length l, area of crosssection A with N number of closely wound turns. If I is the amount of current flowing through the solenoid, then magnetic field B inside the solenoid will be:
B = $\frac{\mu_0 NI}{l}$
Now magnetic flux through each turn of the solenoid is:
$\phi=BA$ = $\frac{\mu_0 N^2 AI}{l}$
Since $\phi$ = LI
LI = $\frac{\mu_0 N^2 AI}{l}$
Hence, L = $\frac{\mu_0 N^2 A}{l}$
If a coil of wire with few turns around metal core carries a charge is passed through. The current will create a magnetic field that runs through the center of the coil pointing downward. If the current is stopped suddenly, then the magnitude of the magnetic field tends to be zero.
It is known that changing magnetic fields will influence the charges in loops of wire. If the magnitude of the magnetic field in the coil approaches to zero, it induces a voltage in the coil which creates the magnetic field. So as per Lenz's law, the voltage induced by changing the magnetic field gives rise to a current which counteracts the changes. Mathematically, the voltage across the inductor, the loop of coil, is
$V_{Ind}$ = $L\frac{dI}{dt}$,
The force above expression looks similar to the expression of
F = $m\frac{dv}{dt}$
Now, $E_{Ind}$ = $\frac{1}{2}LI^2$
$E_{Kinetic}$ = $\frac{1}{2}mv^2$
From the above description, there appears an analogy between mechanical motion and flow of electricity. Here, self-inductance L and mass m, both provide inertia that will resist in changing the current I or velocity v suddenly.

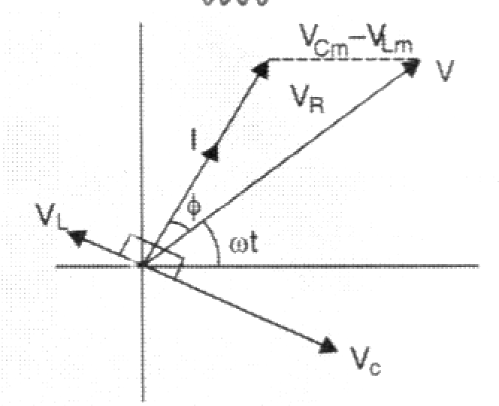
39. a. In both cases, we get magnets each having north and south poles. When we cut transverse to the length, the pole strength of each new magnet is the same as that of an original magnet but the magnetic moment is halved because length is halved. When we cut along the length, the pole strength of each new magnet is half the pole strength of the original magnet; the magnetic moment is also halved, as length remains the same.

b. On melting, the iron bar magnet loses its magnetism. This is because of its temperature exceeds Curie temperature(= 750°C) for iron.
c. When a magnetised needle is put in a uniform magnetic field, forces on north and south poles the needle are equal and unlike. Therefore, the net force is zero. But these forces form a torque that aligns the magnetic needle in the direction of the field. An iron nail is unmagnetised. It experiences a force of attraction; gets magnetised, then experiences a torque and gets aligned along the field.
d. No, it is not necessary that every magnetic field configuration must have a north pole and a south pole. The poles exist only when the source has some net magnetic moment. In the case of a toroid and infinite straight conductor, there are no poles, as a net magnetic moment in both the cases is zero.
e. Magnetic poles always exist in pairs. However, one can imagine magnetic field configuration with three poles-when north poles of two magnets are glued together or south poles of two magnets are glued together to provide a three-pole field configuration.

OR

i. In a series LCR circuit shown,




From the phasor relation, voltages $V_L + V_R + V_C = V$, as $V_C$ and $V_L$ are along the same line and in opposite directions, so they will combine in single phasor $(V_C + V_L)$ having magnitude $|V_{Cm} - VLm|$. Since voltage V is shown as the hypotenuse of a right-angled triangle with sides as $V_R$ and $(V_C + V_L)$, So the Pythagoras Theorem results as :

$V_m^2 = V_R^2 + (V_{Cm} - V_{Lm})^2$

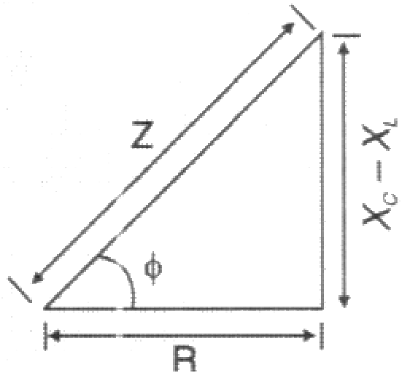
$V_m^2 = (I_m R)^2 + (I_m X_C - I_m X_L)^2$

$V_m^2 = I_m{}^2(R^2 + (X_C - X_L)^2)$

Now current in tire circuit :

$I_m = \frac{V_m}{\sqrt{\left(R^2+(X_C-X_L)^2\right.}}$

$I_m = \frac{V_m}{Z}$ as $Z = \sqrt{\left[R^2 + (X_C - X_L)^2\right]}$




As phasor 1 is always parallel to phasor $V_R$, the phase angle $\phi$ is the angle between $V_R$ and V and can be determined from figure.

$\tan\phi = \frac{V_{Cm}-V_{Lm}}{V_{Rm}}$

$\tan\phi = \frac{X_C-X_L}{R}$

ii. **Resonance frequency** is defined as the **frequency** at which the impedance of the **LCR circuit** becomes minimum or current in the **circuit** becomes maximum. It is shown as: $V_{Cm} = V_{Lm}$ and $X_L=X_C$

$f_0 = \frac{1}{2\pi\sqrt{LC}}$