Q. No. 2 Part (i)

Magnetic Flux:

The number of magnetic field lines passing through a surface is called magnetic flux.

$$\Phi = BA\cos\theta$$

It's unit is weber (Wb).

Magnetic Flux Density:

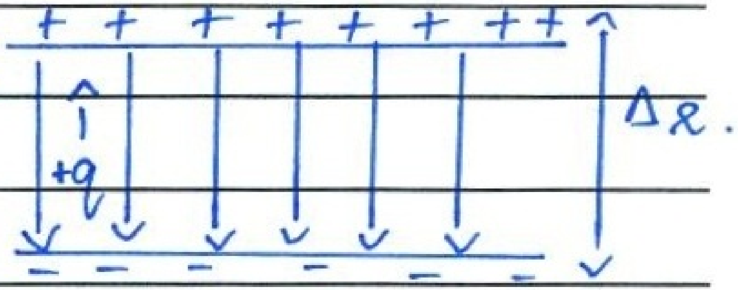
The magnetic flux per unit area is called magnetic flux Density.

$$\text{Magnetic flux density} = \frac{\Phi}{A} = \frac{BA}{A} = B$$

so, magnetic flux density = magnetic Induction.

It's unit is Tesla (T).

Q. No. 2 Part (ii)



Consider a unit positive test charge in between parallel opposite plates. It is moving opposite to the electric field.

$$W = +q_0 E \Delta r \cos\theta$$

$$= +q_0 E \Delta r \cos(180^\circ)$$

$$W = -q_0 E \Delta r$$

also,

$$\Delta V V = \frac{\Delta W}{q_0}$$

$$\Delta V = -\frac{q_0 E \Delta r}{q_0}$$

$$E = -\frac{\Delta V}{\Delta r}$$; electric field is negative of potential gradient.

Q. No. 2 Part (iii)

Each fission reaction produces 2 or 3 neutrons. These neutrons can further generate fission in ^{235}U. In this way a chain fission reaction is formed. When it is uncontrolled i.e all neutrons initiate fission, a large amount of energy is released. This is used in nuclear bombs.

The nuclear chain reaction in which only one neutron is allowed to initiate fission while the rest are absorbed is called controlled chain reaction.

A fission chain reaction is controlled by using elements like boron and cadmium which absorb neutrons.

Q. No. 2 Part (iv)

N - Type Semiconductor :

When a pentavalent imunity is added to semiconductors, an N-type semiconductor is formed. Majority charge carriers are electrons & minority charge carriers are electron. Since electron is negatively charged, such semiconductors are called N-type.

P - Type Semiconductor :-

When a trivalent impurity is added to a semiconductor, a p-type semiconductor is formed. Holes are majority charge carries while electrons are minority charge carriers. Since holes have positive charge, such semiconductors are called P-type. For example, when Aluminium is doped with silicon, a P-type semiconductor is formed.

Q. No. 2 Part (v)

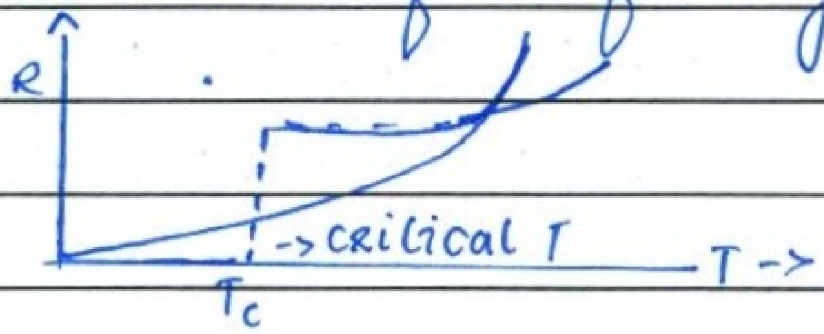
Curie Temperature:

The temperature at which a ferromagnetic substance turns into a paramagnetic substance is called Curie temperature.

-> The Curie temperature of iron is 750°C.

