UNIT - 11

Electromagnetism And Electromagnetic Induction

Electromagnetism :-

Electromagnetism is a branch of physics involving the study of electromagnetic force, a type of physical interaction, that occurs between electrically charged particles. The electromagnetic force is carried by electromagnetic fields composed of electric fields and magnetic fields.

* Electromagnetic force is responsible for electromagnetic radiation such as light and one of the four fundamentals interactions in nature.

$F_e = qE$ (Force on a charged particle in electric field)

$\vec{F_m} = q(\vec{v} \times \vec{B})$ (Force on a charged particle in magnetic field)

$\vec{F_{em}} = q(\vec{E} + \vec{v} \times \vec{B})$ (Force on a charged particle in electromagnetic field)

Problems

(1) Find the equivallent registance of 5 registers of which 2 Ω, 3 Ω, and 5 Ω are connected in serise and 10 Ω, 20 Ω are connected to parallel to them

(2) Find the total capacity when three capacitors of capacity 2 microfarad, 3 -, and 5 microfarad are connected into serise.

(3) Calculate the equivallent registance of 5 registers of 5 Ω is connected in parallel.

(4) Calculate the equivallent capacitance between 3 capacitors of capacity 5 mi, 10 microfarad and 0.3 milli farad connected in parallel.

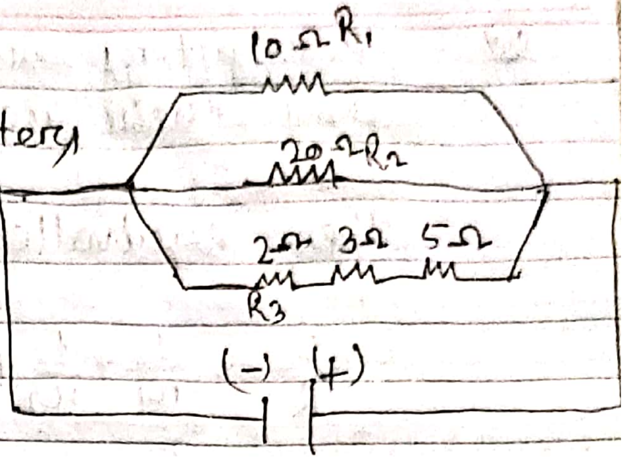
(5) Find the equivallent registance when three registers of registances 2 Ω, 5 Ω, and 10 Ω are connected in parallel.

(6) Find the equivallent registance between 5 registers of 5 Ω is connected in serise.

(1)

We know that if some resistors are in series connection then their resistance is given by;

$$R = r_1 + r_2 + r_3$$



then; in the above figure 2Ω, 3Ω, & 5Ω are in series connection, then their resistance is

$R = r_1 + r_2 + r_3$

$\Rightarrow R = 2\Omega + 3\Omega + 5\Omega$

$\Rightarrow R_3 = 10\Omega$

Then the equivallent resistance is given by;

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

In the above figure R1, R2, & R3 is in parallel connection.

$\frac{1}{R} = \frac{1}{10} + \frac{1}{20} + \frac{1}{10}$

$\Rightarrow \frac{1}{R} = \frac{2+1+2}{20} = \frac{5}{20} = \frac{1}{4} = 4\Omega$

$R_{equivallent} = 4\Omega$

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(3) 5 registers are connected in parallel and their registances are 5 Ω

then equivallent registance =

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \frac{1}{r_4} + \frac{1}{r_5}$$

