Types of wires & cables

The wires used for internal wiring of building may be divided in to different group

(1) Conductor used (copper & aluminium)

(ii) Numbers of cores
(i) single core
(ii) Twine core

(3) voltage reading (250v, 440V)

(600v to 1100 V)

(4) Types of insulation used
(i) Vir (vocalinsed indian rubber)
(ii) Tough rubber
or caf
(1) (240 / 420 / 650 V / 1100)

(iii) lead shashed cables they are available for 240 – 440V grads that provide good protection

(iv) PVC (220 to 440 / 600 – 1100 v grads)
harder than rubber better that insulator

(v) weather proof cable :- they are used for outdoor wiring and industrial used for (200/250, 680/1100)

used for house volte aplines

(vi) Multi strange cables ÷ these are more flaxible and durable having heathy readating capacity skin affect is better in case of higher freequency

* Components of LT switch care:
(low tension voltage)

1ϕ 3ϕ

220V. 440V 11KV, 33KV, 66KV, 110KV (AC)

(i) fuse ÷ function of fuse is to carray the normal working current safely without heating.

(ii) SFU ÷ switch fuse unit
(i) double pole → 1ϕ controlling (i)
(ii) Triple pole → 3ϕ 3wire controlling

Iron dat switch

(iii) protection device → PVC

(iv) ELCB : (i) Earth licage circuit braker

(ii) ~~current~~ valotag operator earth breaker start

Electrical Installation

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Wires and cables

* The wires used for internal wiring of buildings may be divided into different groups

(i) Conductor used
 (i) Cu Conductor cables
 (ii) Aluminium Conductor cables

(ii) Numbers of Cores used
 (i) single core cables
 (ii) twin core cables
 (iii) three core cables

(iii) Voltage grading
 (i) 250/440 volts cables
 (ii) 650/1100 volts cables

(iv) Type of insulation used:-
 (i) (VIR) insulated cables (vulcanized indian rubber) available in 240/415 V & 650/1100V grades.

(v) Tough Rubber sheathed (TRS) cable or Cab Tyre sheathed (CTS) cables.

Electrical Installation

* wire ÷ A wire is made of a single Conductor used for carrying electrical current
* cable ÷ A Cable is a group of multiple Conductor inside a Common Sheathing. used for carrying electrical current.

(*) different between wires & Cable

wire	cable
(i) wire is made of a single conductor.	(i) Cable is made of multiple conductor.
(ii) wire is used to carry electricty to bear(सहना) mechanical loads.	(ii) Cable is used for power signal transmission for telicommunication signle or to carry electricy
(iii) Ex ⇒ copper wire, Al wire.	Ex ⇒ HDMI Cable, USB Cable
(iii) Ex ⇒ type ÷ solid standard	(iii) multi conductor optical fiber Cable

* Types of wires and cables

(1) Conductor material used
(ii) number of cores used
(iii) voltage grading
(iv) type of insulation used
→ (a) (VIR) Volcanized indian Rubber cable (VIR).
→ (b) Tough Rubber Sheathed (TRS)
→ (c) polyvinyl Chloride Cable (PVC)
→ (d) Weather proof cables
→ (E) Lead sheathed cables

(f) flexible cords and cables
(g) Multi-strand cable
(h) XLPE cables

(i) Conductor used :- (i) cuppor conductor cable
(ii) Aluminium conductor cable

(ii) No of cores used :- (i) single core cable
(ii) Twin core cable
(iii) Three core cable

(iii) voltage grading :- (i) 250 v/ 440 v cable
(ii) 650/1100 volts cable

(iv) Types of insulation used :-

(a) VIR :- Vulcanized indian rubber cable available in 240v/415v & 650v/1100v grades.

(b) TRS :- Tough rubber sheathed available in
→ 250v/ 440 & 650 v/ 110 v greades
→ cheaper in cost or lighter in weight & easier in installation and weather proof cable it used in wet condition.

(c) PVC cable :- polyvinyl chloride cables - available in 250v/440 v. & 650v/1100v grades.
→ used in casing - capping battem
→ harder than rubber, better insulating qualitig & flexiblity.

(d) Weather proof Cables :- Weather proof Cables available in 240/415 V & 650V/ 110V grades. used for out door wiring. industrial supply, power supply.

(e) Lead Sheathed Cable :- Lead Sheathed Cables available in 240V/415V grades used for good protection against moisture & protection against mechanical injury.

(f) flexible cords & Cables :- flexible Cords and Cables used for house hold appliances Not used in fixed wiring.

(g) Multi strand Cables :- Multi - strand cable are more flexible & durable. Surface area of multi strand Cable is more so heating radiating Capacity is more

*(h) XLPE Cables :- XLPE Cables built of insulation made of polymers. Higher current rating, longer service life

(*) Define Switchgear :- The apparatus used for switching, controlling, protecting the electrical circuit and equipment from overload & short circuit is Known as Switchgear.

Call of Swith
- LV switchgear → 1000 V to 1500V
- MV switchgear → 3.3 kV to 33 kV
- HV switchgear → above 36 kV.

* LT switchgear → Low tension switchgear
Voltage

* various Components of LT switchgear

(i) fuse
(ii) switch fuse unit (SFU)
(iii) Miniature circuit Breaker (MCB)
(iv) Eearth leakage circuit breaker (ELCB)
(v) Moulded case circuit Breaker (MCCB)

(i) fuse :- A fuse is an electrical safety device which is used in electrical circuit for protecting electrical equipment against overloads or short circuit. It based on the principle of heating effect of electric current.

(ii) (SFU)
Switch fuse unit :- Switch fuse unit is the Combination of one switch and one fuse unit SFU protect the circuit against exessive current, SFU is also known as iron clad switch.

types of sfu (i) Double pole Iron clad
(ii) Triple pole Iron clad
(iii) Triple pole with neutral link ironclad

(i) Double pole iron clad :- 1 ϕ 2 wire circuit
(ii) Triple pole iron clad :- 3 ϕ, three wire circuit
(iii) Triple pole with neutral iron clad :- 3 ϕ, 4 wires
(with neutral wire)

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(MCB)

(iii) Miniature circuit Breaker:- A Miniature circuit Breaker is an automatically operated electrical switch which is used to protect low voltage electrical circuits from excessive current and overload or short circuit.

MCB are available with different current rating 1, 2, 2.5, 3, 4, 5, 6, 7, 7.5, 10, 16, 20, 25, 32, 35 & 40, 63, 100, 125, 160 A
and voltage rating (240/415V) ac and upto 220V dc

uses:- It is used to protect devices such as Air Conditions, refrigerators, & Computers.

(ELCB)

(iv) Eearth leakage circuit Breaker:-
Eearth leakage ciruit Breaker is an electrical device that protect against earth leakage.

If any current leaks from any electrical wire ~~dut~~ due to insulation failure then ELCB detects that earth leakage and makes the power supply off. otherwise it harmfull if anyone touches the insullation.

There are two types of earth leakage circuit breaker
(i) voltage ELCB (ii) Current ELCB

(i) Voltage ELCB:- A voltage ELCB is a voltage operated circuit breaker that contains relay coil which connected to the metallic body and at the other end is connected to ground wire. 3ph 2wire

(ii) Current ELCB :- Current ELCB is current operated circuit breaker it apply on 3 ϕ phase and 3 wires, its works is to break circuit.
both ELCB works on circuit break.

(MCCB)
(v) Moulded case circuit breaker :- MCCB is an automatic operated electrical device which is used to protect the electrical equipment or circuits and divecs from overload, short-circuit and earth fault; MCCB is much large than MCB. ~~MCCB is available in 3 [illegible] upto [illegible]A and voltage range [illegible] to 1.1KV~~
MCCB rating can be change as our requirement it is the beggest advantage of MCCB.

(*) what is eathing? why it is provided?

ans ⇒ Eeathing is the process of connecting metalic body of electrical equipment to earth for transferring the immediate discharge of the electrical energy directly to the earth by the help of low resistance wire, is known as the electrical earthing.
Eearthing is provider
(i) To avoid electric shock
(ii) To avoid risk of fire
(iii) To ~~avoid~~ provide the humans from electric shock.
(iv) To protect equipments from excessive flow of current.

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* Methods of earthing are :
(i) wire or strip earthing
(ii) Rod earthing (1M)
(iii) Pipe earthing (8f)
(iv) plate earthing (1.5m)

* Batteries , Types, characteristics

* Battery : A Battery is the collection of more than one cells to create the flow of electrons within a circuit. Battery is the primary power source for any gadget used in smartphone, laptop, watch, remote. in the batteries chemical energy is converted into electrical energy.

* Types of batteries
(i) primary Batteries
(ii) secondary Batteries

(i) primary Batteries : primary batteries are that batteries which cannot be recharged. primary batteries are made of electrochemical cells whose electrochemical reaction cannot be reversed. primary battery used where low amount of power requires. it cannot be recharge so that it is expensive.
Examples : uses → Remote, watch
Dry Cell, alkaline batteries

Advantags : (i) small in size
(ii) low internal resistance
(iii) long life capacity
(iv) Higher efficiency

* define ampere hour efficiency of battery
→ Ampere hour efficiency is the ratio of output and input ampere hour of the Cell.

* Secondary Batteries:- Secondary batteries are that batteries which can be recharged secondary batteries are made of electro-chemical cells. whose electrochemical reation can be reversed. It is also too expensive.

Ex ⇒ Lithium ion batteries
Nickel Cadmium

* Types of primary battery.
(i) Alkaline battery
(ii) Silver oxide battery

(i) Alkaline battery :- These are the most common type of primary batteries. The have a long life and they can provide reliable power to devices such as flashlights, remote and toys. chemical composition → Zinc with maganese dioxide and Potassium hydroxide → electrolyte.

(ii) Silver oxide battery :- These are the most common types of primary batteries used in small electronic dives such as calculators, watches, they have a long life and provide stable voltage output.

* Types of Secondary battery
(i) Lithium - ion battery
(ii) Lead acid battery

* Explain ~~or~~ any two types of battery

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(i) Lithium-ion battery :- Lithium-ion battery is the most commonly ~~rechable~~ rechargeable battery used for electronic devices such as smartphone, laptops. They are lightweight and high energy density.

Anode → Graphite
cathode → lithium metal oxide
electrolyte → aq. solution dissolved with lithium salts.
voltage → 3.7 – 3.85 V
used in → smartphones, laptops

(ii) Lead acid battery :- These are the commonly used in cars and other vehicles and backup power supplies, It has high energy density. It can provides a lot of power for short periods of time.

Anode → Lead metal
cathod → lead dioxide
electrolyte → H_2SO_4.
voltage → 2V
used in → cars, vehicles.

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(PYQ) What are important characteristic for a battery?

(1) Capacity :- Capacity refers to the amount of energy of a battery that can ~~be~~ store and it is measured in ampere-hours (Ah)

(2) Voltage :- Voltage is the electrical potential difference between two points in a circuit and it determines how much energy a battery can deliver to a devics.

(3) Charge time :- This is the amount of time it takes for a battery to fully recharge and it's important for devices that need to be charged quickly.

(4) Cycle life :- cycle life refers to the number of times a battery can be charged and discharged before its capacity begins to degrade.

(5) Cost :- finally the cost of a battery is an important consideration as it can very widely depending on the technology, capacity and other features.

(6) power :- power is the rate at which a battery can deliver energy to a device. it is measured in watts (W)

(*) Beriefly discuss different methods of charging battery.

ans ⇒ Two methods of charging battery.

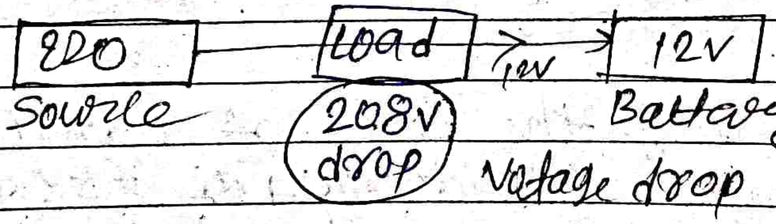
(i) constant current method
(ii) constant voltage method

① Constant current method :-

(i) DC source voltage is more greater than battery voltage

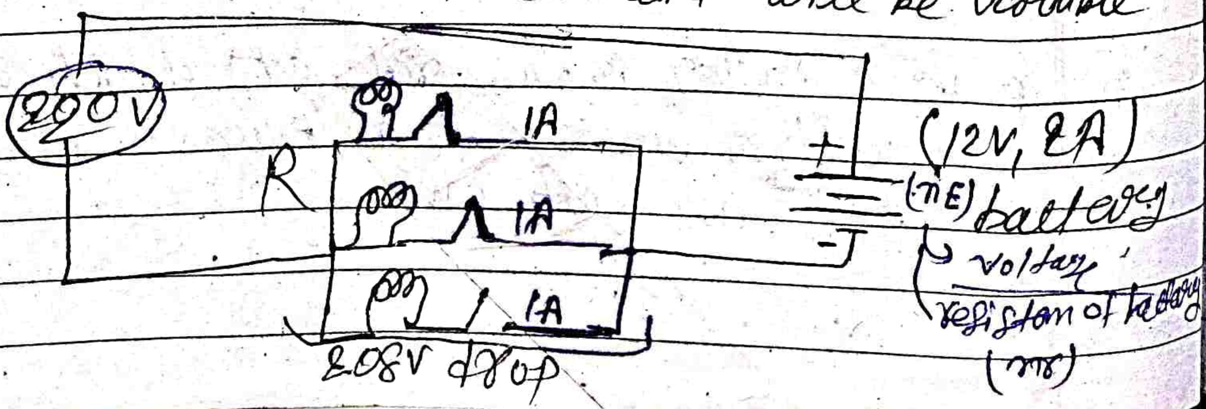
DC Source (↑↑↑) (220V) battery (6, 8, 10, 12, 20)

(ii) Current should be constant till discharging to charging the battery.



Votage drop $V = IR$

So there voltag drop so current drop hence there current will be variable



$V = IR$ $\quad I = \frac{V_{total}}{R_{total}}$ $\quad \boxed{I = \frac{V - nE}{R + nr}}$

$$\boxed{R = \frac{V - nE}{I} - nr}$$

(2) Constant voltage method

(i) DC source voltage is little greater then battary.

DC Source (24V) Battary (8, 10, 12, 20V)

(ii) Voltage should be constant till discharging to charging the battary.

Constant Voltage

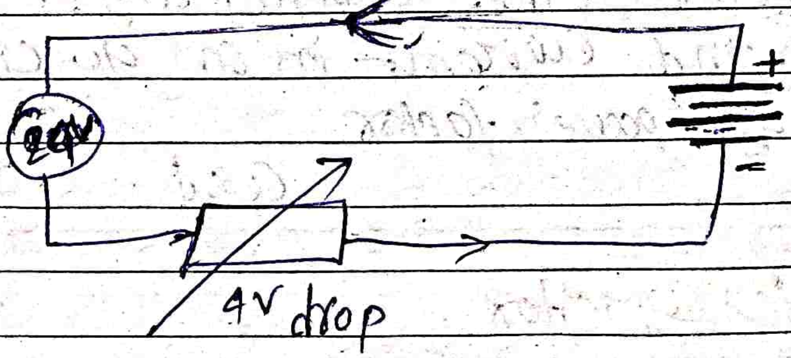
DC source

[24V] → [Load] → [20V] battary

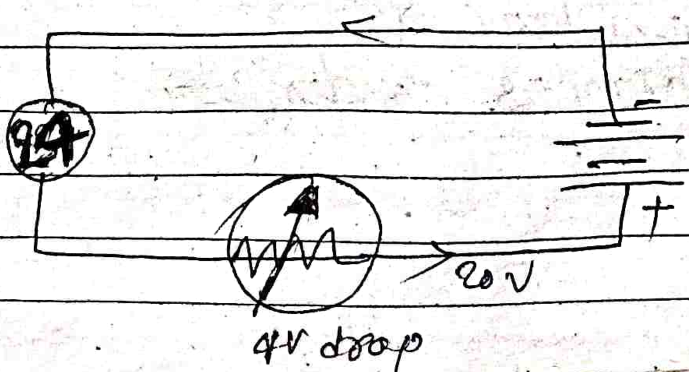
4V drop 20V

$V = IR$

voltage constant



battary (20V) resistance - nr
voltag - nE



Battary (20V)

(*) What are electrical measuring instruments. Explain
What are different types of electric measuring instruments.

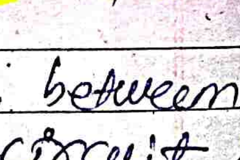
ans → (i) Ammeter → It finds current in a conductor
(ii) Voltmeter → It finds voltage in a conductor
(iii) Multimeter → It can find both V & I ac order
(iv) Wattmeter → It finds power in a wire.
(v) Ohmmeter → It finds resistance in a wire
(vi) galvanometer
(vii) digital multimeter

→ Electrical measuring tools are a device which is used to measure the magnitude of an electric current, voltage, resistance, power.

* Enlist two methods for power factor improvement. What are power factor its significance
* Describe the methods of power factor improvement.

* power factor :- The cosine angle between voltage and current in an ac circuit is known as power factor

$\cos\phi$



* Significance of power factor
(i) less electricity costs
(ii) less heat
(iii) long life of the electrical system.

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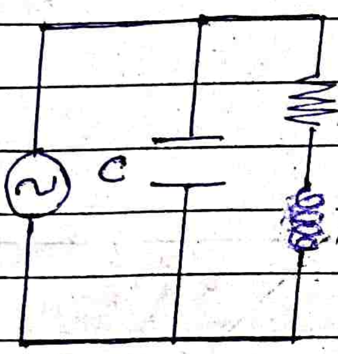
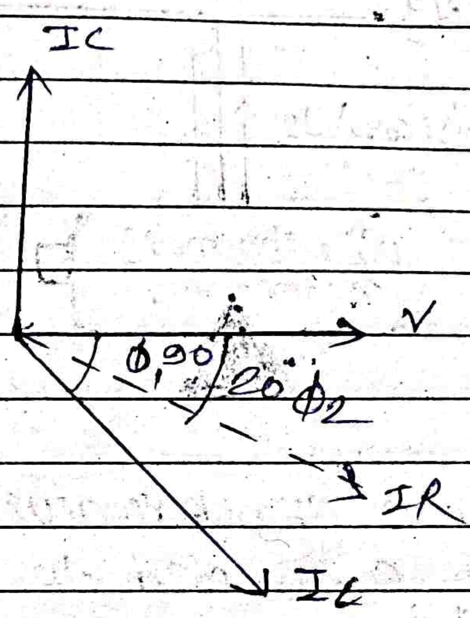
(PYQ) Describe methods of power factor improvement.

① Static Capacitor:





$\cos\phi_1 = \cos 90° = 0$

$\cos\phi_2 = \cos 20° = 0.9$

Here static capacitors are connected parallel with power supply, this static capacitor provides leading current and delivers reactive power to the inductive load thereby power factor is improved in system.