Critical Temperature:

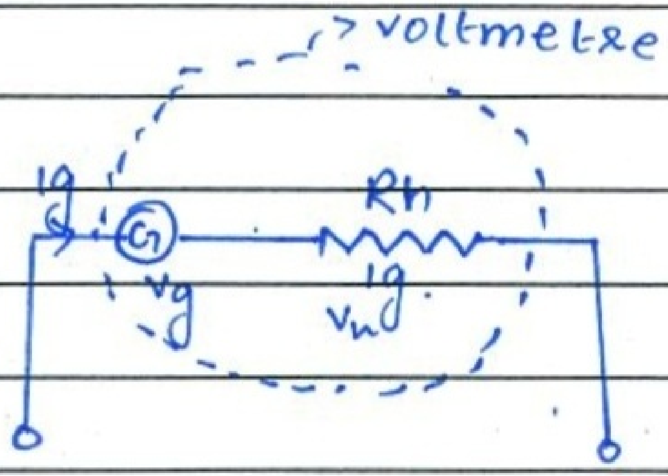
The temperature below which the resistance and resistivity of a substance become zero is called critical temperature. No heat or other form of energy is lost because the resistance becomes zero.



Q. No. 2 Part (vi)

Galvonometer Into Voltmeter:

A galvanometer can be converted into voltmeter by connecting a high resistance in series with it. if I_g is current through galvanometer, then $I_g = I_h$.



Potential: $V = V_g + V_h$

$V_g = I_g R_g$; $V_h = I_g R_h$.

R_g is the internal resistance of galvanometer.

$$V = I_g R_g + I_g R_h$$

$$V = I_g (R_g + R_h)$$

$$R_h = \frac{V}{I_g} - R_g$$

Q. No. 2 Part (vii)

Eddy Currents:

When a conductor passes through a magnetic field, it produces forces that spin inside the conductor. Eddy currents flow in planes perpendicular to the magnetic field. These eddy currents produce their own magnetic fields, which oppose the magnetic field that caused them. The magnetic fields repel and a braking force is produced. Eddy currents are used in induction cooktops for heating & cooking. Eddy currents produced in the base of the pan due to magnetic field of coil, generate heat. Also, the core of a transformer heats up due to eddy currents.

Q. No. 2 Part (viii)

Paramagnetic	Diamagnetic
The substances whose electrons support the magnetic field of one another to form a net magnetic affect. It is weakly attracted by magnetic field.	Substances whose electrons cancel the effect of magnetic field of one another. It is not attracted

x

Given Data: $R = 10\,\Omega$; $L = 32 \times 10^{-3} H$, $V = 220$, $f = 50 Hz$.

$I = ?$

Solution:

$\Rightarrow X_L = 2\pi f L = 10.05\,\Omega$

$\Rightarrow Z = \sqrt{R^2 + X_L^2} = 14.17\,\Omega$

$$I = \frac{V}{Z}$$

$$I = \frac{220}{14.17} = 15.52\,A$$

Q. No. 2 Part (ix)

Peak Value:

The maximum value attained by an AC supply is called peak value. It is also called amplitude of alternating quantity. AC reaches its peak value twice, once in positive direction, once in negative direction. It is represented by Im, Vm.

Effective or R.m.s value:

Effective value is the equivalent of AC thats provides the same power to the load as a D.C circuit. It is represented by Irms, Vrms.