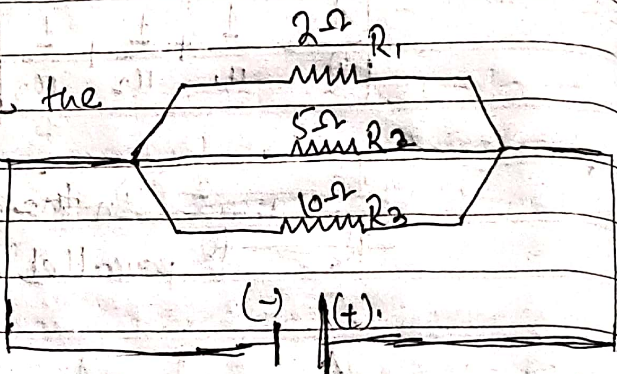
$$\Rightarrow \frac{1}{R} = \frac{1}{5} + \frac{1}{5} + \frac{1}{5} + \frac{1}{5} + \frac{1}{5}$$

$$\Rightarrow \frac{1}{R} = \frac{5}{5} = 1$$

$$\Rightarrow R_{eq} = 1\,\Omega$$

$\therefore$ **R equivallent = 1 Ω**

(5) In the above figure the all registers are in parallel connection,



then registance ;

$$\Rightarrow \frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

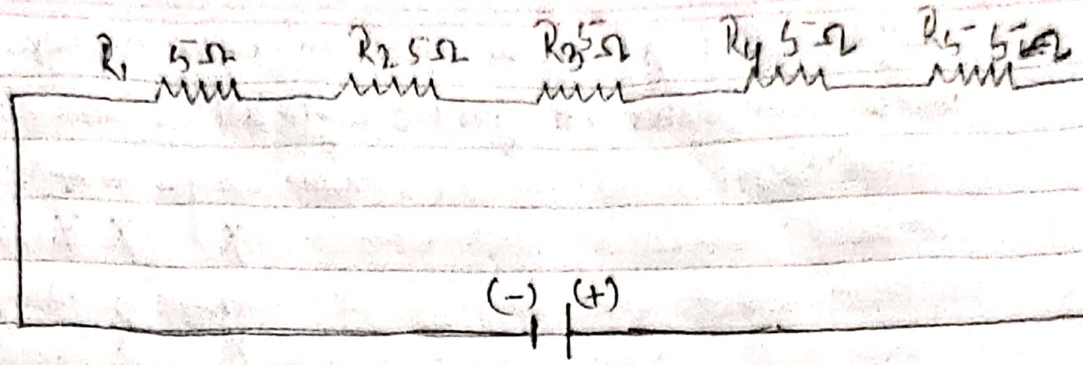
$$\Rightarrow \frac{1}{R} = \frac{1}{2} + \frac{1}{5} + \frac{1}{10}$$

$$\Rightarrow \frac{1}{R} = \frac{5+2+1}{10}$$

$$\Rightarrow \frac{1}{R_{eq}} = \frac{8}{10} \Rightarrow R_{equivallent} = \frac{10}{8} = \frac{5}{4} = 1.25\,\Omega$$

$\therefore$ **equivallent registance = 1.25 Ω**

(3)



In the above figure resistors are in series connect then resistance is given by ;

$R = r_1 + r_2 + r_3 + r_4 + r_5$

$\Rightarrow R = 5+5+5+5+5$

$\Rightarrow R = 25\,\Omega$

$\therefore R_{equivallent} = 25\,\Omega$

(4) given 3 capasitors capacity 5, 10 microfarad and 0.3 millifarad.

$C_1 = 5$ microfarad, $C_2 = 10$ microfarad, $C_3 = 0.3$ millifarad

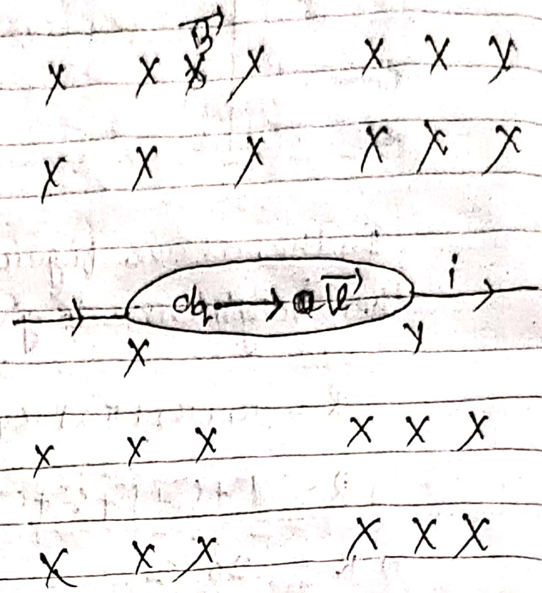
$C = 5\times10^{-6} + 10\times10^{-6} + 0.3\times10^{-3}$