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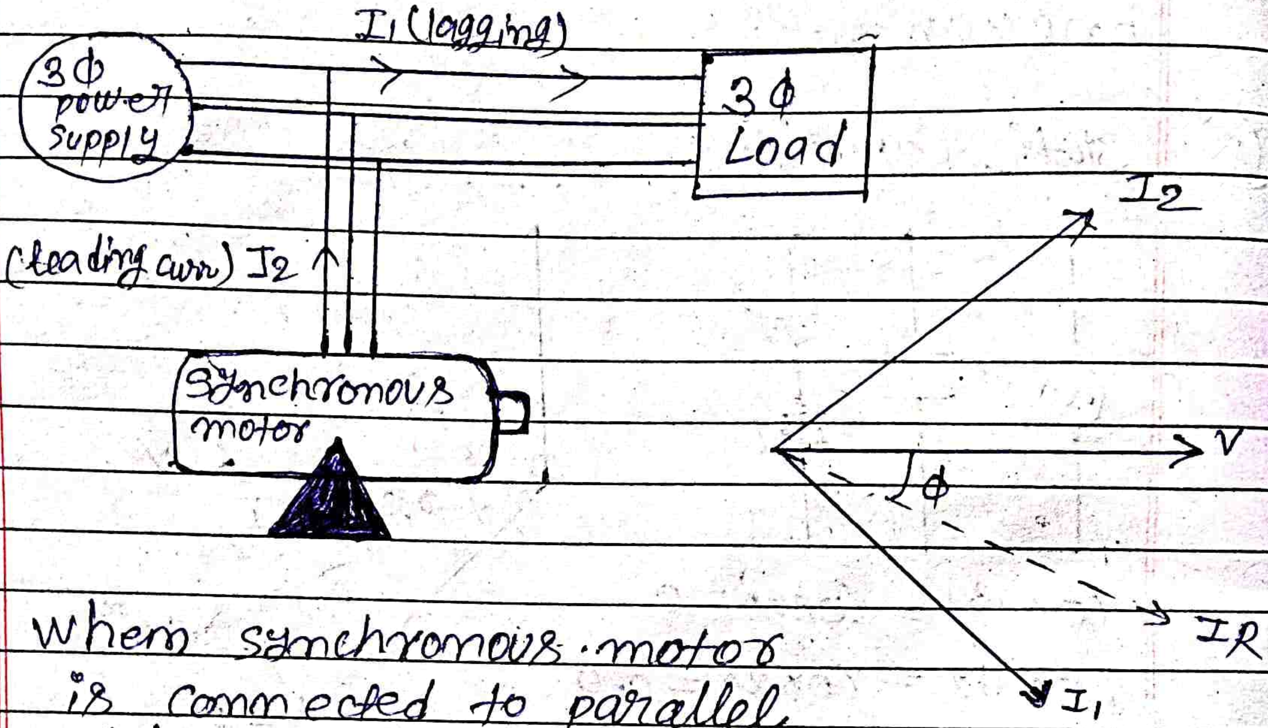
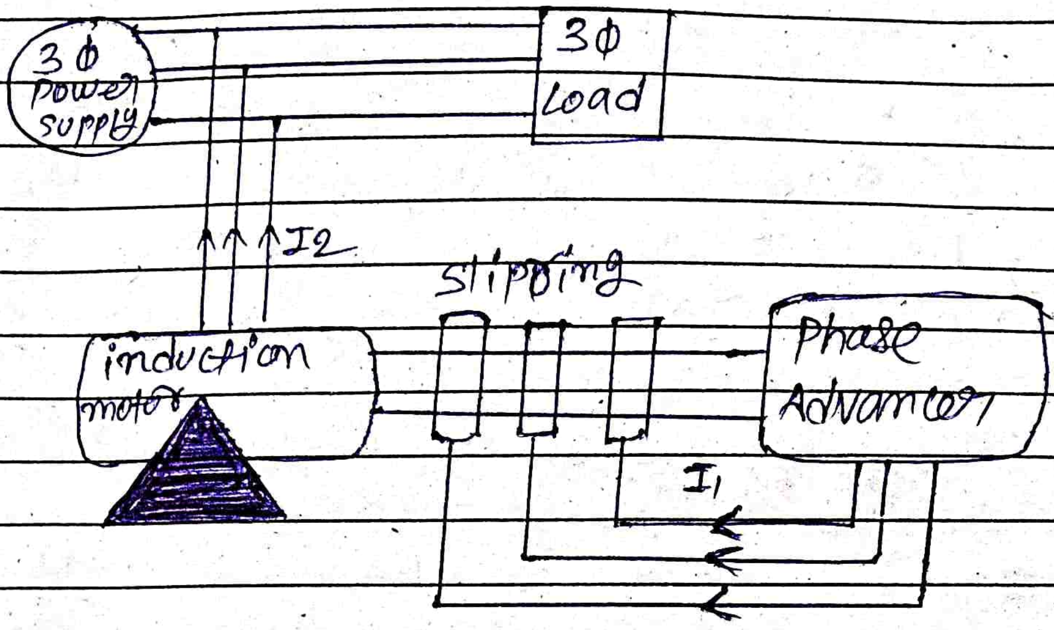
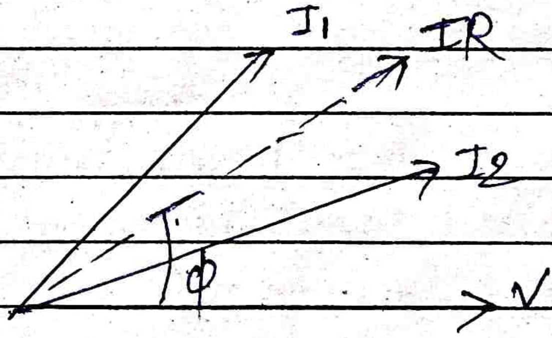
(2) Synchronous condenser :-



when synchronous motor is connected to parallel with power supply, It provides leading current or reactive power to system thereby power factor is improved in the system

(3) Phase advancer :





Phase advancer is a devic used in induction motor to improve their power factor, They are installed in the rotor circuit of the motor and provide additional excitation current to the rotor winding ~~and reduce reactive power~~ and improve the power factor.

PYQ Give concept of work and energy.

ans ⇒ Work → The concept of work is refers to the amount of energy that is transformed when a force is applied over an object to move from one place to another place is called work.

Energy :- Energy refers to the ability of a system to perform work is called energy.

PYQ Give Analogy between Electric and Magnetic circuits.

(i) Just as electric circuits have components like resistors, capacitors, inductors, that affect the flow of current
Just like that
Magnetic circuits have components like magnetic cores, air gaps, coils that affects the flow of magnetic flux.

(2) Just as electric circuits can be used to perform tasks like transmitting power or processing signals.
Just like that
Magnetic circuits can be used to perform tasks like storing energy or controlling motion

(pyq) Explain how rotating magnatic field is produced? give expression for its magnitude

ans ⇒ A rotating magnatic field is produced when a set of coils carrying an alternative current is arranged in a specific way such that the magnatic fields generated by each coil combine together to create a rotating magnetic field.

$$B = B_m \sin(wt)$$
$$B = B_m \sin(2\pi f t)$$

where B is the magnitude of the magnatic field and B_m is the maximum magnitude of the magnetic field, ω is the angular frequency that is equal to two times of frequency and t is time.

DC ↓

* **diff b/w Node & Junction**

node	Juction
(i) node is a point in network where two or more circuits are joined.	Junction is a point where three or more than three circuits are joined
(ii) every junction canbe a node.	(ii) every node cannot be a junction
(iii) Ex ⇒ A	Ex ⇒ B

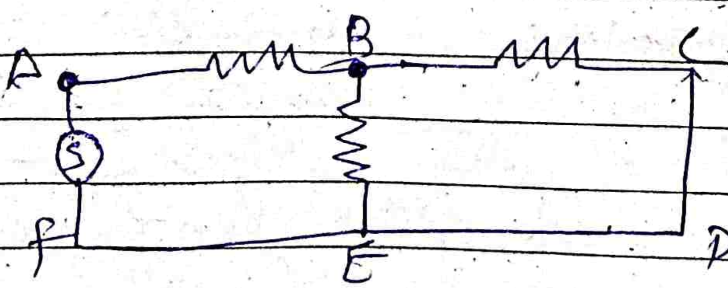
~~Explain the concept of voltage and current~~

* **Define the term phase splitting**

→ A device by which a single phase current is splited into two or more currents differing in phase which is used to starting a single-phase inductor motor.

* **diff b/w mesh and loop. with example**

mesh	loop
(i) The loop which can't be further dived is called mesh.	loop is the closed path of network is called loop.
(ii) mesh can be exists in loop.	loop cannot be exist in mesh.
(iii) Ex ⇒ ABEFA	Ex ⇒ ABCDEFA



DC circuits

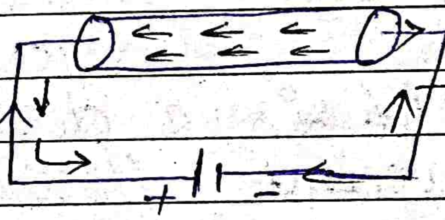
* Electricity :- The flow of electrons in a closed circuits to do work called electricity.

* Electric current :- The continous movement of free electron in an electric circuit from -ve terminal of the cell to the +ve terminal through external circuit

$$\text{current} = \frac{q}{t} \Rightarrow \boxed{I = \frac{q}{t}} \text{ Ampere}/s$$

or

It is the rate of flow of electron or charge flowing per sec is called electric current.



flow of electron

* Electric potential :- The capacity of a charged body to do work called electric potential.

$$V = \frac{\text{wordone}}{\text{charge}} \Rightarrow \boxed{V = \frac{W}{q}}, \text{volt}$$

* Ohm's law :- Keeping the physical condition & temprature of conductor as constant, current flowing between any two points of a conductor is directly proportional to potential difference across temperature.

$$I \propto V \Rightarrow \frac{V}{I} = \text{constant}$$

$$\boxed{V = IR}$$

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* Limitation of ohm's law

(i) This law is not applicable to non linear element such as electric arc, powdered carbon, th etc.

(ii) this law is not applicable to unilateral networks such as electronic tubes & diode.

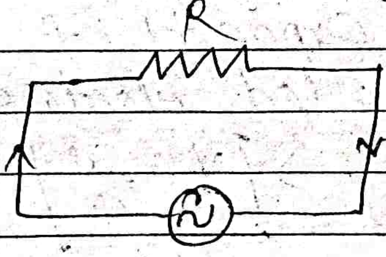
* Electric power :- The rate at which work is done in an electrical circuit

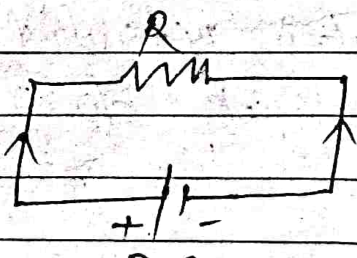
$\boxed{P = \frac{\text{work done}}{\text{Time}}}$ $P = \frac{VI\cancel{t}}{\cancel{t}}$ $\boxed{P = VI}$ watt

$\boxed{P = \frac{W}{t}}$ $W = VQ \Rightarrow W = Vit$

* Circuit :- It is a closed path through which current flow

2 types





* linear element :- Linear elements are the elements that show a linear relationship between voltage and current Ex ⇒ Resistor, inductor

→ The circuit containing only linear resistance are called linear circuits.

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* Non linear element ÷ Non-elements are those that do not show a linear relation between voltage and current.
Ex ⇒ gas diode, electric arc, inductor

→ The circuit containing non linear element are called non linear circuit.
Ex → Transistor etc

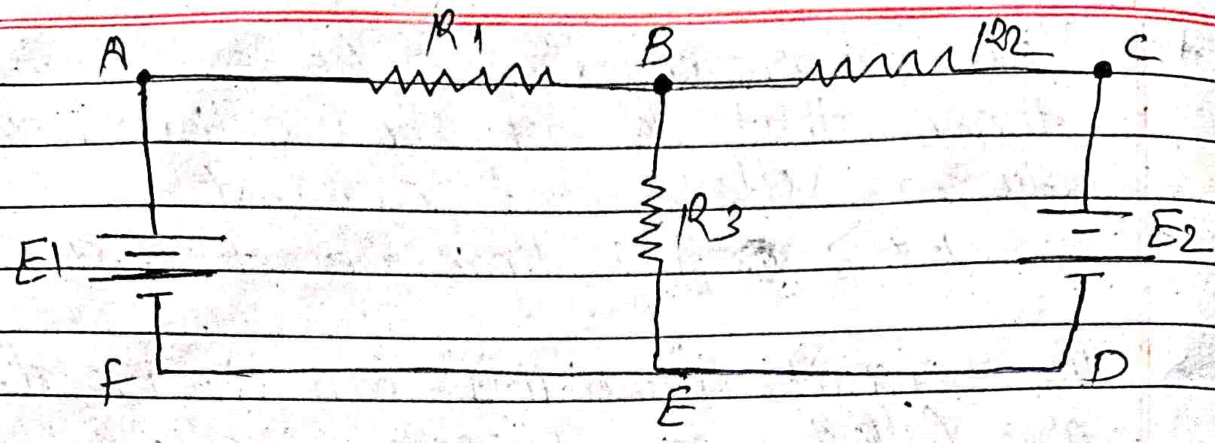
* Unilateral circuit ÷ An electric circuit whose characteristic properties change with the direction of its operation.
Ex → diode

* Unilateral circuit ÷ Unilateral circuit are those circuit which allows the current flow only in one direction
Ex diode

* bilateral circuit ÷ bilateral circuit are those circuit which allows the current flow in both direction.

* active element ÷ Those element which supplies energy to circuit is called active element.
→ Networ having active element is called active network Ex → DC or AC source

* Passive element ÷ Those element which receives energy are called passive element.



* **Node** ÷ A node is a point in network where two or more circuit are joined
Ex = A, B, C, D

* **Junction** ÷ A junction is a point in the network where 3 or more element joined
eg →, B

* **loop** ÷ the closed path of network is called loop. → ABEFA

* **Mesh** ÷ The loop which can't be further divided is called mesh.
Ex → ABEFA, BCDEB

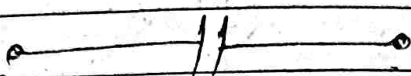
electric
* **Resistance** ÷ Resistance is a measure the opposition of current flowing in an electrical circuit. $\boxed{R = \rho \frac{l}{A}}$ Ohm → unit
factors depend → (i) Length of wire
(ii) area of wire
(iii) $R \propto \rho$

$\boxed{P = \frac{V^2}{R}}$ $\boxed{H = I^2Rt}$

* Inductance ÷ It is the property of a material by the virtue of which a change in electric current through it induces emf in conductor.

$\boxed{V = L\frac{di}{dt}}$ $\boxed{i = \frac{1}{L}\int v\,dt + i_0}$

* Capacitance :- The capability of an element to store electric charges with in it.

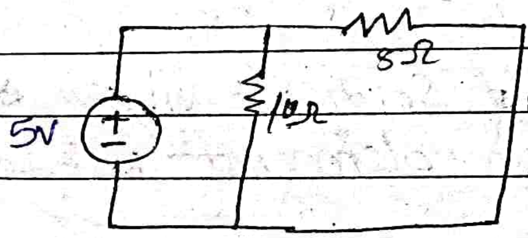


$\boxed{C = \frac{Q}{V}}$ $\boxed{U = \frac{1}{2}CV^2}$

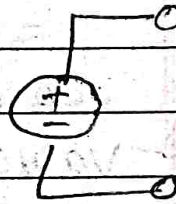
* Voltage and current sources / Energy source

(1) Independent Sources

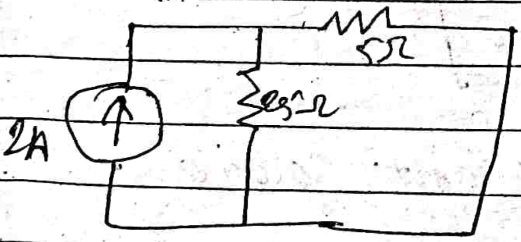
(i) independent voltage source :- whose voltage value does not depend on element present in the circuit.



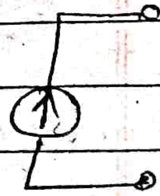
or ideal V.C



(ii) Independent current source :- whose current value does not dependent on element present in circuit.



or ideal C.S →



(2) Dependent sources

(i) dependent voltage sources

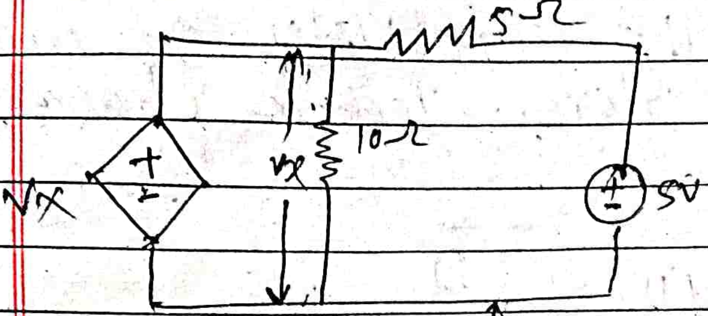
(ii) dependent current sources

~~dependent voltage sources~~ Voltage controll voltage source

current control voltage source

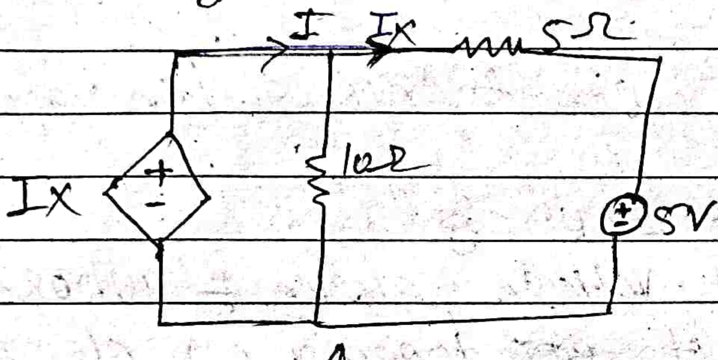
(i) dependent voltage source : whose voltage value depends on element present in circuit.

(a)



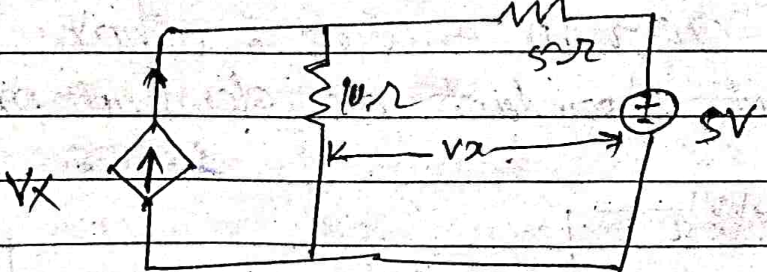
voltage controll voltage source

(b)

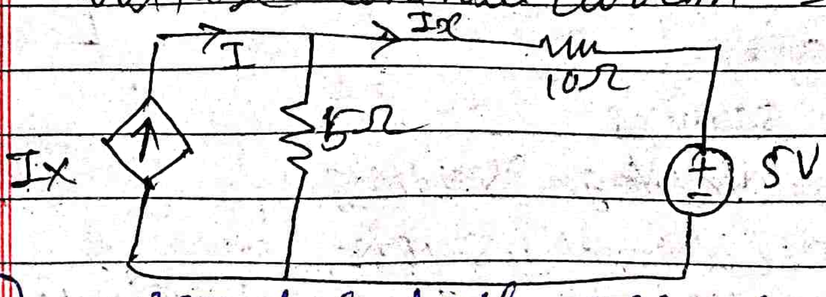


current controll voltage source

(ii) dependent current source : whose ~~voltage~~ current value depends on element present in circuit.