$$I_{r.m.s} = \frac{I_m}{\sqrt{2}}$$

$$V_{r.m.s} = V_m / \sqrt{2}.$$

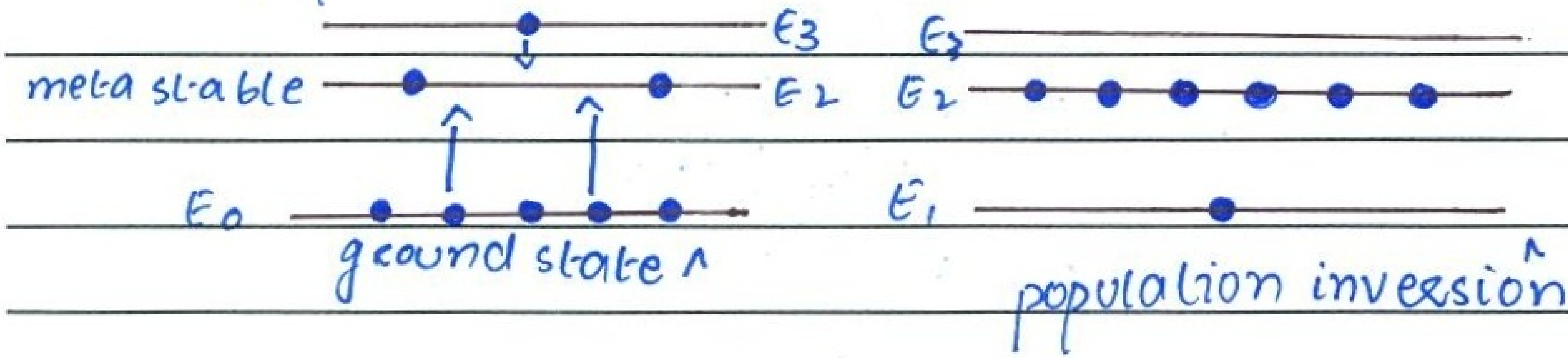
Q. No. 2 Part (x)

Meta Stable State:

The excited state in which an atom stays for a slightly longer duration (10^{-3} s) is called meta-stable state. It is used to achieve population inversion.

Population Inversion:

When the number of atoms in the excited/metastable state are more than the number of atoms in the ground state, then this phenomenon is called population inversion.



Q. No. 2 Part (xi)

Given Data:

$K.E = 1200 \times 10^{3}\ eV$

Formula:

$$\lambda = \frac{h}{\sqrt{2mVe}} \Rightarrow \frac{h}{\sqrt{2m\,K.E}}$$

Solution:

$$\lambda = \frac{(6.63 \times 10^{-34})}{\sqrt{2(9.11 \times 10^{-31})(1200 \times 10^{3} \times 1.6 \times 10^{-19})}}$$

$$\lambda = 1.12 \times 10^{-12}\ m.$$

Q. No. 2 Part (xii)

Alpha factor:.

It is the ratio of collector current to emitter current. $\alpha = I_C/I_E$

Beta factor:.

It is the ratio of collector current to base current.

$$\beta = \frac{I_C}{I_B} \qquad \therefore \; I_E = I_C + I_B$$

$$I_B = I_E - I_C$$

$$\beta = \frac{I_C}{I_E - I_C} \qquad \therefore \div \text{ by } I_E$$

$$\beta = \frac{I_C/I_E}{I_E/I_E - I_C/I_E}$$

$$\beta = \frac{\alpha}{1-\alpha} \qquad \Rightarrow \beta = \alpha/(1-\alpha)$$

Q. No. 2 Part (xiii)

Electron Volt:

Electron volt is the microscopic unit of energy.
" It is the energy lost or gained by an electron as it moves through a potential difference of one volt".

$$E = 1eV$$

$$1eV = (1 \times 1.6 \times 10^{-19}) \times 1V$$

$$1eV = 1.6 \times 10^{-19} J \; (JC^{-1})$$

$$1eV = 1.6 \times 10^{-19} J$$

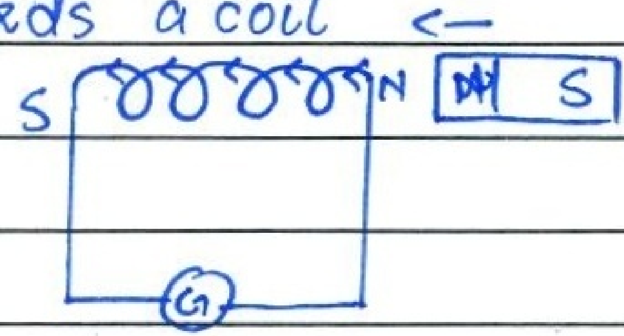
$$1J = 6.25 \times 10^{18} \text{ electron volt.}$$

Q. No. 2 Part (xiv)

Lenz's law:

The direction of induced current is such that it opposes its cause.

Consider is a magnet is moving towards a coil then due to change in magnetic flux, an e.m.f is current is induced. It opposes its cause and flows in anticlockwise direction.