$\Rightarrow C = \left(\frac{5}{10^{6}} + \frac{10}{10^{6}}\right) + \frac{0.3}{10^{3}}$

$\Rightarrow C = \frac{15}{10^{6}} + \frac{0.3}{10^{3}}$

$\Rightarrow C = 215\times10^{-6}$ Farad

Force acting on a current carrying conductor placed in a uniform magnetic field :-



force on a conductor carrying current placed in a magnetic field.

Consider a conductor x y placed in a uniform magnetic field $\vec{B}$ acting inward at right angle to the plane of paper. Let a current i flows through the conductor from x to y.

Let "dq" be a small amount of positive charge moving from x to y with a velocity $\vec{v}$. The force $d\vec{F}$ be expressed by this charge is

$$d\vec{F} = dq(\vec{v} \times \vec{B})$$

If the charge travels a small distance dl in time dt then

$$\vec{v} = \frac{d\vec{l}}{dt}$$

$$\Rightarrow d\vec{F} = dq\left(\frac{d\vec{l}}{dt} \times \vec{B}\right)$$

$\Rightarrow \frac{dq}{dt} (\vec{dl} \times \vec{B})$

$\Rightarrow i (\vec{dl} \times \vec{B})$ — (ii)

Now net force $\vec{F}$ acting on the conductor can be obtaind by integrating eqn (ii)

$$\vec{F} = \int d\vec{F} = \int i(\vec{dl} \times \vec{B})$$

$$= i(\vec{l} \times \vec{B})$$

$$= \vec{F} = i l B \sin\theta \, \hat{n} \quad \text{— (iii)}$$

where θ is the angle betwn $\vec{l}$ & $\vec{B}$ and $\hat{n}$ is the unit vector in a direction perpendicular to the plane containing $\vec{l}$ & $\vec{B}$.

Faraday's Law of Electromagnetic induction:-

Faraday's First Law (qualitative):-

Whenever magnetic flux link with a circuit ~~changes~~, an emf is induced in it.

* The induced emf is exist in the circuit so long as the change in magnetic flux link with it contin[ues]

Faraday's second Law (quantitative):-

The induced emf is directly proportional to the nagative rate of change of magnetic flux link with the circuit.

If $d\Phi_B$ is the change in magnetic flux linked with a circuit that takes place in a time dt then rate of change of magnetic flux is =

$$\text{Rate of change of magnetic flux} = \frac{d\Phi_B}{dt}$$

If E is the emf induced in the circuit as a result of this change then ;

$$E \propto \frac{-d\Phi_B}{dt}$$

$$\Rightarrow E \propto -K \frac{d\Phi_B}{dt}$$

The selecting units of "E", Φ_B and t in a proper ways & we can have K = 1

$$\text{Hence} \Rightarrow \boxed{E = \frac{-d\Phi_B}{dt}}$$

negative sign is due to the direction of induced emf which is explained by Lenz's Law.

Lenz's law :-

It states that " direction of induced emf is such that it tends to oppose the very cause which produces it."

Fleming's Left Hand Rule :-

Whenever a conductor carrying current is placed in a magnetic field, it experiences a force, and tends to move under it's action. Fleming's left hand rule gives the direction of the motion of the conductor.

"① Stretch first finger, central finger and the thumb of your left hand in three mutually perpendicular directions. If first finger points towards the magnetic field, the central finger towards current, then the direction of the motion of the conductor is given by the direction of thumb."

Fleming's Right Hand rule :-

It is rule to find the direction of induced current in a conductor. It can be stated as follows.

"Stretch first finger, central finger and thumb of your right hand in three mutually perpendicular direction. If the first finger points towards the magnetic field, thumb point towards the direction of motion of conductor, then the direction of central finger gives the direction of induced current set up in the conductor."