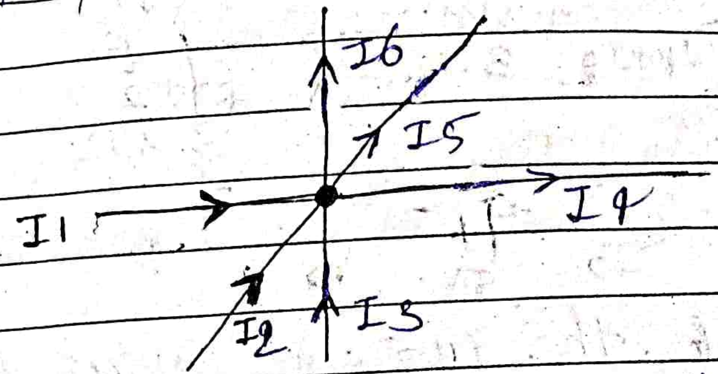


(a) voltage controll current source



(b) current controll current source

* **Kirchhoff current law**: The algebric sum of all current meeting at a junction or a point is ~~zero~~ equal to zero.



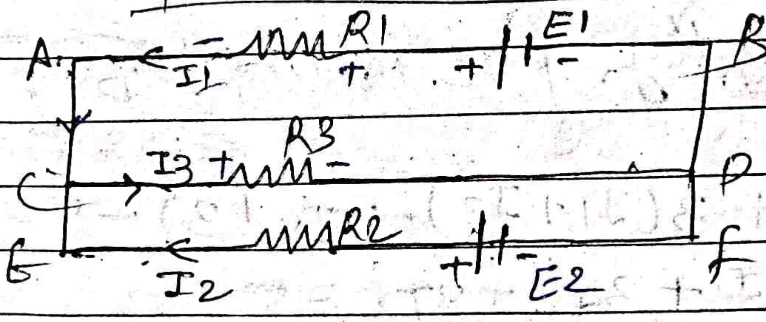
$$I1 + I2 + I3 - (I4 + I5 + I6) = 0$$

$$\boxed{\Sigma i = 0}$$

* **Kirchhoff's voltage law**: It states that the algebric sum of all the voltage and Emf in a closed loop is equal to zero

$$\Sigma \mathcal{E} + \Sigma V = 0$$

$$\boxed{\Sigma \mathcal{E} + \Sigma IR = 0}$$



Apply KVL rule in mess ACDBA

$$\boxed{I1R1 + I3R3 - E1 = 0}$$

$$\boxed{I1R1 + I3R3 = E1}$$

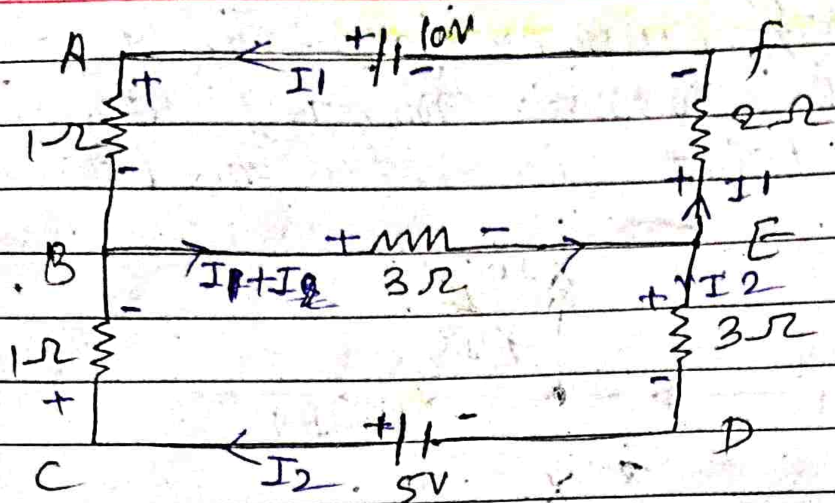
Apply KVL in mess CEFDC

$$\boxed{I2R2 + I3R3 - E2 = 0}$$

$$\boxed{I2R2 + I3R3 = E2}$$

Numericle on KVL

*



Calculate the current in each branch.

Apply KVL in first mess ABEFA

$I_1 \times 1\Omega + 3\Omega(I_1+I_2) + 2\Omega(I_1) - 10V = 0$

$I_1 + 3I_1 + 3I_2 + 2I_1 = 10$

$6I_1 + 3I_2 = 10$ —— (A)

again apply KVL in mess BCDEB

$I_2 + 3(I_1+I_2) + I_2(3) - 5 = 0$

$I_2 + 3I_1 + 3I_2 + 3I_2 = 5$

$3I_1 + 7I_2 = 5$ —— (B) $\times$ 2

Solving eq A and B

$6I_1 + 3I_2 = 10$

$6I_1 + 14I_2 = 10$

$-11I_2 = 0$

$\boxed{I_2 = 0}$

put in (A)

$6I_1 + 3(0) = 10$

$I_1 = \frac{10}{6} = \frac{5}{3}$

$\boxed{I_1 = \frac{5}{3}}$

$I_3 = I_1 + I_2$

$\boxed{I_3 = 5/3}$

* **Network :** A network is Collection of interconnected components (resistor, capacitor)

Network theorem

(i) Superposition theorem
(ii) Norton theorem
(iii) Theovenin theorem

* Superposition theorem :

* Current division Method :

$$\boxed{I_x = I_T \times \frac{\text{Resi's of opposition branch}}{\left(\text{Resis of OPP branch} + \text{Resi's of current branch}\right)}}$$

* Voltage division Method

$$\boxed{V_x = \frac{R_x}{R_T} \times V(\text{input})}$$

$$\boxed{R_S = R_1 + R_2 + R_3}$$

$$\boxed{R_P = \frac{R_1 \cdot R_2}{R_1 + R_2}}$$

* **Superposition theorem** :- If a number of voltage and current source are acting in a linear network then the resulting current in each branch is the algebraic sum of all the currents that would be produced in it, and other source will be replaced by open and short-circuit.

Procedure :-

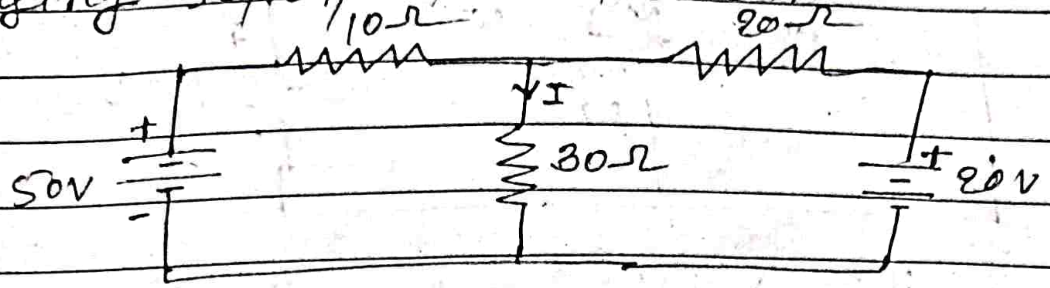
(i) Consider one source at a time & other source are removed.
Note :- Voltage source → short circuit
current source → open circuit

(ii) Current is calculated in each require branch due to single source.

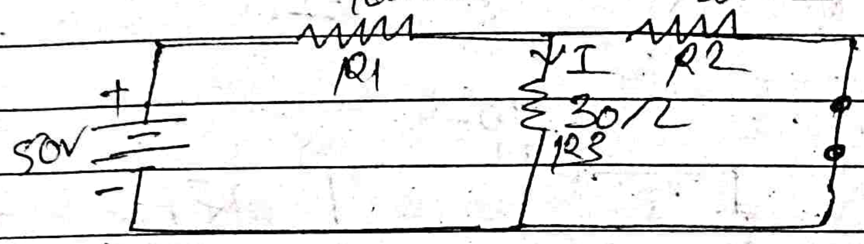
(iii) Repeat this process for other source at a time.

(iv) Finally calculate the algebraic sum of all the currents that produced in each branch.

* find current I for the circuit shown by using superposition theorem:

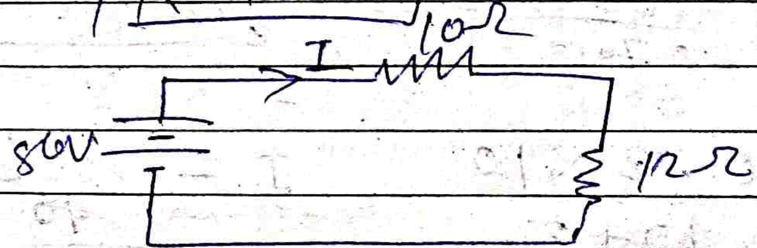


Step -1 → consider one source 50 V at a time



$R = \frac{R2 \times R3}{R2 + R3} = R = \frac{30 \times 20}{50} = \frac{600}{50} = 12$

$\boxed{R = 12\,\Omega}$



$R_s = 10 + 12 = 22\,\Omega$

$R_{Total} = 22\,\Omega$

from ohm law $\boxed{V = IR}$

$I = \frac{V}{R}$ $\quad I_t = \frac{50}{22}$ $\quad I_t = \frac{25}{11}$

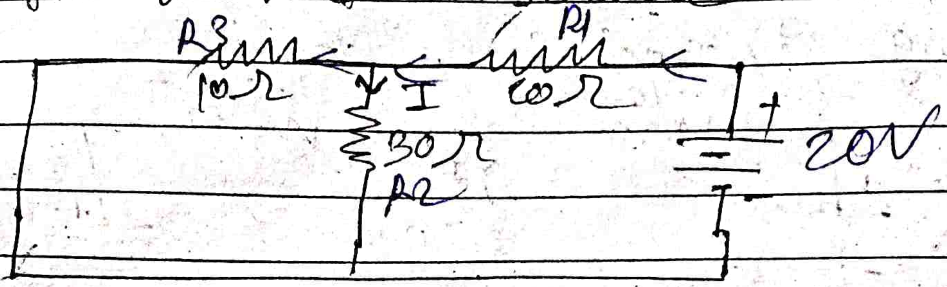
$\boxed{I_t = 2.27\,A}$

∴ from current division method

$I_1 = I_t \times$ opp. of current (resis of opp branch) / opp resis + ress of curr brach

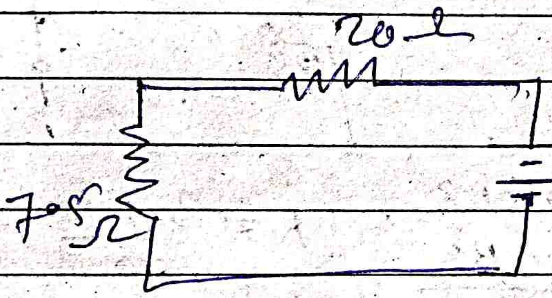
$I_1 = \frac{2.27 \times 20}{20 + 30} \Rightarrow I_1 = 0.908A$

Consider another Source 20V



$R = \frac{R3 \times R2}{R2+R3}$ $R = \frac{30 \times 10}{40} = \frac{30\cancel{0}}{4\cancel{0}}$

$R = \frac{15}{2}$ $R = 7.5\Omega$



$R_T = 20 + 7.5$

$\boxed{R_t = 27.5\Omega}$

$I_t = \frac{20}{27.5}\Omega$ $= \boxed{I_t = 0.72A}$

$I = \frac{0.72 \times 10}{10+30}$ $I = \frac{\cancel{7.2}}{\cancel{40}}$

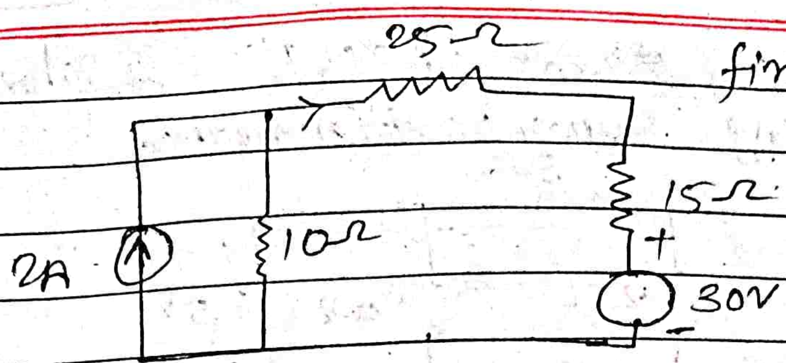
$\boxed{I_2 = 0.18 A}$

total current flow from I

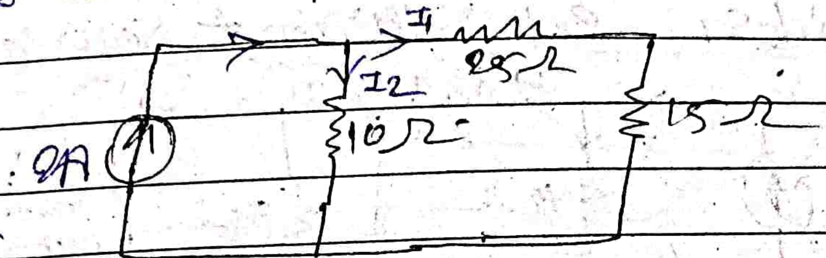
$I = I_1 + I_2 \Rightarrow I = 0.18 + 0.908$

$\boxed{I = 1.088A}$

* find current from 25Ω resistance



consider ~~2A~~ C. source

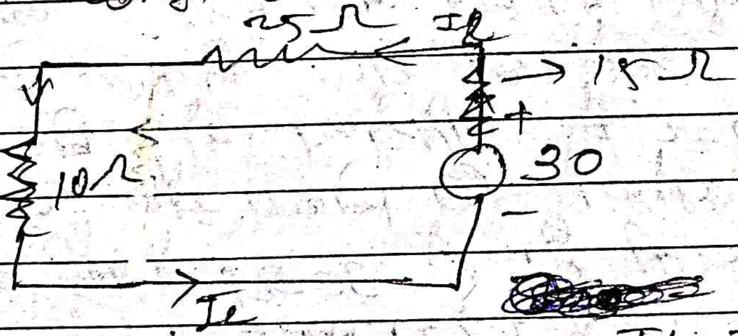


current division rule

$I_T = 2A$

$I_1 = \frac{2 \times 10}{10 + 40}$, $I_1 = \frac{20}{50}$ $\boxed{I_1 = 0.4A}$ $(\rightarrow)$

again consider 30 V source



$R_T = 50\Omega$

$I_t = \frac{30}{50}$ $\boxed{I_t = 0.6}$

$\boxed{I_{25} = 0.6 \leftarrow}$

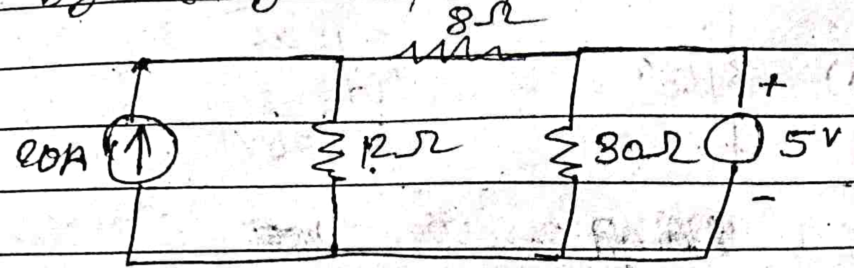
$I = I_{25} - I_1$

$I_{25} = I_2 - I_1$

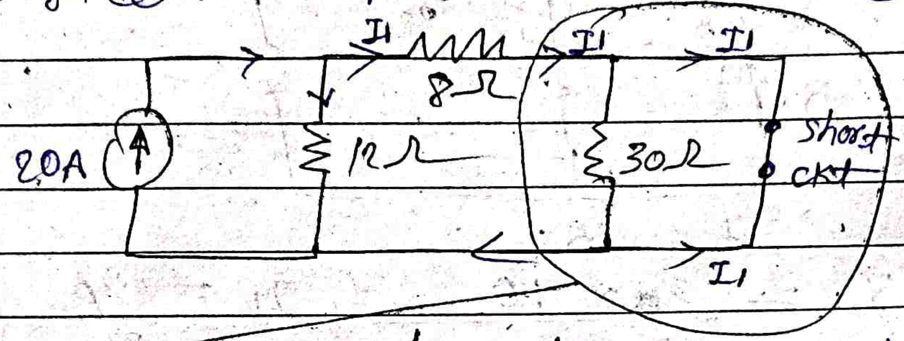
$I_{25} = 0.6 - 0.4$

$\boxed{I_{25} = 0.4 (\leftarrow)}$

* find the current through 8 ohm resist by using super position method

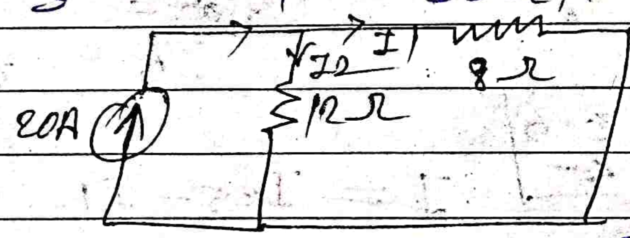


Step-1 → Consider 20A current source



dummy branch

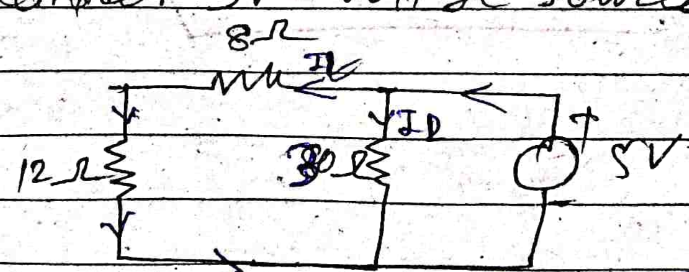
30Ω प्रतिरोध वाले से को धारा प्रवाहित नही होगा क्योंकि जो short ckt है उससे ही धारा निकल जाएगी बिना 30Ω के प्रतिरोध से निकले बिना क्योंकि धारा हमेशा सिधा और आसान मार्ग चुनती है। तो 30ΩR से कोई धारा नही जाएगी



$$\boxed{I_x = \frac{I_t \times \text{opp resist}}{\text{opp resist} + \text{resist of currents}}}$$

$I_1 = \dfrac{20 \times 12}{12+8}$ $I_1 = \dfrac{240}{20}$ $\boxed{I_1 = 12A}$ (→)