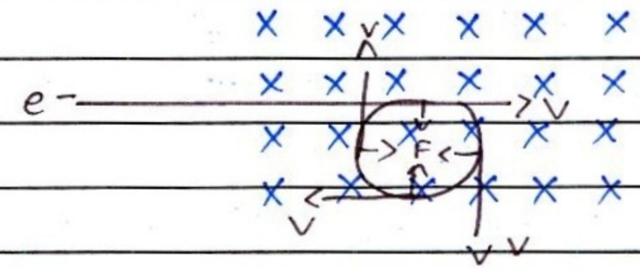
Lenz's law and law of conservation of energy:

Lenz's law is in accordance with the law of conservation of energy as the mechanical energy supplied to move the magnet appears as electrical energy in the coil.

Q. No. 3 (Page 1)

Charge to Mass Ratio of Electron

To find the charge to mass ratio of an electron, let an electron enters into a perpendicular uniform magnetic field. It will move in a circular path.



The required centripetal force is provided by the magnetic force;

$$F_c = F_B$$

$$\frac{mv^2}{r} = qvB$$

$$\frac{mv}{r} = eB \quad -i)$$

$$\frac{e}{m} = \frac{v}{Br} \quad -ii)$$

from i)

Velocity of the electron:-

To find velocity, we must know the potential difference by which electron was accelerated.

$$K.E = \frac{1}{2}mv^2 = eV$$

$$eV = \frac{1}{2}mv^2$$

Q. No. 3 (Page 2)

$$v^2 = \frac{2Ve}{m}$$

$$v = \sqrt{\frac{2Ve}{m}}$$

put in ii)

$$\frac{e}{m} = \sqrt{\frac{2Ve}{m}} \div Br$$

squaring

$$\frac{e^2}{m^2} = \frac{2Ve}{mB^2r^2}$$

$$\boxed{\frac{e}{m} = \frac{2V}{B^2r^2}}$$

The experimently determined value of e/m of electron $1.175 \times 10^{-11}\, C\,kg^{-1}$

Determination of Radius:.

To determine the radius of the close circular path of electron. Take an evacuated glass tube filled with oxygen at low pressure. When electrons excit accelerated by certain potential difference enter the tube, the hydrogen atoms are excited and upon deexcitation, they emit light. And the path of electron becomes visible.

$$T = \frac{2\pi m}{qB}$$

$$f = \frac{qB}{2\pi m}.$$

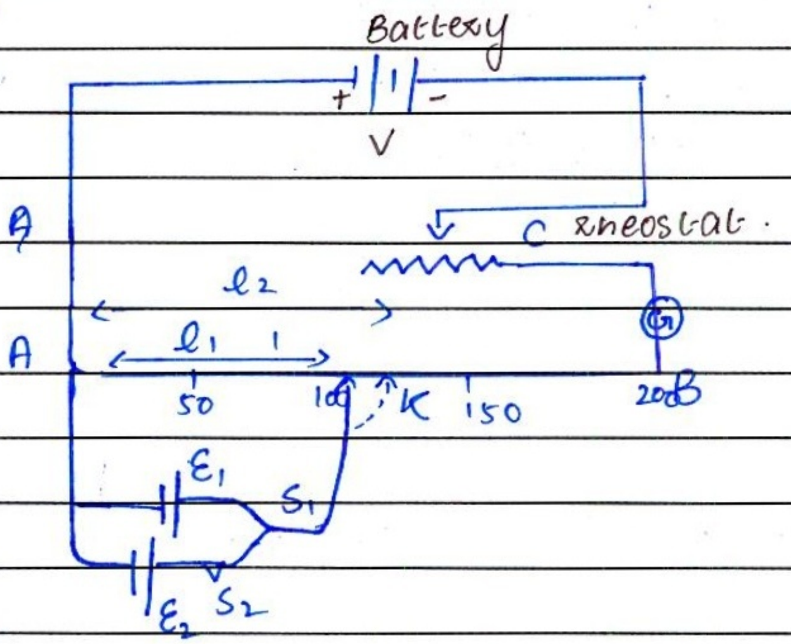
Q. No. 3 (Page 3)

POTENTIOMETER

Potentiometer is a device which is used to measure and compare potential accurately.