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UNIT - 12

Modern Physics

LASER and Laser Beam :-

LASER stands for Light Amplification by stimulated ~~emit~~ emission of Radiation. A laser is a machine that makes an amplified single colour source of light, it uses special gasses or crystals to make the light with only a single colour.

Principles of laser →

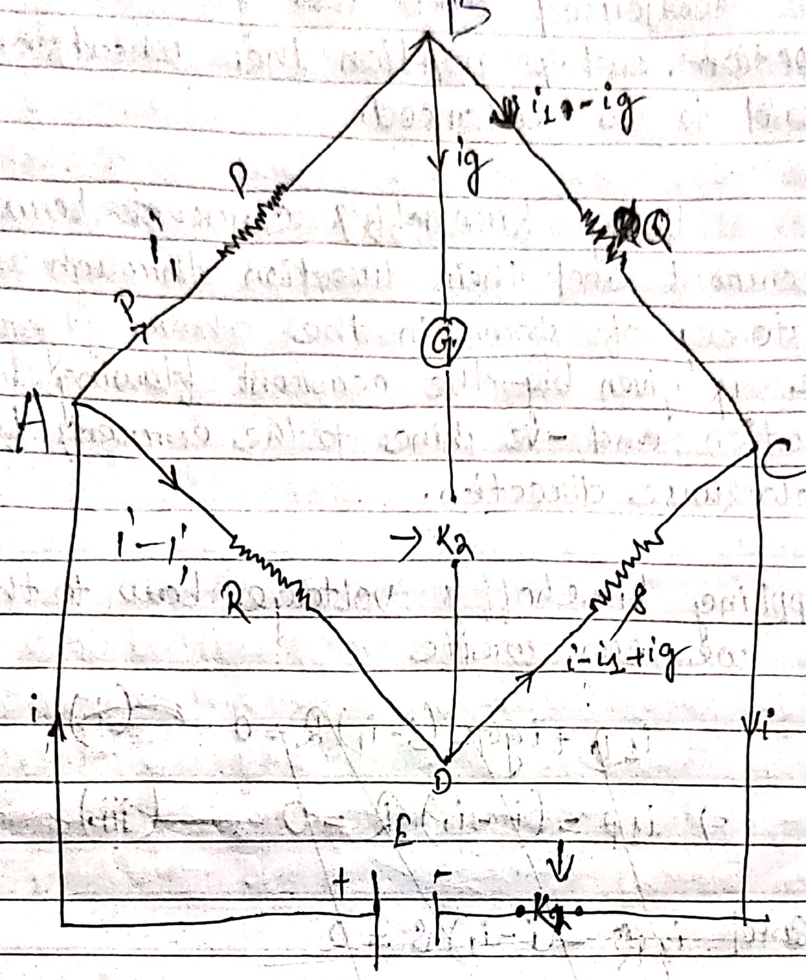
(i.) Population Inversion :- It is the condition in which the number of atoms in the excited states are more than the number of atoms in the ground state i.e. $N_2 >> N_1$. Population inversion is archieved by pumping. External energy must be provided to pump the atoms from ground states to excited states. Pumping could be optical pumping or electrical pumping.

* laser transition always takes place from metastable states.

(ii.) Optical Pumping → It is a process in which light is used to raise or (Pump) electrons from a lower energy lable in an atom and molecule to a higher energy lable.

ii-i1 + BC

Wheatstone Bridge :-



Wheatstone Bridge

Wheatstone Bridge is an electrical arrangement which forms the basics of most of the instrument used to determine an unknown resistance.

It consists of four resistance P, Q, R, S connected in the 4 arms of a square ABCD as shown in the above figure. A cell of emf (E) is connected between the points A & C through one way key K_1. A sensitive galvanometer of resistance (G) is connected between the terminals B & D through another one way key, K_2. After passing the keys k_1 & k_2 the resistances P, Q, R & S are show adadjusted that the galvanometer shows no deflection. In this position the wheatstone Bridge is said to be balanced.