Step-2 → Consider 5V voltage source



$R_t = \dfrac{20 \times 30}{20+30}$ $R_t = \dfrac{600}{50}$ $\boxed{R_t = 12\Omega}$

$\boxed{I_t = \dfrac{5}{12}}$ $I_t = 0.416$

by current divi rule

$$I_2 = \frac{I_t \times \text{reff of opp b}}{\text{reff of opp b} + \text{reff of curr b}}$$

~~$I_2 = \frac{12 \times 30}{30+20}$ $I_2 = \frac{360}{50}$ $I_2 = 6.12$~~

$$I_2 = \frac{0.416 \times 30}{30+20} \qquad I_2 = \frac{12.48}{50}$$

$$\boxed{I_2 = 0.249A} \; (\leftarrow)$$

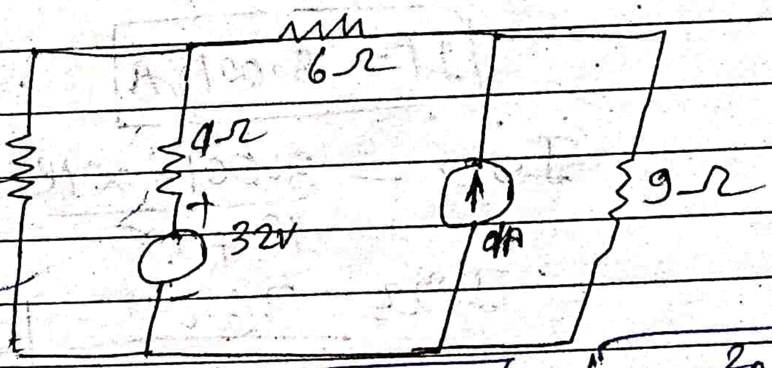
$I_{8\Omega} = I_1 - I_3$

$I_{8\Omega} = 12 - 0.249$

$\boxed{I_{8\Omega} = 11.751A}$ $(\rightarrow)$

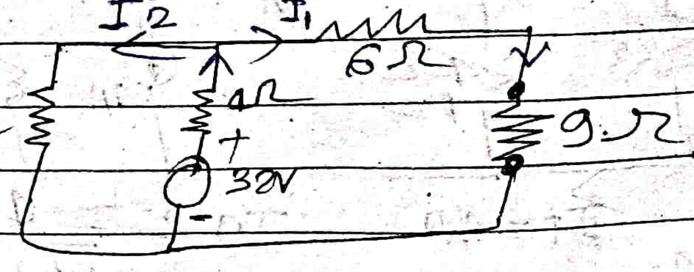
* find the power dissipated across 9 ohm resistance by using superposition theorem

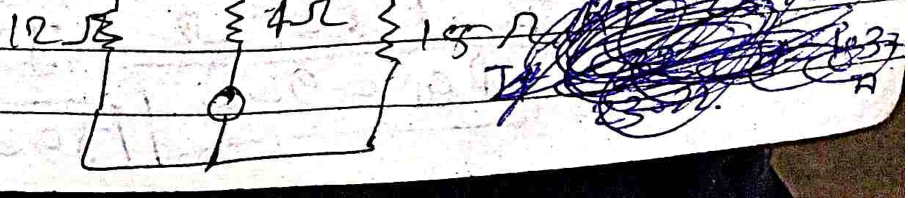
ans →

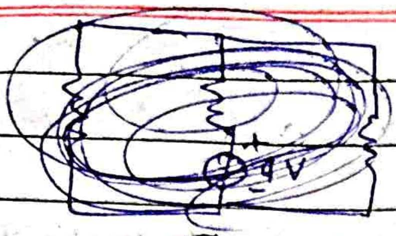


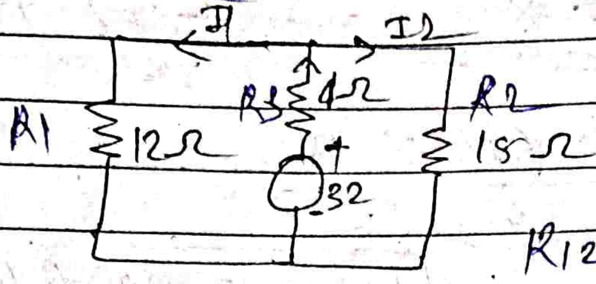
∴ $\boxed{P = VI}$, $\boxed{P = I^2R}$

Consider 32 V voltage source



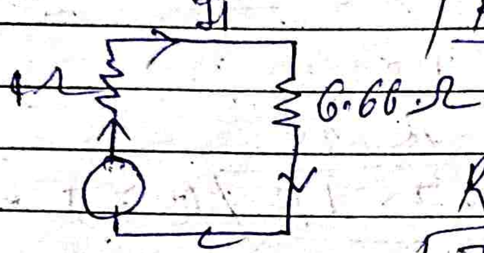






$$R_{12} = \frac{12 \times 18}{12+18}$$

$$\boxed{R_{12} = 6.66\ \Omega}$$



$$R_T = 6.66 + 4$$

$$\boxed{R_T = 10.66\ \Omega}$$

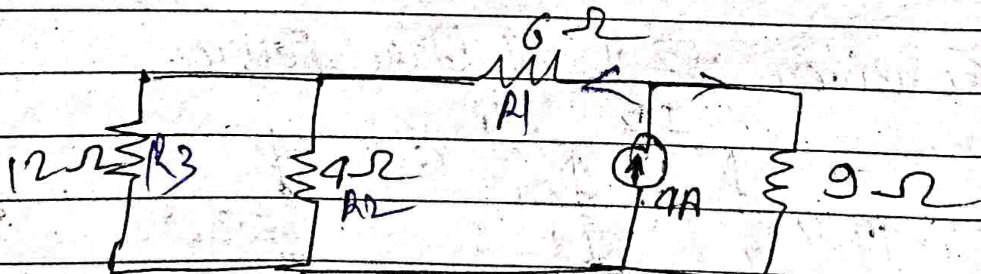
$$I_T = \cancel{10.66}\ \frac{32}{10.66}$$

$$\boxed{I_T = 3.0018A}$$

$$I_{9\Omega} = \frac{3.0018 \times 12}{12+15}$$

$$I_{9\Omega} = \frac{36.022}{27} \qquad \boxed{I_{9\Omega} = 1.33A \downarrow}$$

Consider 4A current source



$I_T = 4A$ $\qquad I_{9\Omega} = \frac{4 \times 9}{9+9}$

$R_{23} = \frac{48}{16}$ $\quad R_{23} = 3\Omega$ $\qquad I_{9\Omega} = \frac{36}{18}$

$\boxed{R_{eq} = 9\Omega}$ $\qquad \boxed{I_{9\Omega} = 2A}$ $\downarrow$

$I_{9\Omega} = 2 + 1.33A$

$\boxed{I_{9\Omega} = 3.33A}$ ↓

So power dissipated across $9\,\text{ohm}\,\Omega$

$P = I^2R$ $\quad P = (3.33)^2 \times 9$

$P = 9.99 \times 9$

$\boxed{P = 99.98\ W}$

\# obtain the power dissipation in $10\,\Omega$ resistor using

0

Hard

don't do this ↓

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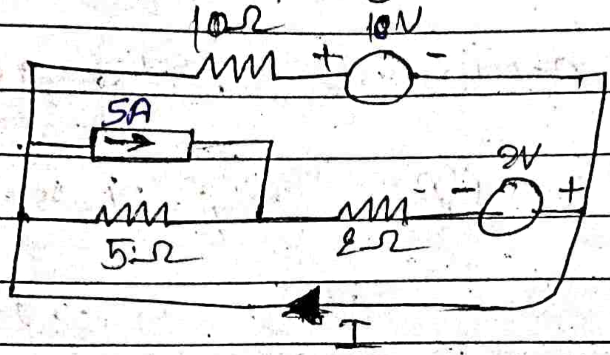
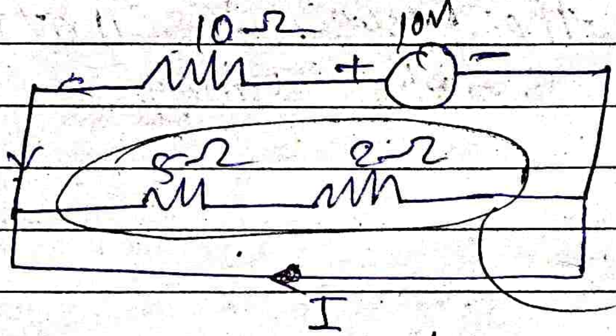
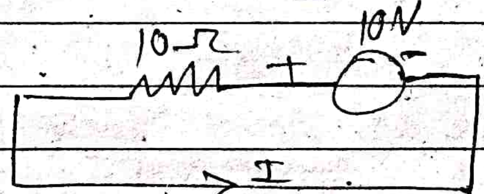
* find the current 'I' for the circuit shown below by using superposition theorem



Step-1 → Consider 10V voltage source



dummy current



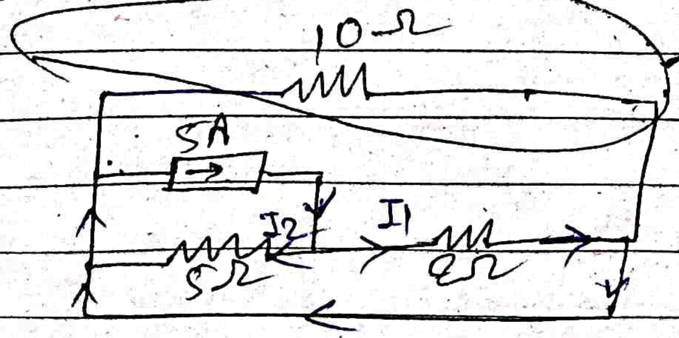
$R_T = 10 \quad I_t = \frac{10}{10}$

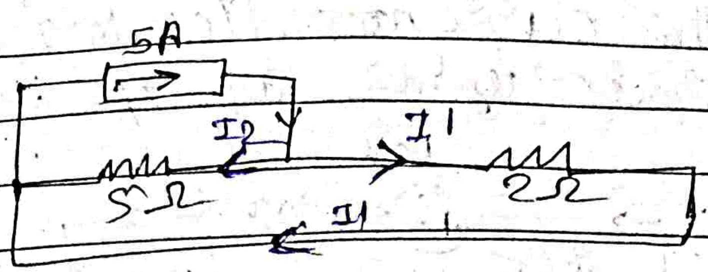
$\boxed{I_t = 1}$

$\boxed{I_1 = 1}$ (→)

Step ② Consider 5A current source

dummy current



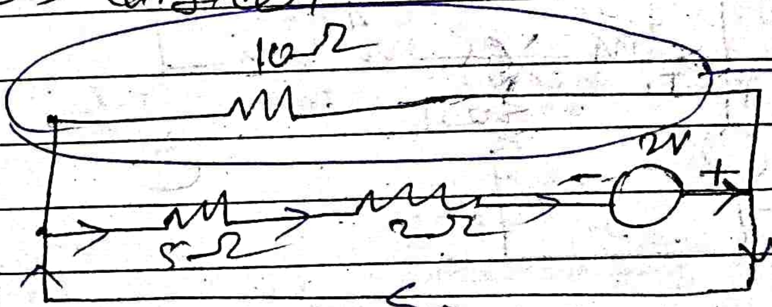


$I_T = 5A$ by current division

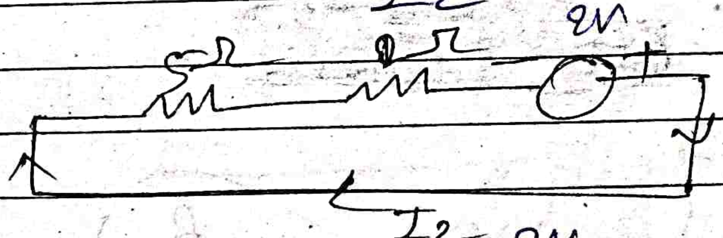
$$I_1 = \frac{5 \times 5}{5+2}$$

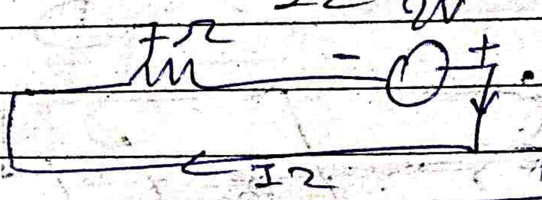
$$I_1 = \frac{25}{7} \qquad \boxed{I_1 = 3.5A}\ (\leftarrow)$$

Step-3 → Consider 2V Voltage Source



dummy current





$$I_T = \frac{2}{7} \qquad \boxed{I_T = 0.285A}$$

$$\boxed{I_2 = 0.285A}\ (\leftarrow)$$

Total current through I

$I = I' + I_1 + I_2$

$I = 3.5 + 0.28 + (1)$

$\boxed{I = 2.78A}\ (\leftarrow)$

don't do this

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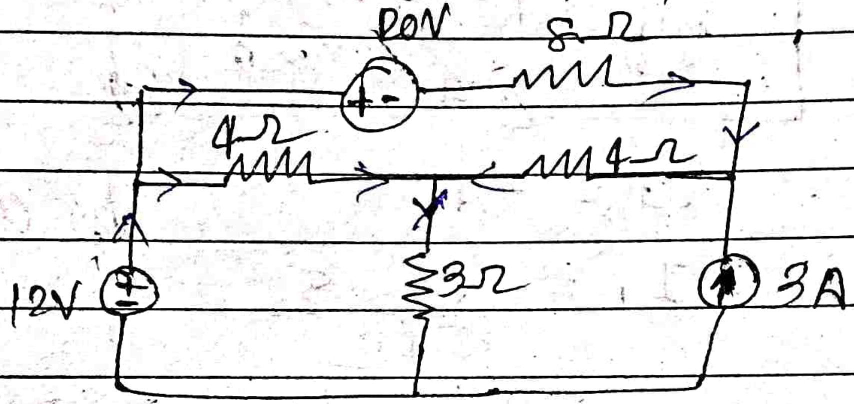
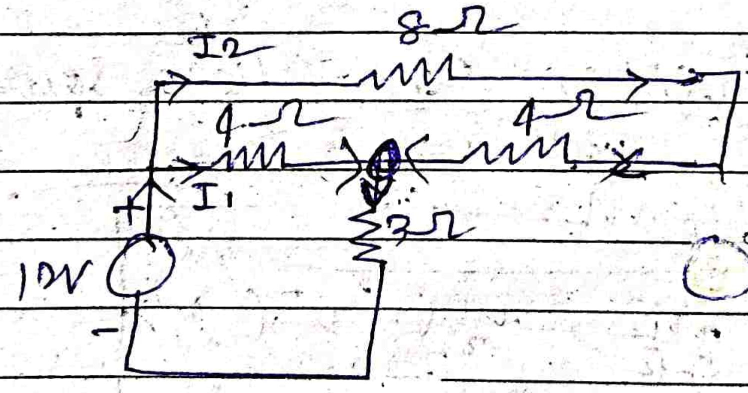
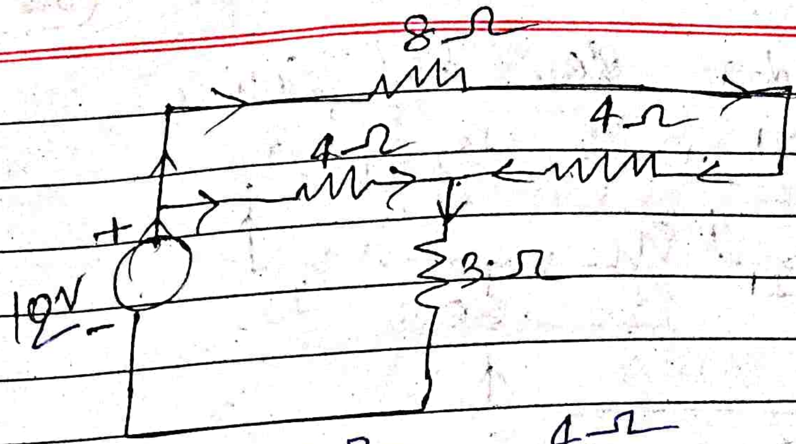
find the current flowing through 3 ohm resistor using superposition theorem