Working Principale:-

It works on the principle of balancing condition or and null point.



Construction:.

A potentiometer is shown in the figure. It consists of a battery, rheostate sliding contact. And two smaller e.m.f's. One is known while other is unknown. They have a switch. And a galvanometer.

Working:.

The battery and the rheostate supply the working current. The switch S_1 is turned on while the other is off. The contact k is pressed

Q. No. 4 (Page 2)

momentarily against AB and the galvanometer shows deflection. The current is varied using the rheostat until the galvanometer shows zero point deflection. This point is the null point. Let l_1 be the length of A & K that shows zero deflection. Then the potential drop at l_1 will be the same as the e.m.f $\mathcal{E}_1$.

Now, change the switch to S_2 and do the same for l_2. l_2 will have the same potential as $\mathcal{E}_2$ at null point.

$$\frac{\mathcal{E}_2}{\mathcal{E}_1} = \frac{l_2}{l_1}$$

$$\mathcal{E}_2 = \frac{l_2}{l_1} \times \mathcal{E}_1$$

In this way, $\mathcal{E}_2$ can be found.

Uses of Potentiometer:

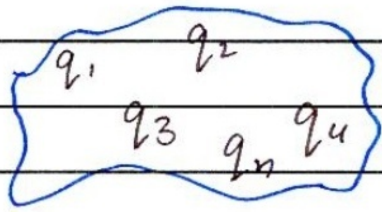
- Used for the measurement of small and large e.m.f
- It can be used to compare e.m.f of two cells.
- It is used for callibration of ammeter and voltmeter.
- It is used to find current and voltage.

Q. No. 4 (Page 3)

GAUSS'S LAW

"The electric flux enclosed in any arbitrary closed surface is equal to $\frac{1}{\varepsilon_0}$ times the total charge of enclosed by the surface".

Gauss's law states that the magnetic flux through a closed surface does'n't depend on the mass or geometry of a surface but the total charge.



Suppose we have divided the charge on an arbitrary closed surface into n number. so,

flux due to q_1;

$$\phi_1 = \frac{q_1}{\varepsilon_0}$$

flux due to q_2;

$$\phi_2 = \frac{q_2}{\varepsilon_0}$$

⋮

⋮

flux due to q_n;

$$\phi_n = \frac{q_n}{\varepsilon_0}$$

Total flux $\phi_T = \phi_1 + \phi_2 + \phi_3 + \cdots + \phi_n$

$$\phi_T = \frac{q_1}{\varepsilon_0} + \frac{q_2}{\varepsilon_0} + \frac{q_3}{\varepsilon_0} + \cdots + \frac{q_n}{\varepsilon_0}$$

$$\Phi_T = \frac{1}{\varepsilon_0}(q_1 + q_2 + \cdots + q_n)$$

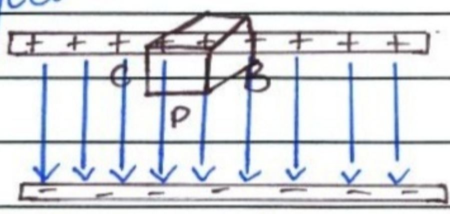
$$= \frac{1}{\varepsilon_0}(\text{Total charge})$$

$$\Phi_T = \frac{1}{\varepsilon_0} Q$$

Gauss's law can be used to find flux, charge and intensity.

Electric Intensity between two oppositely charged parallel plates:

Consider two oppositely charged parallel plates of infinite length to avoid fringing at the ends.



The electric field is directed from positive to negative plate. To find electric intensity, consider a guassian surface in the form of a box in between the plates. The top of the box is in the positive plate.