Using Kirchoff's current law the distribution of current and their direction through various resistances of shown in the above figure. Positive shine is given to the current flowing in clockwise direction and -ve shine to the currents flowing in anticlockwise direction.

Appling kirchoff's voltage law to the mesh ABD we can write

~~$i_1 P + i_g G - (i - i_1) R = 0$ — (i)~~

~~$\Rightarrow i_1 P = (i - i_1) R = 0$ — (iii)~~

~~And $i_1 Q - (i - i_1) S = 0$~~

~~$\Rightarrow i_1 Q = (i - i_1) S = 0$ — (iv)~~

$$i_1 P_1 + i_g G - (i - i_1) R = 0 \text{ — (i)}$$

Similarly applying KVL to mesh BCD we can write

$$(i_1 - i_g) Q - (i - i_1 + i_g) S - i_g . G = 0 \text{ — (ii)}$$

Similarly applying KVL to mesh ~~BCD~~ ~~we~~ can write $\Rightarrow (i_1 - i_g) Q$ ~~$(i - i_1 + i_g)$~~ S

(1) Define Joule's Mechanical equivalent of heat.

(2) State the properties of Magnetic lines of force.

Since the bridge is balanced therefore the current 'ig' flowing through the BD is zero.

putting ig is zero in eqn (1) & (2) we have;

$$i_1 P - (i - i_1) R = 0$$

$$\Rightarrow i_1 P = (i - i_1) R \quad \text{--- (3)}$$

and $i_1 Q - (i - i_1) S = 0.$

$$\Rightarrow i_1 Q = (i - i_1) S \quad \text{--- (4)}$$

Dividing eqn (3) & (4)

$$\Rightarrow \frac{i_1 P}{i_1 Q} = \frac{(i - i_1) R}{(i - i_1) S}$$

$$\boxed{\Rightarrow \frac{P}{Q} = \frac{R}{S}} \quad \text{--- (5)}$$

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Wireless Transmission →

Ground wave →

Ground wave propagation is a type of electro-magnetic wave propagation which is also known as surface wave. The waves propagate over the earth's surface in low and medium frequency these are mainly used for transmission betw the surface of earth and ionosphere.

Space wave →

Space wave propagation is defined for the radio waves that occur within 20 k.m. of the atmosphere That is Troposphere comprising up direct and reflected waves from earth's surface.

Sky wave →

Sky wave propagation is also a type of radio wave propagation which is reflected or refracted back to the earth from the ionosphere, which is an electrically charged layer of the upper atmosphere.

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* Calculate the amount of heat required to convert 5 g.m. ice at -5°c to water at 60°c. Given that specific of ice = 0.5 $\frac{\text{calorie}}{\text{g.m.°c}}$ and latent heat = 80 $\frac{\text{calorie}}{\text{g.m.c}}$

Specific Heat of ice = 0.5 $\frac{\text{cal}}{\text{g.m°c}}$

Specific Heat of water = $\frac{1 \text{ cal}}{\text{g.m°c}}$

Latent heat of ice = 80 $\frac{\text{cal}}{\text{g.m.°c}}$

(i.) Heat required to covert ice from -5°c to ice at 0°c

$Q = CM\Delta T$

$C = \frac{Q}{M\Delta T}$

$Q_1 = 0.5 \times 5 \times 5 = 12.5$ cal

(ii) Heat required to covert 0°c ice to 0°c water

$Q_2 = 5 \times 80 = 400$ cal

(iii) Heat required to covert water 0°c to water at 60°c ;

$Q_3 = CM\Delta T$

$= 1 \times 5 \times 60$

$= 300$ cal

∴ Total Heat = $Q = Q_1 + Q_2 + Q_3 = 12.5 + 400 + 300$

$= 712.5$ cal.

Ohm's Law
It states that "at constant temprature the current flow through a conductor of uniform area of crossection is directly proportional to the potential difference accross the two ends of the conductor.

"at" constant temprature the current flow through a conductor of uniform area ~~is directly propert~~ of crossection is directly proportional to the potential difference accross the two ends of the conductor.