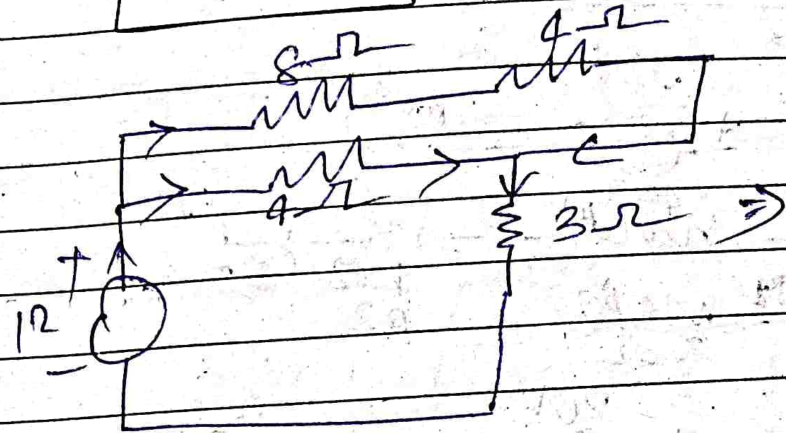
ans ⇒



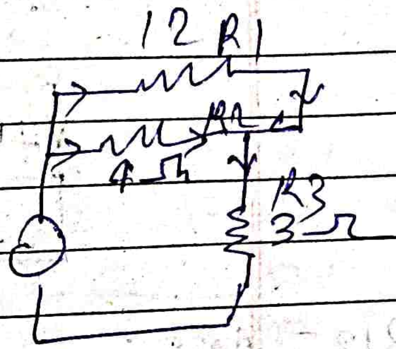
Step-1 → Consider 120V Voltage source





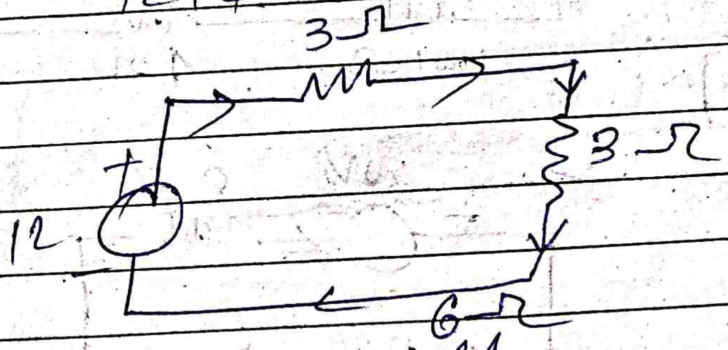


⇒

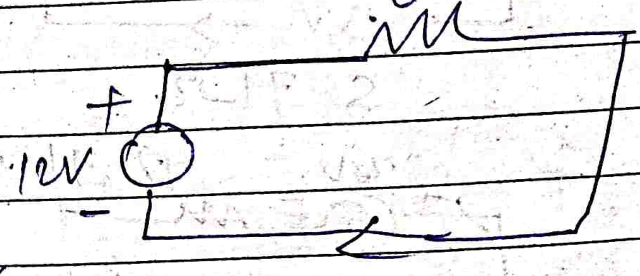


$R_{12} \Rightarrow \frac{12\times4}{12+4} = \frac{48}{16} = 3\Omega$

⇒



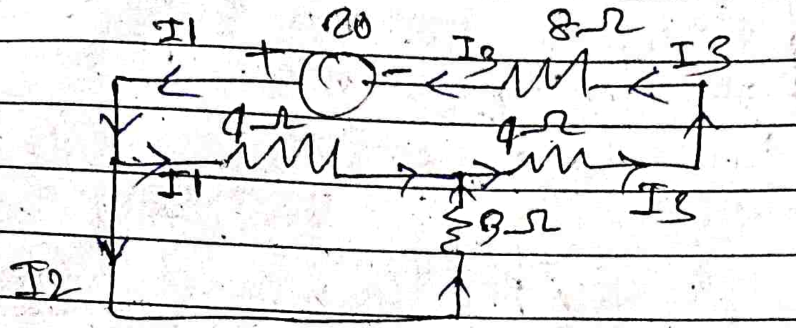
⇒

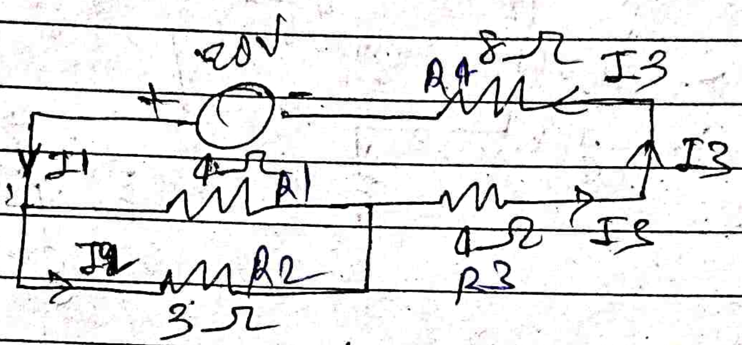


$I_T = \frac{12}{6}$ $\boxed{I_t = 2A}$

~~I_3 = 2A~~ $\boxed{I_{3\Omega} = 2A}$ ↓

Consider 20V Vol source

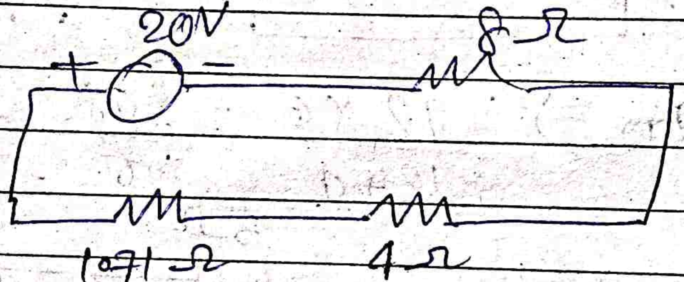


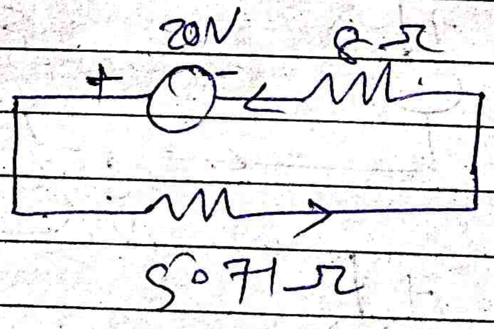


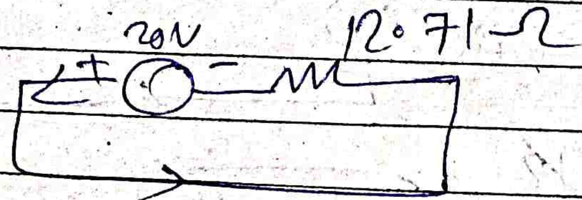
$R12 = \frac{4 \times 3}{4+3}$

$R12 = \frac{12}{7}$

$\boxed{R12 = 1.71\ \Omega}$







$I = \frac{20}{12.71}$ $\boxed{I_T = 1.57A}$

$I_3 = \frac{20}{3}$ $\boxed{I_{3_R} = 6.66A}$

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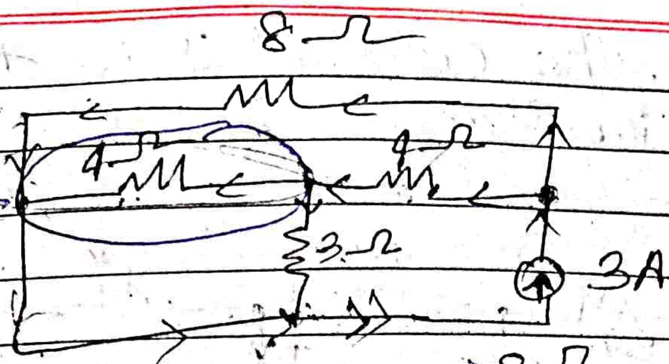
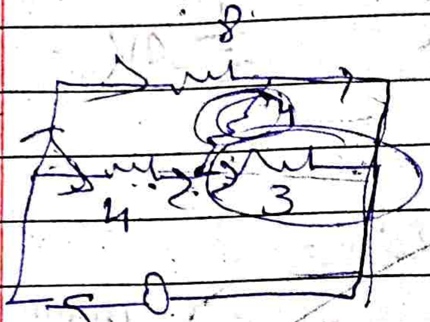
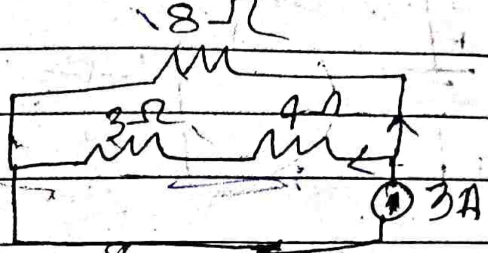
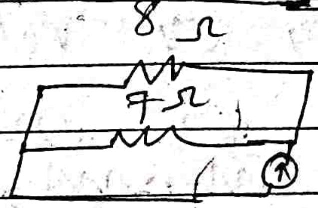
Consider 3A current source.

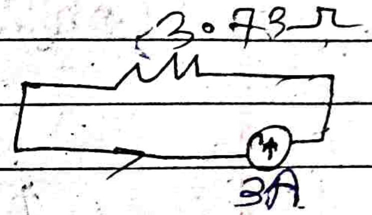
dummy current











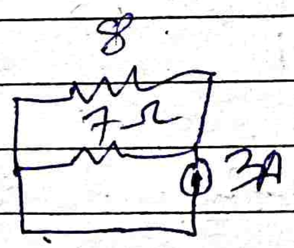
$$\rightarrow \frac{8 \times 7}{15} = \frac{56}{15} = 3.73\,\Omega$$

$V = IR$

$V = 3 \times 3.73$

$\boxed{V = 11.19\,V}$

$\boxed{I = \frac{V}{R}}$



$\frac{8 \times 7}{15} = \frac{56}{15}$

$R = 3.73$

$I = \frac{11.19}{3.73}$

$\boxed{I_{3\Omega} = \quad A}$

$\boxed{I_{3\Omega} = 3A}$ ↓

$I = \cancel{6A}\ 3A + 2A + (-6.66)$

$\boxed{I = -1.66A}$

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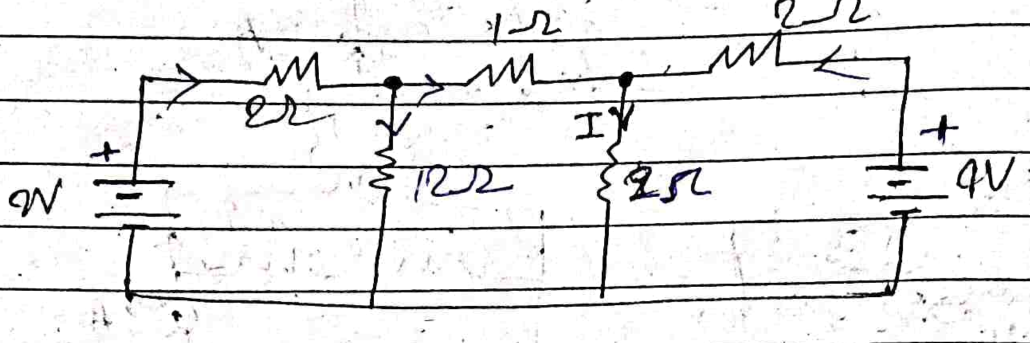
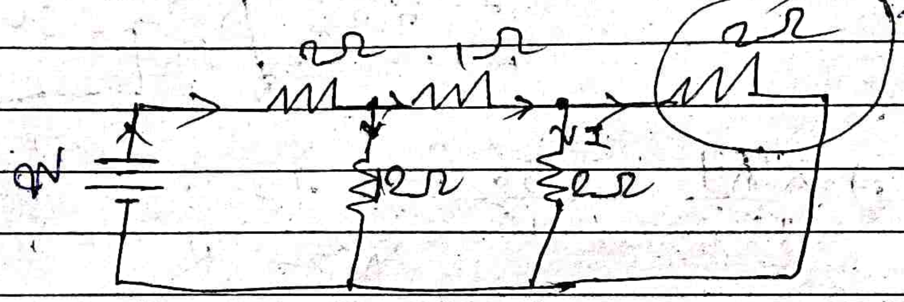
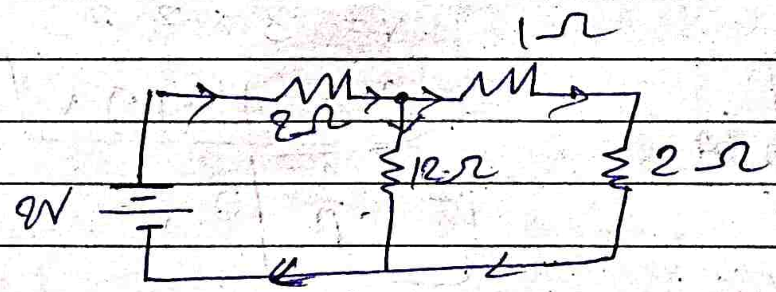
\# Calculate the current I in the circuit shown in figure 1 by using superposition theorem

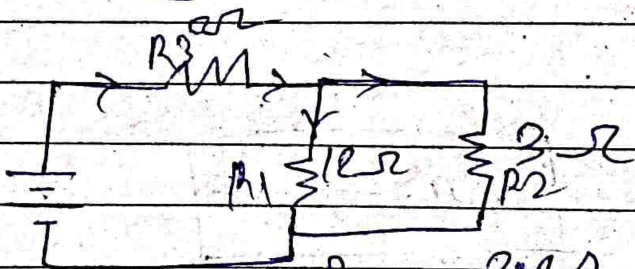


Consider 2V Vol Source



- dummy current

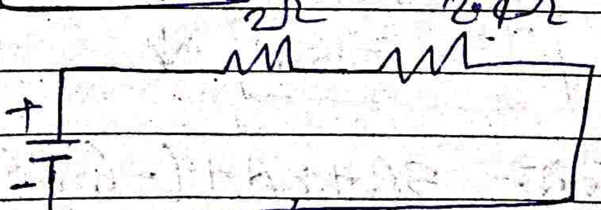


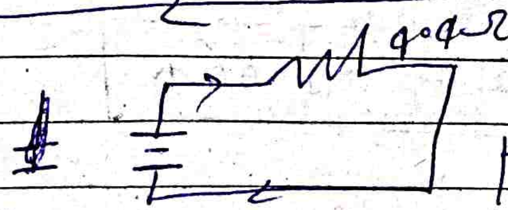


$R_{12} = \frac{12 \times 3}{15}$

$R_{12} = \frac{36}{15}$

$R_{12} = 2.4\Omega$



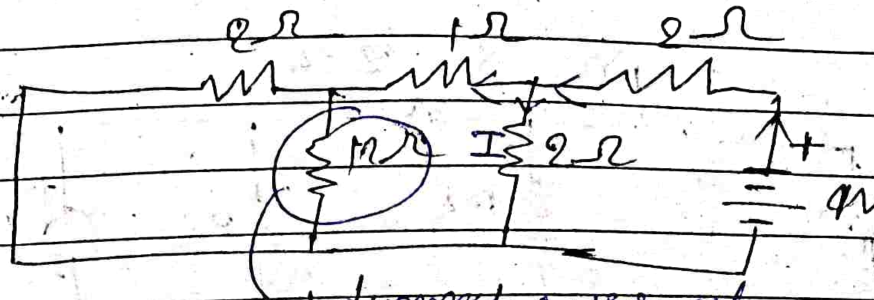


$I_L = \frac{2}{4.4}$

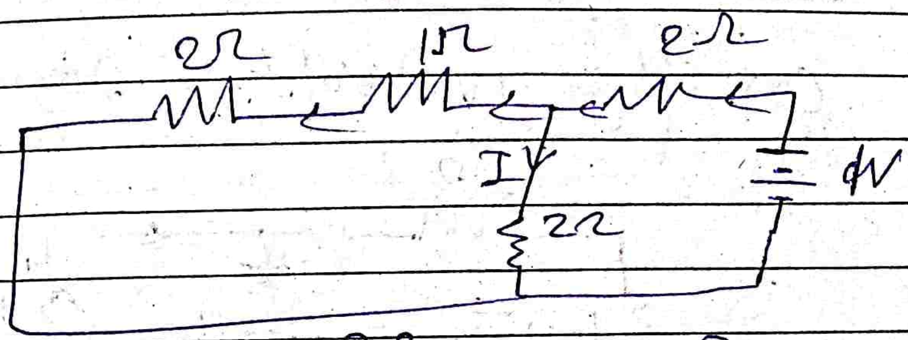
$\boxed{I_L = 0.487A}$

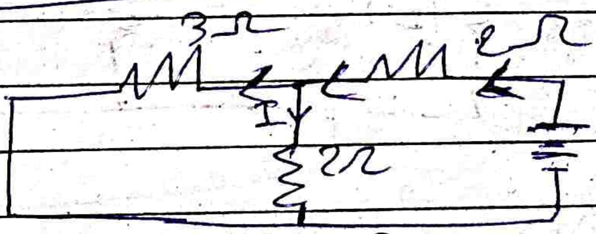
$I_2 = \frac{0.45 \times 2}{2+2}$ $I = \frac{0.9056}{4}$ $\boxed{I = 0.22A}$

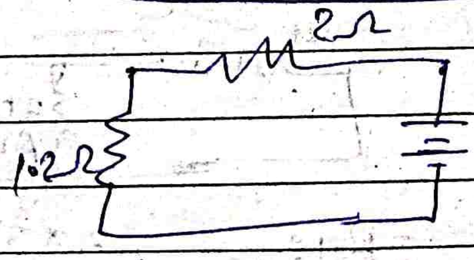
Consider 4V Vol sour

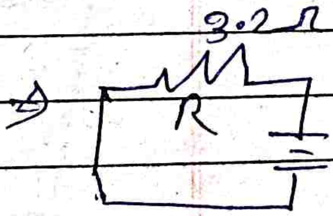


dummy current









$\frac{3R}{3+R}$

$= \frac{6}{5}$

$=$

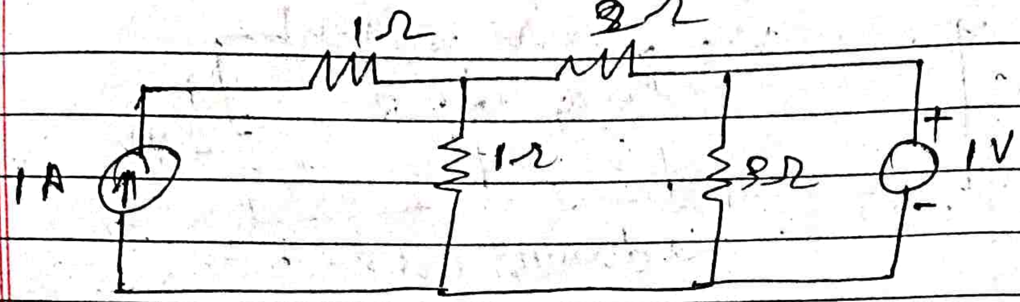
$I_t = \frac{4}{3.2}$ $\boxed{I_t = 1.25\,A}$

$I_t = \frac{1.25 \times 1}{1+2}$

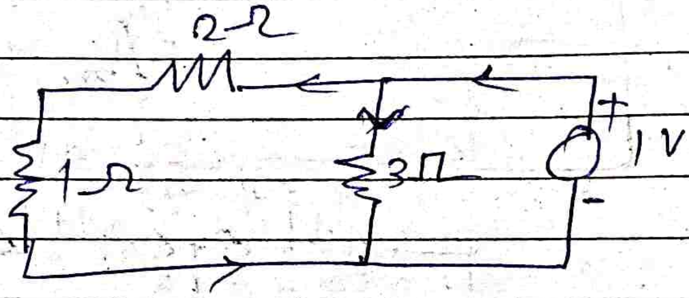
$\boxed{I = 0.416\,A}$ (↓)

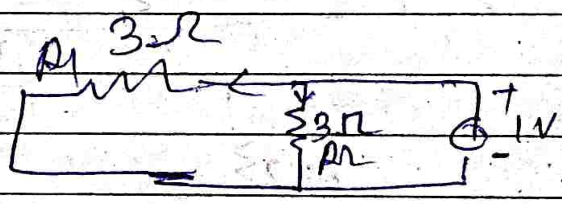
$\boxed{\text{total } I = 0.636\,A}$ (↓)

* find current through 2 Ω resistor in the circuit as shown in figure



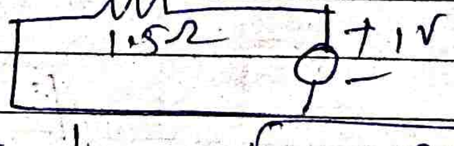
consider 1V voltage current





$$R_{12} = \frac{3 \times 3}{3+3} \Rightarrow \frac{9}{6} = \frac{3}{2}$$

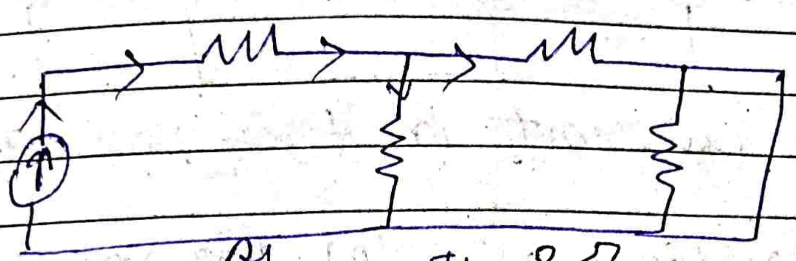
$$R_{12} = 1.5\ \Omega$$

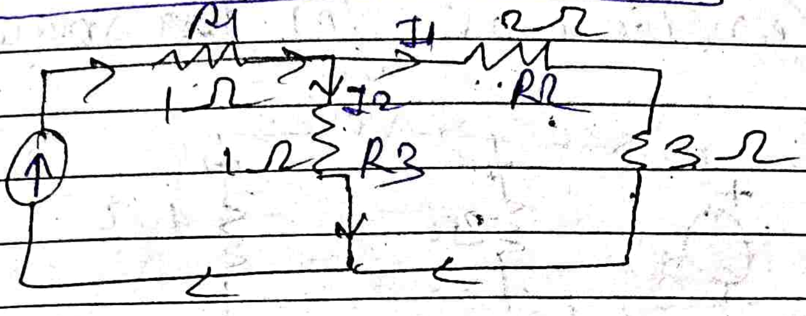


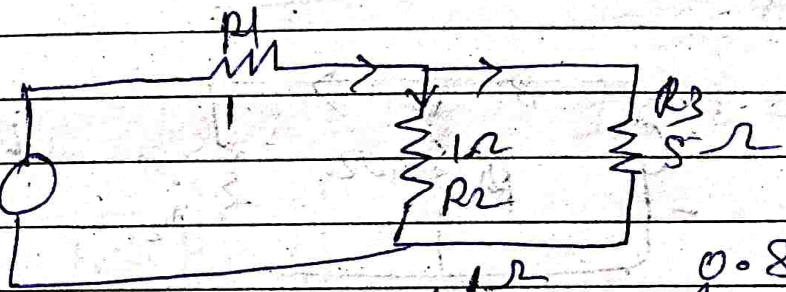
$$I_t = \frac{1}{1.5} \qquad \boxed{I_t = 0.66\,A}$$