The surface charge density is given by;

$$\sigma = q/A$$

$$q = \sigma A$$

flux at C;

$$\Phi_1 = EA\cos 90^\circ = 0$$

flux at B;

$$\Phi_2 = EA\cos 90^\circ = 0$$

Q. No. 5 (Page 3)

Flux at bottom surface;

$$\Phi = EA\cos 0^\circ = EA = EA$$

Total flux;

$$\Phi_T = 0 + 0 + EA$$

$$EA = \Phi_T \quad -i)$$

as;

$$\Phi = \frac{q}{\varepsilon_0}$$

$$\Phi = \frac{\sigma A}{\varepsilon_0}$$

put in i)

$$EA = \frac{\sigma A}{\varepsilon_0}$$

$$E = \frac{\sigma}{\varepsilon_0}$$

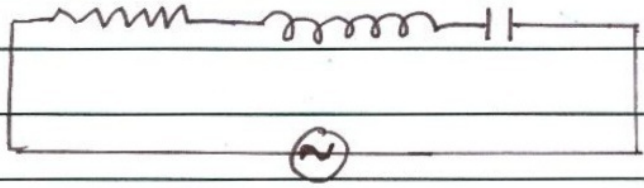
$$\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{x}$$

so, electric intensity between two oppositely charged parallel plates depends upon surface charge density and medium between the plates.

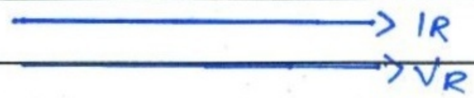
Q. No. 6 (Page 1)

RLC series Circuit

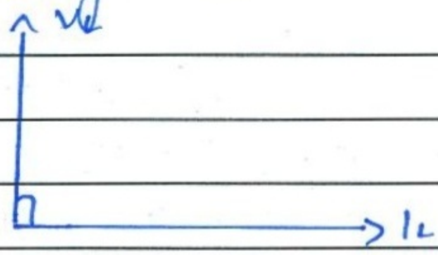
Consider an inductor, resistor and capacitor connected in series with an AC supply.



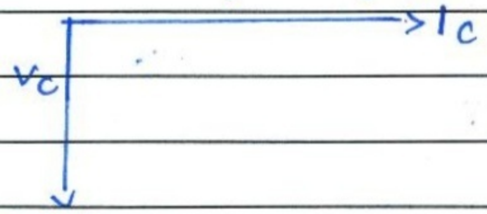
In a resistor current and voltage are in phase.



In an inductor voltage leads current by 90°.



In a capacitor, voltage lags by 90°.



Also, $X_L = 2\pi f L$

$X_L \propto f$

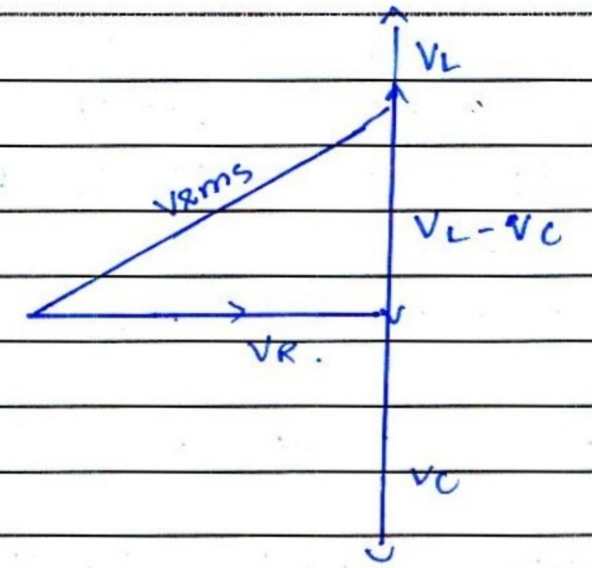
$X_C = \dfrac{1}{2\pi f C}$

$X_C \propto 1/f$

when frequency is high

$X_L > X_C \Rightarrow V_L > V_C$

Q. No. 6 (Page 2)



$$Vrms = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$Vrms = \sqrt{(Irms\,R)^2 + (Irms\,X_L - Irms\,X_C)^2}$$

$$Vrms = Irms\sqrt{R^2 + (X_L - X_C)^2}$$

$$\frac{Vrms}{Irms} = \sqrt{R^2 + (X_L - X_C)^2}$$

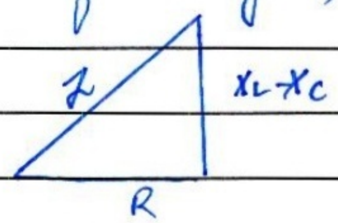
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

∧ impedence is given by the following relation.