Strength of Magnetic Field → ($\vec{B}$)

The number of flux lines passing through a unit area placed normally to the flux lines at the point.

the number of flux lines passing through a unit area placed normally to the flux lines at the point

Magnetic Flux → Magnetic flux is defined as a flux line passing through ~~the point~~ a surface.

Magnetic field intencity is defined as

$$\vec{B} = \mu \vec{H}$$

In free space $\vec{B} = \mu_0 \vec{H}$

$$\rightarrow \vec{H} = \frac{\vec{B}}{\mu_0}$$

Faraday 1st law

When a magnetic flux liked with a circuit an emf is induced in it.

* The induced emf is exist in the circuit of the change in magnetic flux linked with it.

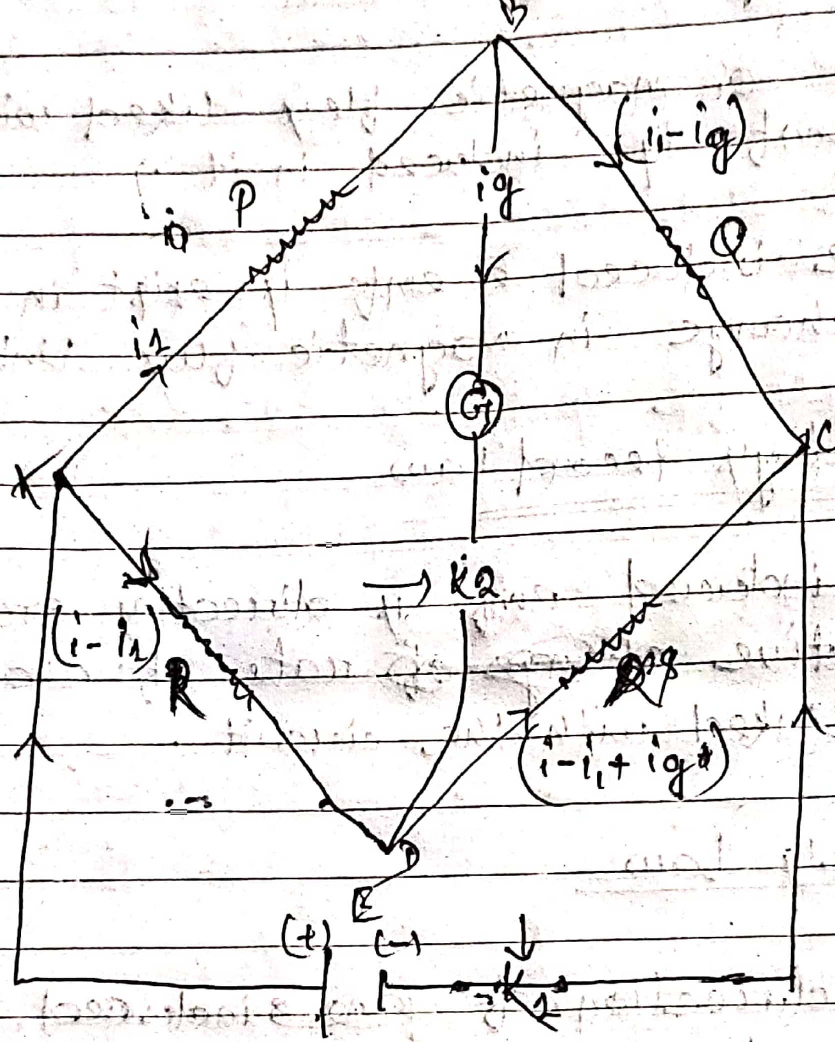
Faraday's second law

The induced emf is directly propertional to the nagative ~~change of~~ rate of change of magnetic flux linked with the circuit.

Lenz's law

The direction of induced emf is such that it tends to oppose very cause which produces it.

The direction of induced emf is such that it tends to oppose very cause which produces it.



B
P
Q
i
i_1
i_g
$(i_1 - i_g)$
G
C
K_2
$(i - i_1)$
R
$(i - i_1 + i_g)$
D
E
(+)
(−)
K_1