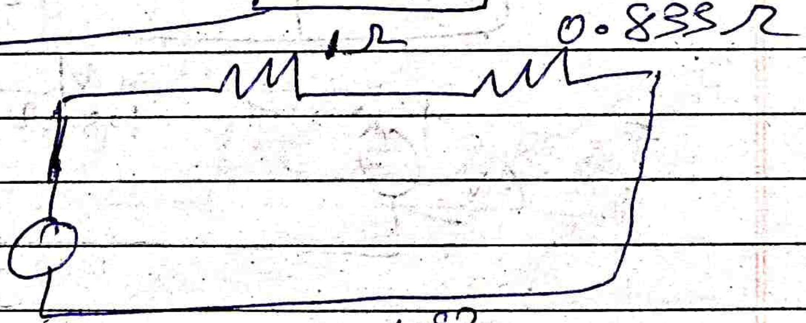
$$I_{2\Omega} = \frac{0.66 \times 3}{3+2} \qquad \boxed{I_{2\Omega} = 0.39\,A}$$

Consider 1 A current ~~voltage~~ source



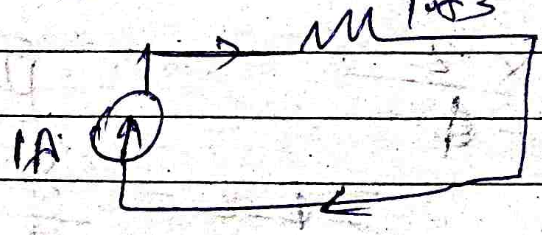






$R_{23} = \frac{5}{1+5}$

$= \frac{5}{6}$

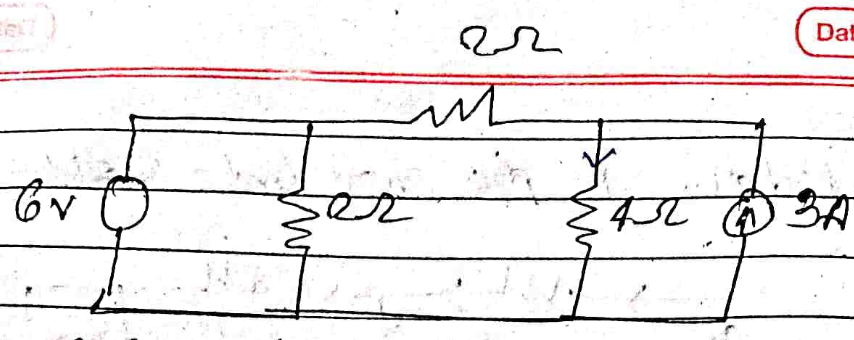


$I_1 = 1A$ $I_{2\Omega} = \frac{1 \times 1}{2+1}$ $I_{2\Omega} = \frac{1}{3}$

~~I2 = 1A~~

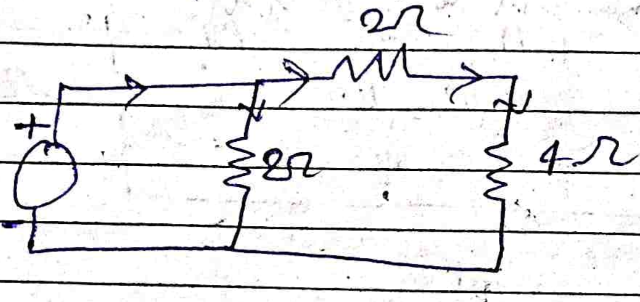
~~I = 0.6A~~ $\boxed{I_2 = 0.33\ A}$

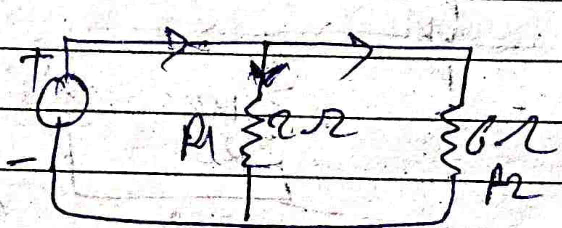
$\boxed{I = 0.06\ A}$



the current in 4 Ω resistence using sp

Consider 6V vol source

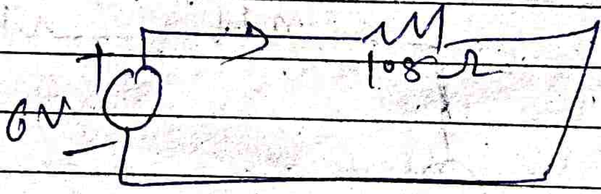




$R_{12} = \frac{6 \times 2}{6+2}$

$R_{12} = \frac{12}{8}$

=



$\boxed{R_{12} = 1.5\,\Omega}$

$I_t = \frac{6}{1.5}$

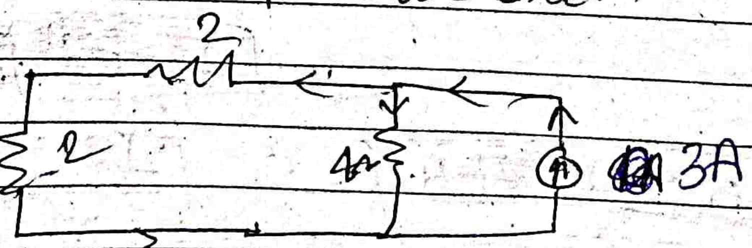
$\boxed{I_t = 4A}$

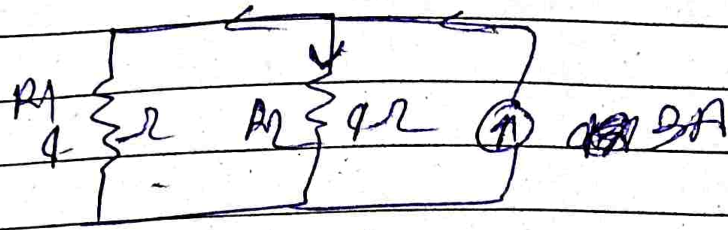
$I_{4\Omega} = \frac{4 \times 2}{2+4}$

$I_{4\Omega} = \frac{8}{6}$ ~~$I_{4\Omega} = 1A$~~ ↓

$\boxed{I_{4\Omega} = 1.33 \downarrow}$

Consider 3A current.



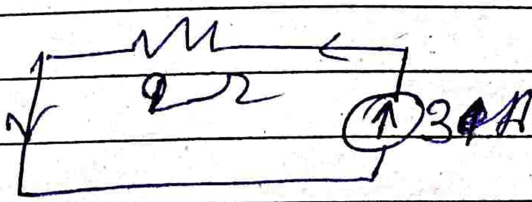


$R_{12} = \frac{4 \times 4}{4+4}$ $R_{12} = \frac{16}{8}$ $R_{12} = 2\Omega$

$V = IR$

$I = \frac{6}{2}$

$\boxed{I = 3A}$



$I_t = 4A$ $I_{4\Omega} = \frac{\cancel{3}A \times 2}{2+4}$

$I_{4\Omega} = \frac{\cancel{6}}{6}$ $I_{4\Omega} = 1$

$\boxed{I_{4\Omega} = 1.33A \downarrow}$

$I = 1 + 1.33$ $\boxed{I = 2.33A}$

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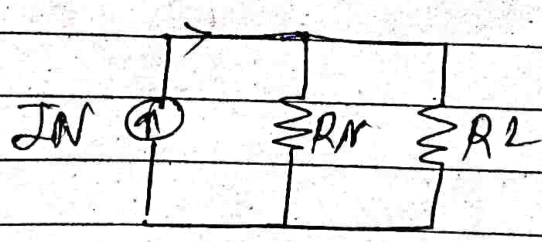
★ Norton Theorem :- Any linear network consisting a number of voltage sources and resistance can be replaced by an equivalent network having a single current source (I_N) and single resistance (R_N) and single load terminal.

Procedure

Step → (1) find Norton resistance (R_N) in order to find Norton resistance (R_N) open the load terminal and short circuit the voltage source.

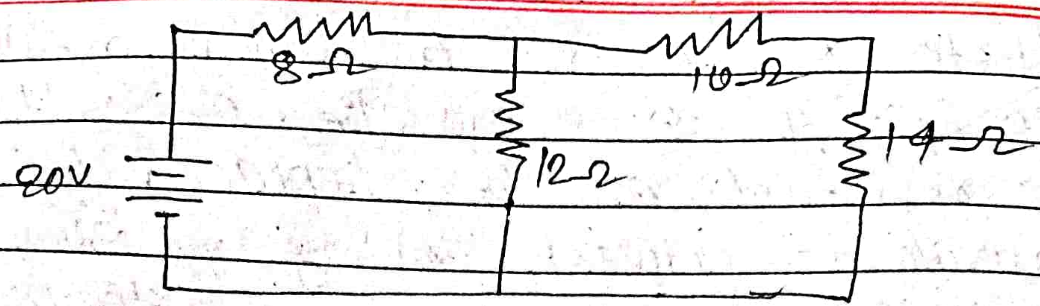
Step → (ii) find Norton current in order to find Norton current (I_n) then short the load terminal.

Step (iii) finally make a equivalent network with Norton current I_n and Norton resistance and load terminal



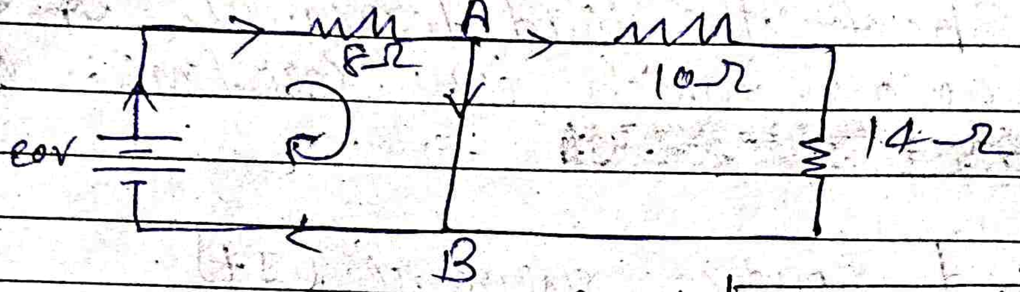
Step (iv) by using current division rule find the norton current.

Q



find current in 12Ω resistance

Step → short the load resistance



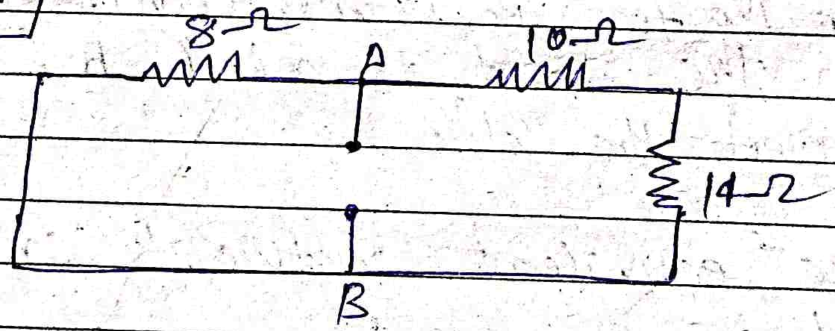
$IN = \frac{V}{R}$

$IN = \frac{20}{8}$

$\boxed{IN = 2.5A}$

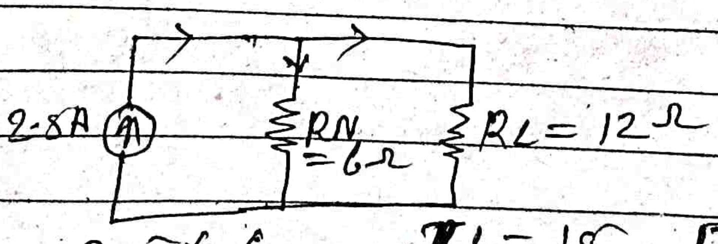
To find $\boxed{IL = \frac{IN \times RN}{RN + RL}}$

$\boxed{RL = 12\Omega}$



$RN = (24 \| 8)$ $RN = \frac{24 \times 8}{24 + 8}$ $RN = \frac{192}{32}$

$\boxed{RN = 6\Omega}$



$IL = \frac{2.5 \times 6}{6 + 12}$ $IL = \frac{15}{18}$ $\boxed{IL = 0.833A}$

find current from 2Ω resistance

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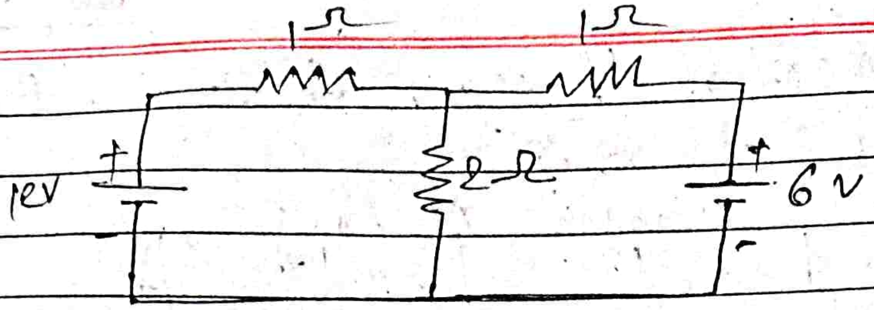
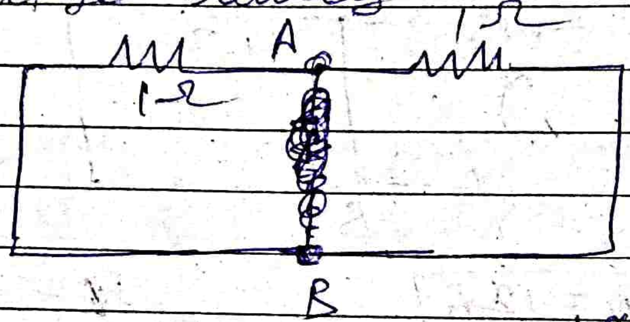
PYQ



Step 1 → To find R_N

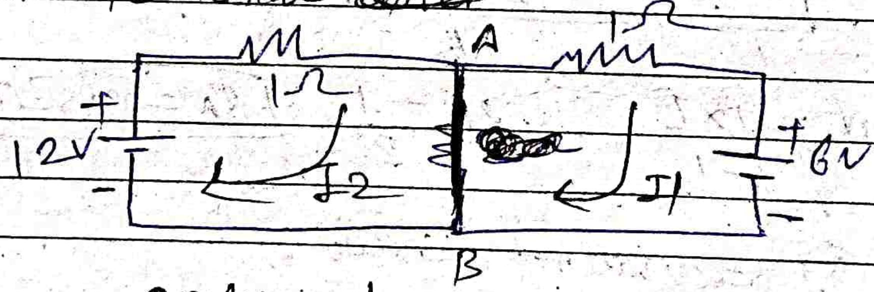
Open the load terminal and short the voltage sources



$R_N = \frac{1\times1}{1+1}$ $R_N = \frac{1}{2}$

$\boxed{R_N = 0.5\,\Omega}$

Step-2 To find I_N short the load terminal



apply KVL

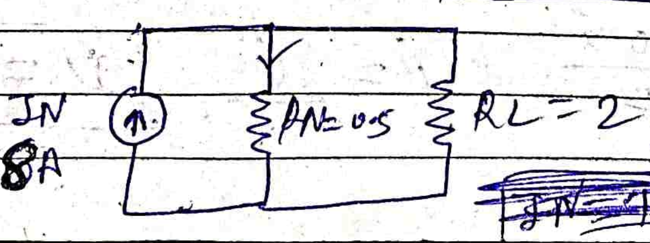
$\boxed{I_1 = -6A}$ (↑)

~~$I_2 = 12$~~

$\boxed{I_2 = 12A}$ (↓)