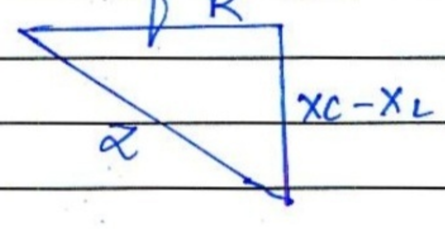
$$\tan\varphi = \frac{X_L - X_C}{R}$$

<u>Impedence triangle</u>:

when f is high;



when f is low



When $X_L > X_C$, circuit behaves as RL series circuit.

When $X_C > X_L$, circuit behaves as RC series.

In between high & low frequencies, there is a frequency at which $X_L = X_C$, called resonance frequency.

At resonance frequency;

$$X_L = X_C$$

$$\omega L = \frac{1}{\omega C}$$

$$\omega^2 = \frac{1}{LC}$$

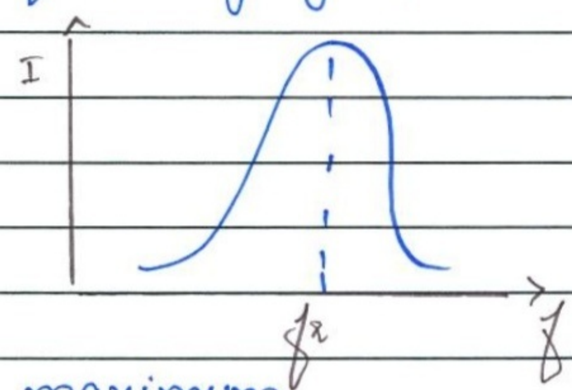
$$(2\pi f)^2 = \frac{1}{LC}$$

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

resonant frequency is given by $\frac{1}{2\pi\sqrt{LC}}$.

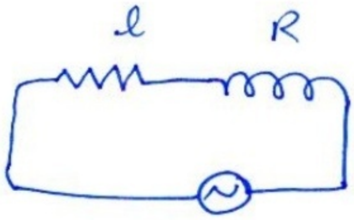
Properties of Circuit at Resonance:

- Circuit is purely resistive.
- Power factor is 1 ; $\cos\theta = 1$
- Impedence of the circuit is minimum
- Current in the circuit is maximum.
- $X_L = X_C$.
- Current & frequency graph is shown;



- Power loss is maximum.

$$P = I_{rms} V_{rms}$$



$R = 10\ \Omega$

$l = 32 \times 10^{-3}$ H

$X_L = 2\pi f L$

$X_L = 10.05\ \Omega.$

$Z = \sqrt{R^2 + X_L^2}$

$Z = 14.17\ \Omega$

$I = \frac{220}{14.17} = 15.52$ A

$F = Eq.$

$F = \frac{kqq}{r^2}$

$= 0$

B =

$\frac{V}{\frac{N}{Am}}$ m

$V - A/N^{-1}$

$K.E = 1200 \times 10^3$

$K.E = \frac{1}{2} m v^2$

$v^2 = \frac{2K.E}{m}$

$v = \sqrt{\frac{2K.E}{m}}$

$\frac{\phi}{1} = \frac{NAB}{c}$ } small. (smalll.)

$\alpha \frac{c}{NAB}$

$v = 6.5 \times 10^8$

$C_e = 1 \times 10^{-6}$ F.

$Q = CV$

$N_s = N_p$

$\frac{N_s}{N_p} = \frac{V_s}{V_p}$

$t = 10$ s

$\frac{\phi}{1} = \frac{NAB}{c}$

$P = 60$ W.

$t = 10$ s

$ef = 50$

$E = 60 \times 10$

$= 600$

$E = \frac{W}{t}$

$2l.$

$\frac{2l - l}{l} = 1$

$\lambda = \frac{h}{mv}$

$= \frac{h}{2mv} = \frac{1}{2}\lambda$