$I_N = 12 - (-6)$ ↓

$\boxed{I_N = 18}$ ↓



$I_N = \frac{18 \times 0.5}{0.5 + 2}$

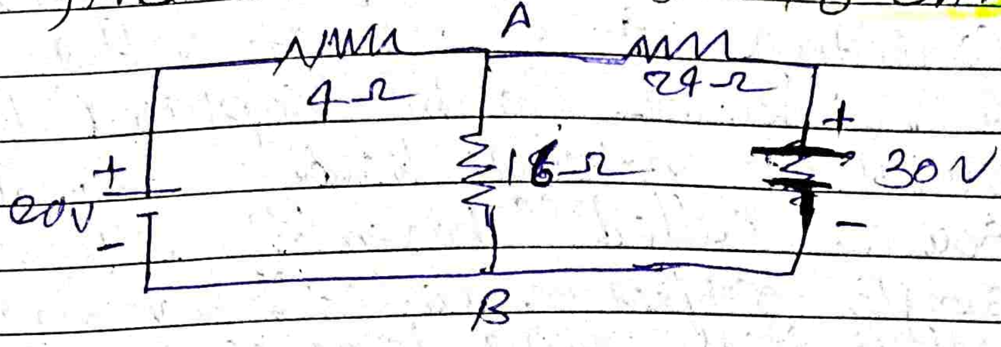
$I_N = \frac{9}{2.5}$

~~$I_N = 4.2A$~~

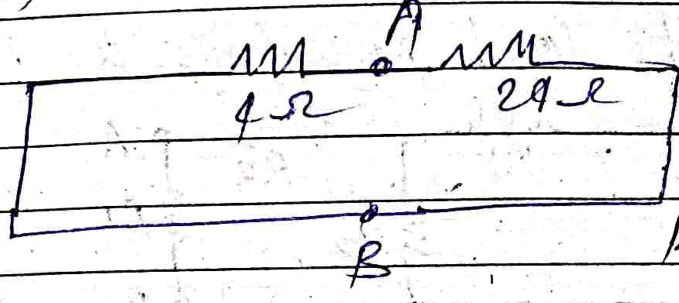
$\boxed{I_N = 3.6}$ ↓

F
12

Q7 find current through 16 ohms



Step 1) find RN

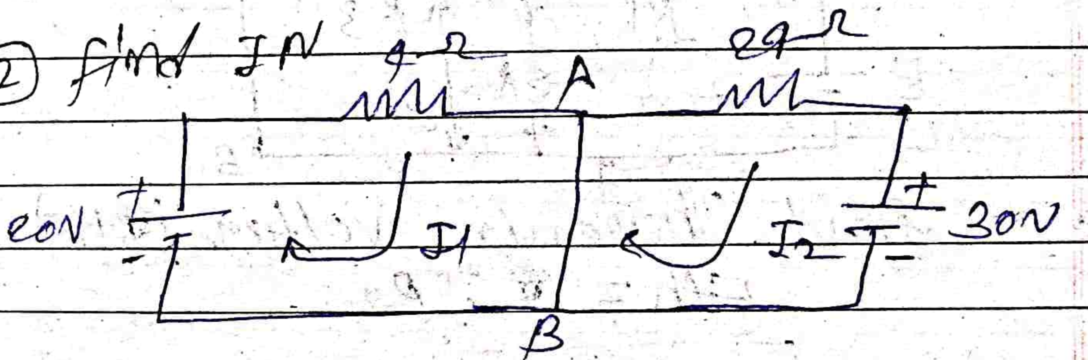


$RN = \frac{4 \times 24}{4 + 24}$

$RN = \frac{96}{28}$

$\boxed{RN = 3.42\ \Omega}$

Step ② find IN



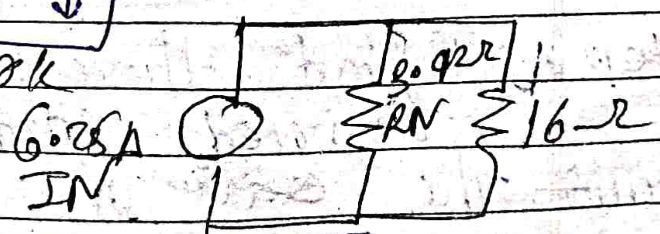
$4 I1 = 20V$, $24 I_2 = -30$

$\boxed{I1 = 5A} \downarrow$ $\quad I_2 = -\frac{30}{24}$ $\quad \boxed{I_2 = -1.25 A}$

$IN = (5A)\downarrow - (-1.25 A)\uparrow$

$\boxed{IN = 6.25 A \downarrow}$

Step ③ equivalent network



Step ④

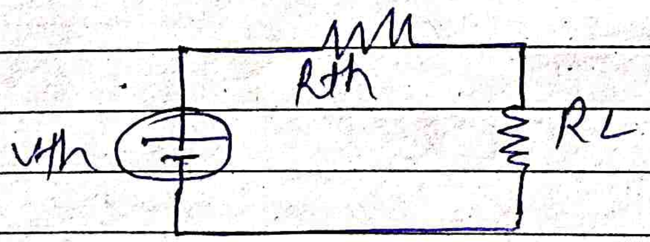
$IN = \frac{6.25 \times 3.42}{3.42 + 16}$ $\quad \boxed{IN = 1.10A} \downarrow$

* Thevenin theorem :- Any linear network consisting a number of voltage source and resistance can be replaced by an equivalent network having a single voltage source and a single resistance and a single load terminal.

Step-1 → find Rth, To find Rth ~~remove~~ open the load resistance and short circuit the voltage source.

Step-2 → find Vth, To find Vth open the load terminal.

Step-3 → Make equivalent Network with Vth and Rth and load terminal



Step-4 → find Ith with the help of current division rule.

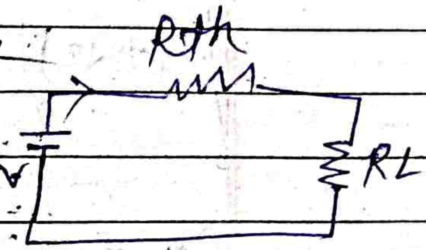
~~Rth = R1+R2 || R3~~

$Rth = R1 || R2 + R3$

$$Rth = \frac{R1R2}{R1+R2} + R3$$

$$\boxed{Rth = \frac{R1R2}{R1+R2} + R3} \quad \text{— (B)}$$

Step-4 → find load current



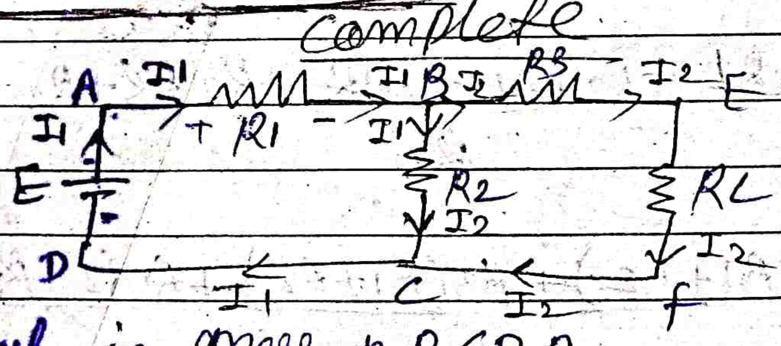
$$\boxed{IL = \frac{Eth}{Rth + RL}}$$

from Eq (A) & (B)

$$\boxed{IL = \frac{\dfrac{ER2}{R1+R2}}{\left(\dfrac{R1R2}{R1+R2} + R3\right) + RL}}$$

complete

proof



apply kvl in mess ABCDA

$I1R1 + I1R2 - I2R2 = E \Rightarrow I1(R1+R2) - I2R2 = E$

again apply kvl in mess BEFCB

$I2R3 + I2RL + I2R2 - I1R2 = 0$

$I2(R3 + RL + R2) - I1R2 = 0$ — (B)

$$\boxed{I1 = \frac{I2(RL + R2 + R3)}{R2}} \quad \text{— (C)}$$

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$$I_1(R_1+R_2) - I_2R_2 = E \quad \text{—— (A)}$$

$$\frac{I_2(R_L+R_2+R_3)}{R_2}R_1+R_2 - I_2R_2 = E$$

$$\left[(R_1+R_2)\frac{(R_L+R_2+R_3)I_2}{R_2}\right] - I_2R_2 = E$$

$$\left[(R_1+R_2)\frac{R_L+R_2+R_3}{R_2} - R_2\right]I_2 = E$$

$$\frac{R_1R_L+R_1R_2+R_1R_3+R_2R_L+R_2R_2+R_2R_3 - R_2}{R_2} = E$$

$$\cancel{\left[\frac{R_1R_2+R_2(R_1+R_L)+R_3(R_1+R_2)+R_2^2-R_2^2}{R_2}\right]} = E$$

$$\cancel{R_1R_2+R_3(R_1+R_2)}+R$$

$$\left[\frac{R_1+R_L+R_2+R_L+R_1R_3+R_2R_3+R_2^2+R_1R_2-R_2^2}{R_2}\right]I_2 = E$$

$$\left[\frac{R_L(R_1+R_2)+R_3(R_1+R_2)+R_1R_2+\cancel{R_2^2}-\cancel{R_2^2}}{R_2}\right]I_2 = E$$

$$\left[R_1R_2+R_3(R_1+R_2)+R_L(R_1+R_2)\right]I_2 = ER_2$$

$$I_2 = \frac{ER_2}{R_1R_2+R_3(R_1+R_2)+R_L(R_1+R_2)}$$

Dividing numerator & denominator by (R_1+R_2) we get

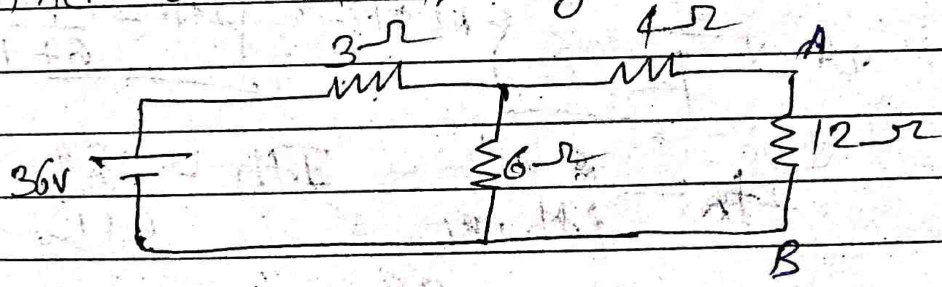
$$I2 = \frac{\dfrac{ER2}{R1+R2}}{\left(\dfrac{R1R2}{R1+R2}+R3\right)+R2}$$

$$\boxed{I2 = IL}$$

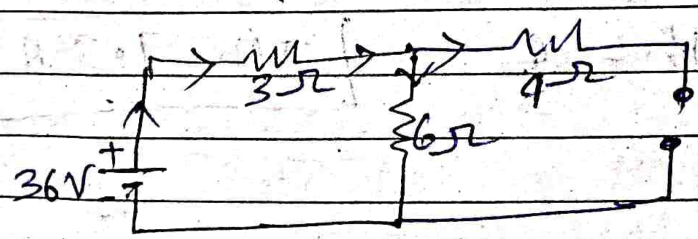
$$\boxed{IL = \frac{\dfrac{ER2}{R1+R2}}{\left(\dfrac{R1R2}{R1+R2}+R3\right)+RL}}$$ proooved

Thevenin theorem

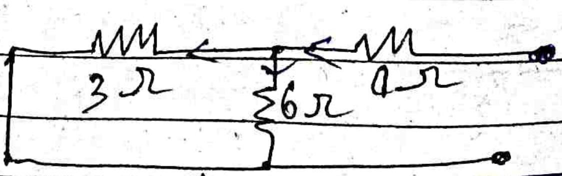
* find current through 12Ω



Step 1 → Remove the load resistance

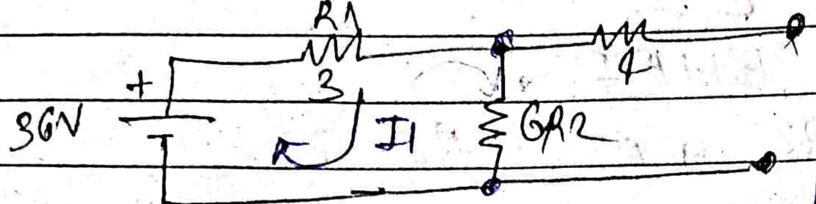


Step 2 → find equ Rth
(i) voltage source → S.C
(ii) Current so → O.C



Rth = (3||6) + 4 $\boxed{Rth = 6\Omega}$

Step 3 → find Thevenin equ voltage



$9I_1 - 36 = 0$

$I_1 = \frac{36}{9}$

$\boxed{I_1 = 4A}$

$V_{th} = 4 \times 6$

$\boxed{V_{th} = 24V}$

$V = 36$, $R_{12} = 3 + 6$

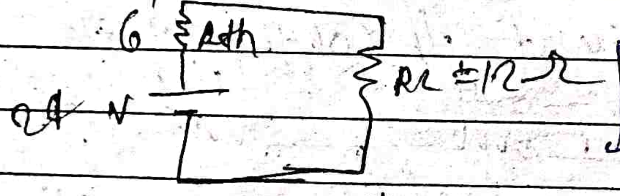
$R = 9\Omega$

$I' = \frac{36}{9}$ $\boxed{I' = 4\Omega}$

$V_{th} = 4\Omega \times 6$

$\boxed{V_{th} = 24V}$

Step-4 equivalent circuit



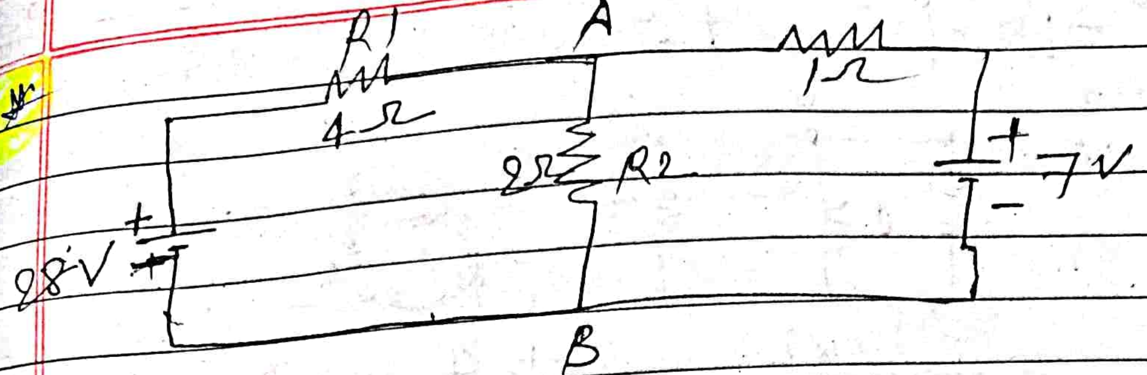
$\boxed{I_{th} = \frac{4 \times 6}{6 + 12} = \frac{24}{18}}$

$I_{th} = \frac{V_{th}}{R_{th} + R_L}$ $I_{th} = \frac{24}{6+12}$

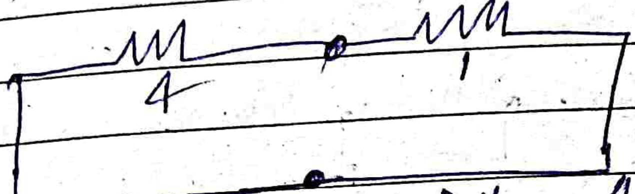
$I_{th} = \frac{24}{18}$ $I_{th} = \frac{8}{6}$

$I_{th} = \frac{4}{3}$ $\boxed{I_{th} = 1.33A}$

find current accross AB

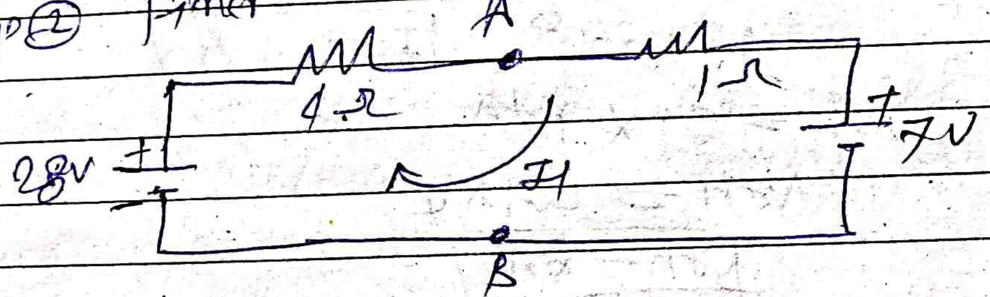


Step ① find Rth



$Rth = \frac{4 \times 1}{4+1}$ $\quad Rth = \frac{4}{5}$ $\quad \boxed{Rth = 0.8\,\Omega}$

Step ② find Vth



KVL

$$5I_1 + 7 - 28 = 0$$

$$5I_1 = 21 \qquad I_1 = \frac{21}{5} \qquad \boxed{I_1 = 4.2\,A}$$

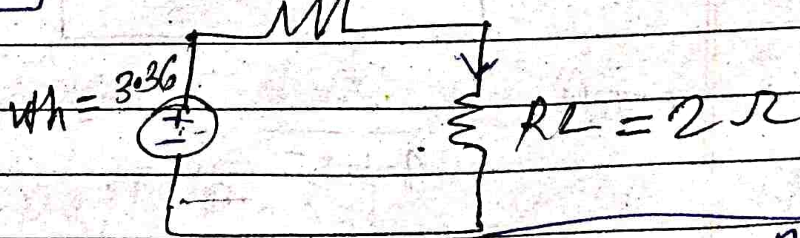
$V = IR$

$Vth = 4.2 \times 0.8$

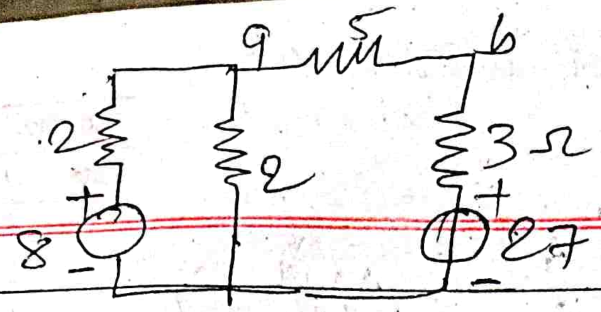
$\boxed{Vth = 3.36\,V}$

$Rth = 0.8\,\Omega$

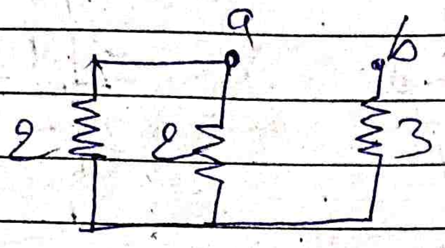
Step ③



$$Ith = \frac{4.2 \times 0.8}{0.8+2} \qquad Ith = \frac{3.36}{2.8} \qquad \boxed{Ith = 1.2\,A}$$



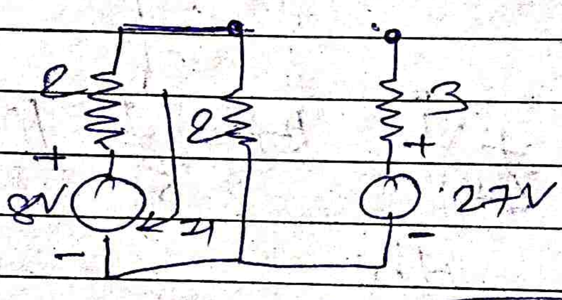
find Rth →



$3 + \frac{2 \times 2}{2+2}$ $\quad 3 + \frac{4}{4} = 4$

$\boxed{Rth = 4\Omega}$

find Vth →

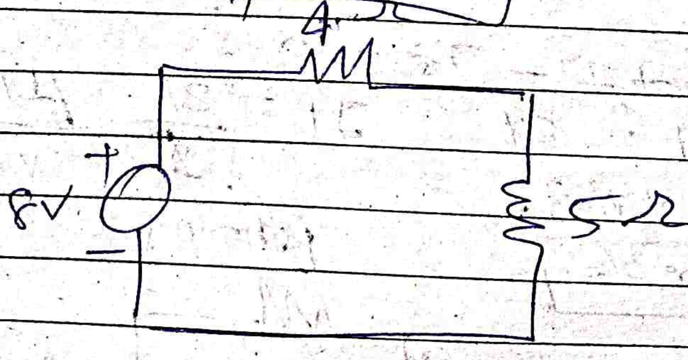


$4I_1 = 8$ $\quad \boxed{I_1 = 2A}$

$Vth = I_1 \times Rth$

$Vth = 2A \times 4$

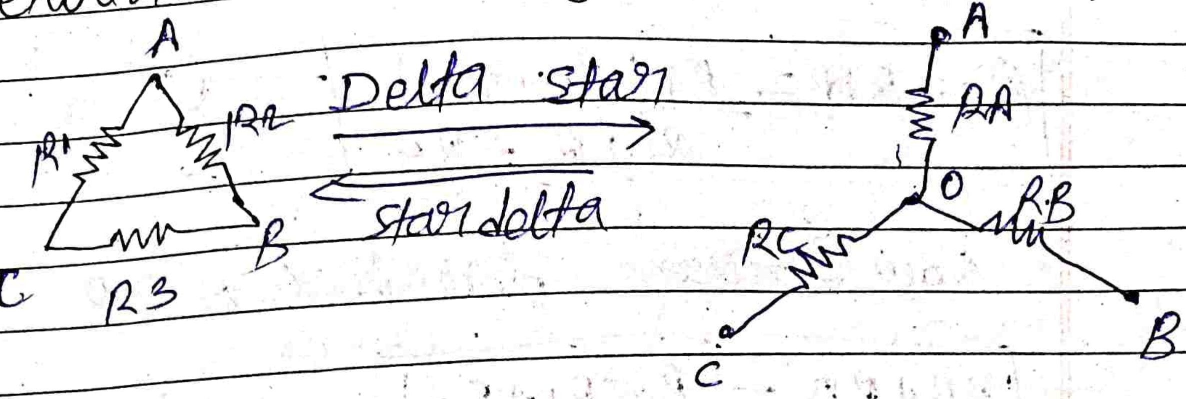
$\boxed{Vth = 8V}$



$Ith = \frac{8}{4+5}$ $\quad Ith = \frac{8}{9}$

$Ith =$

* Network Reduction by Δ : star transformation



* Delta
3 R connected nose to tell are said to be delta or mess connected

* 3R connected together at a common point O are said to be stare or delta connected

* Replacement of delta or mess equivalent star system is known as delta star transformation

The two systems will be equivalent if the resistances measure between any pair of line is same in both of the system and third line is open

* Resistances between terminals B & C in Δ

$$R_{BC} = R_3 \| (R_1+R_2) = \frac{R_3(R_1+R_2)}{R_1+R_2+R_3}$$

for star → $R_{BC} = R_B + R_C$

$$\boxed{R_B + R_C = \frac{R_3(R_1+R_2)}{R_1+R_2+R_3}} \quad \text{--- (1)}$$

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between terminal C & A

$$\boxed{R_C + R_A = \frac{R_1(R_2+R_3)}{R_1+R_2+R_3}} \quad (2)$$

Now between terminal A & B

$$\boxed{R_A + R_B = \frac{R_2(R_1+R_3)}{R_1+R_2+R_3}} \quad (3)$$

from eqn (1), (2) & (3) add 1+2+3

we have

$$2(R_A + R_B + R_C) = \frac{2(R_1R_3 + R_2R_3 + R_1R_2)}{R_1+R_2+R_3}$$

~~$R_A + R_B + R_C = R_1R_3$~~

$$\boxed{R_A + R_B + R_C = \frac{R_1R_3 + R_2R_3 + R_1R_2}{R_1+R_2+R_3}} \quad (4)$$

subtract (1) (2) (3) from 4

(4) − (1)

$$\boxed{R_A = \frac{R_1R_2}{R_1+R_2+R_3}} \quad (5)$$

① − ②

$$RB = \frac{\cancel{R1R2} + \cancel{R1R3} + \cancel{R1R3} + R2R3 + \cancel{R1R2}}{R1+R2+R3}$$

$$RB = \frac{+\ R2R3}{R1+R2}$$

$$\boxed{RB = \frac{R2R3}{R1+R2}} \quad ⑥$$

① − ③

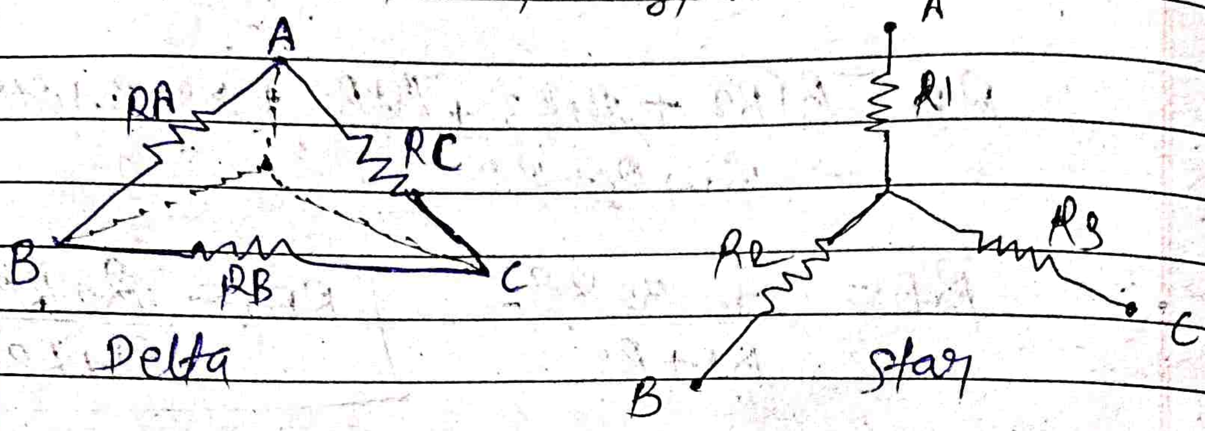
$$RC = \frac{R1R3 + R2R3 + R1R2}{R1+R2+R3} - \frac{R1R2 - R1R3}{R1+R2+R3}$$

$$RC = \frac{\cancel{R1R3} + R2R3 + \cancel{R1R2} - \cancel{R1R2} - \cancel{R1R3}}{R1+R2+R3}$$

$$\boxed{RC = \frac{R2R3}{R1+R2+R3}} \quad ⑦$$

* Delta to star transformation

Sol^n :-



equivalent resistance between A & B

$RA \| (RB+RC)$

$\Rightarrow \dfrac{RA(RB+RC)}{RA+RB+RC}$ —— (1)

Similarly equ resi b/w B & C

$RB \| (RA+RC) \Rightarrow \dfrac{RB(RA+RC)}{RA+RB+RC}$ —— (2)

equva resis b/w C & A

$RC \| (RA+RB) \Rightarrow \dfrac{RC(RA+RB)}{RA+RB+RC}$ —— (3)

Eq val resis b/w A & B in star

$R1+R2$ —— (4)

Similarly eq resi b/w BC

$R2+R3$ —— (5)

equ resi b/w CA

$R3+R1$ —— (6)

Equ^n (1) & (4) equate

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$$\frac{RA(RB+RC)}{RA+RB+RC} = R1+R2 \quad \text{——} \quad (7)$$

Similarly Equating eqn (2) & (5)

$$\frac{RB(RA+RC)}{RA+RB+Rc} = R2+R3 \quad \text{——} \quad (8)$$

Equating equation (3) & 6.

$$\frac{Rc(RA+RB)}{RA+RB+Rc} = R3+R1 \quad \text{——} \quad (9)$$

Eqn (7) − (8)

$$\frac{RA(RB+RC) - RB(RA+RC)}{RA+RB+RC} = R1-R3 \quad \text{——} \quad (10)$$

add eqn (9) + (10)

$$\frac{\cancel{RA\cdot RB}+RA\cdot RC-\cancel{RB RA}+\cancel{RB RC}+RARC+\cancel{RBRC}}{RA+RB+Rc} = 2R1$$

$$\frac{\cancel{2}RARc}{RA+RB+Rc} = \cancel{2}R1 \Rightarrow$$

$$\boxed{R1 = \frac{RA\cdot RC}{RA+RB+Rc}}$$

Similarly

$$\boxed{R2 = \frac{RA\cdot RB}{RA+RB+Rc}} \quad \boxed{R3 = \frac{RB\cdot RC}{RA+RB+Rc}}$$

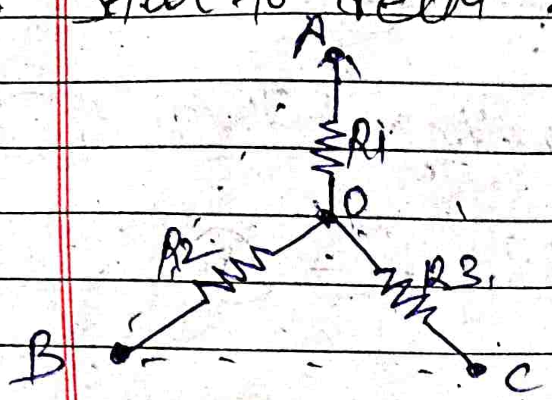
Suppose in delta $RA = RB = Rc = RD$

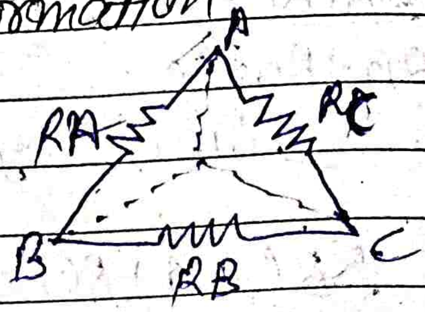
and in star $\Rightarrow R1 = R2 = R3 = RS$

$$RS = \frac{RD\cdot RD}{RD+RD+RD}, \quad RS = \frac{\cancel{RD}^2}{3\cancel{RD}}$$

$$\boxed{RS = \frac{RD}{3}} \qquad \boxed{RD = 3RS}$$

* Star to delta transformation





$R_1 = \frac{R_A R_C}{R_A+R_B+R_C}$ $R_2 = \frac{R_A R_B}{R_A+R_B+R_C}$ $R_3 = \frac{R_B R_C}{R_A+R_B+R_C}$ (25)

multiply $R_1 \times R_2 + R_2 \times R_3 + R_3 \times R_1$

$$\frac{R_A^2 R_B R_C}{(R_A+R_B+R_C)^2} + \frac{R_B^2 R_A R_C}{(R_A+R_B+R_C)^2} + \frac{R_C^2 R_A R_B}{(R_A+R_B+R_C)^2}$$

$$\frac{R_A R_B R_C \cancel{(R_A+R_B+R_C)}}{(R_A+R_B+R_C)^{\cancel{2}}}$$

$$\boxed{R_1R_2+R_2R_3+R_3R_1 = \frac{R_A R_B R_C}{R_A+R_B+R_C}}$$ from eq (25)

$$R_1R_2+R_2R_3+R_3R_1 = R_A \cdot R_3$$

$$\frac{R_1R_2}{R_3} + \frac{R_2\cancel{R_3}}{\cancel{R_3}} + \frac{\cancel{R_3}R_1}{\cancel{R_3}} = R_A \quad (26)$$

$$\boxed{\frac{R_1R_2}{R_3} + R_2 + R_1 = R_A}$$ similarly

$$\boxed{\frac{R_2R_3}{R_1} + R_2 + R_3 = R_B}$$

$$\boxed{\frac{R_1R_3}{R_2} + R_1 + R_3 = R_C}$$

from eq (26)

$$\frac{\cancel{R_S}R_S}{\cancel{R_S}} + R_S + R_S = R_D$$

$$3R_S = R_D$$

$$\boxed{R_D = 3R_S}$$

Suppose $R_1 = R_2 = R_3 = R_S$

$R_A = R_B = R_C = R_D$

$$\boxed{R_S = \frac{R_D}{3}}$$

AC circuit

* Equation of alternative current V & I

Max flux $\boxed{\phi = \phi_m \cos\omega t}$

across x axis $\boxed{N\phi = N\phi_m \cos\omega t}$

Emf induced in coil $\propto$ rate of change of flux linkage in the coil.

$$\varepsilon \propto -\frac{d\phi}{dt} \Rightarrow \varepsilon = -\frac{d(N\phi_m \cos\omega t)}{dt}$$

$$\varepsilon = -N\phi_m(-\sin\omega t \cdot \omega)$$

$$\varepsilon = +N\phi_m \sin\omega t \cdot \omega$$

$$\boxed{\varepsilon = \omega N \phi_m \sin\omega t}$$

$\because \omega t = \theta$
$\theta = 90$

$\therefore \boxed{\varepsilon_m = \omega N \phi_m}$

$\because \phi = BA$
$\omega = 2\pi f$

$$\boxed{\varepsilon = \varepsilon_m \sin\theta}$$

$\therefore$

Similarly ϕ_m

$$I = \omega N \phi_m \sin\omega t$$

$\therefore \boxed{I_m = \omega n \phi_m}$

$$\boxed{I = I_m \sin\omega t}$$

$$\boxed{I = I_m \sin\theta}$$

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Time period ⇒ $\boxed{T = \frac{1}{f}}$

frequency $\boxed{f = \frac{1}{T}}$

$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$ $\boxed{I_{rms} = \frac{I_m}{\sqrt{2}}}$

$\boxed{\text{V/c}}$ → $\boxed{\text{RMS value} = 0.707 \times \text{Max. Value}}$

$\boxed{\text{Average value} = 0.637 \times \text{Maximum value}}$

$\boxed{\text{form factor} = \frac{\text{RMS Value}}{\text{Avg value}}}$

(K_f) form factor $= \frac{0.707 \text{ Max val}}{0.637 \text{ Max val}}$

$\boxed{\text{form factor} = 1.11}$

$\boxed{\text{Amplitude} = 1.414}$

$\boxed{\text{Peak factor} = \frac{\text{max val}}{\text{rms val}}}$ $\boxed{K_p = 1.414}$

* The ac supply at a house is 230V, so find maximum, Average and value of voltage :- $V_{max} = 230V$

$V_{rms} = 0.707 \times \text{Max. value}$

$\text{Max value} = \frac{V_{rms}}{0.707}$ $V_{Max} = \frac{230}{0.707}$

$\boxed{\text{Max}V = 325.31}$

$V_{avg} = 0.637 \times \text{Max}V$

$\boxed{V_{avg} = 207.22}$ V

* Define peak factor and form factor of an alternative current.

* Peak factor :- peak factor is the ratio of maximum value and rms value is called peak factor

$$\boxed{K_p = \frac{\text{Max value}}{\text{rms value}}}$$

* form factor :- form factor is the ratio of rms value and average value is called form factor.

$$\boxed{K_f = \frac{\text{RMS value}}{\text{average value}}}$$

* Average value :- Average value is the multiplication of maximum value and 0.637.

$$\boxed{\text{Average val} = 0.637 \times \text{max val}}$$

* Define magnetic flux and give its unit ?

ans => Total magnetic field which is passes through a given area is called magnetic flux. it's unit is SI unit is (weber).

* Average value of alternative current :- area of first half cycle divide by π is called Average value of A.C

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* Define RMS value of ac → $I_{rms} = \frac{Max}{\sqrt{2}}$

The ratio of maximum current and $\sqrt{2}$ is called RMS value of ac.

$$\boxed{I_{rms} = \frac{I_{max}}{\sqrt{2}}}$$

* The eq^n of alternative current
$i = 42.42 \sin 628t$
(i) peak or max value (iv) average value
(ii) frequency (v) form factor
(iii) rms value

Sol^n :- $i = 42.42 \sin 628t$
Compair with $i = I_m \sin \omega t$

(i) $\boxed{i_{max} = 42.42}$ $\boxed{\omega = 628}$

$\because \omega = 2\pi f$ so $f = \dfrac{628}{2\pi}$ [illegible]

(ii) $\boxed{f = 100\ Hz}$ $I_{rms} = 0.707 \times I_{max}$
$I_{rms} = 0.707 \times 42.42$
(iii) [illegible] A
$\boxed{I_{rms} = 30A}$

(iv) $I_{avg} = 0.637 \times$ max value
$I_{avg} = 0.637 \times 42.42$
(iv) $\boxed{I_{avg} = 27A}$

(v) form factor $\Rightarrow K_f = \dfrac{I_{rms}}{I_{avg}}$
$K_f = \dfrac{30}{27}$ $\boxed{K_f = 1.11}$

(i) peak factor $= \dfrac{\text{max val}}{\text{rms val}}$
$K_p = \dfrac{42.42}{30}$
$\boxed{K_P = 1.414}$

* An alternative voltage $V = 100 \sin 100t$ find
(i) amplitude (ii) time period (iii) frequency
(iv) angular velocity (v) form factor
(vi) peak factor
Sol^n :- $V = 100 \sin 100t$
Compair with $v = V_m \sin \omega t$

$\boxed{V_{max} = 100}$, $\omega = 100$

$\omega = 2\pi f$ $f = \frac{100}{2\pi}$

(iii) $\boxed{f = 15.92}$ Hz, $T = \frac{1}{f}$ (ii) $\boxed{T = 0.0628}$

(iv) angular velocity $\Rightarrow \omega = 2\pi f$

$\boxed{\omega = 100}$

$K_f = \frac{RMS\ val}{avg\ val}$, $K_f = \frac{0.707\ max\ val}{0.607\ max\ val}$

$V_{rms} = 0.707\ V_{max}$

$V_{rms} = 0.707 \times 100$ avg val $= 0.637 \times$ max val

$\boxed{V_{rms} = 70.7\ V}$ avg val $= 0.637 \times 100$

$\boxed{avg\ val = 63.7\ V}$

$K_f = \frac{70.7}{63.7}$ (v) $\boxed{K_f = 1.11}$

$K_P = \frac{100}{70.7}$ (vi) $\boxed{K_P = 1.414}$

* The equation of alternative voltage $v = 42.42 \sin 628t$ Determine.

(i) average value (ii) rms value

(iii) form factor (iv) peak factor.

$v = 42.42 \sin 628t$

Campair with $v = V_m \sin \omega t$

$\boxed{V_{max} = 42.42}$, $\boxed{\omega = 628}$

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$V_{rms} = 0.707 \times max$ ✓
$= 0.707 \times 42.42$

$\boxed{V_{rms} = 30}$ ✓

average val $= 0.637 \times max$ ✓
average val $= 0.637 \times 42.42$

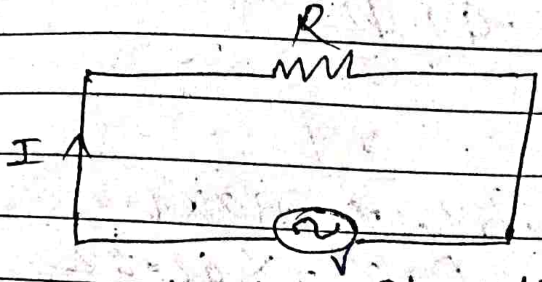
$\boxed{\text{average val} = 27\ V}$

$Kf = \frac{30}{27}$ $\boxed{Kf = 1.11}$

$KP = \frac{42.42}{30}$ $\boxed{Kp = 1.414}$

* Define power factor

* Ac through pure resistance



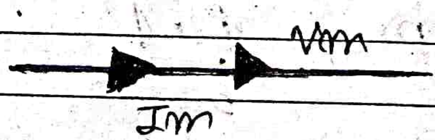
$V = V_m \sin\omega t$

$I = I_m \sin\omega t$

$$\boxed{I_m = \frac{V_m}{R}}$$

$V = (V_m \angle 0^\circ)$

$I = (I_m \angle 0^\circ)$



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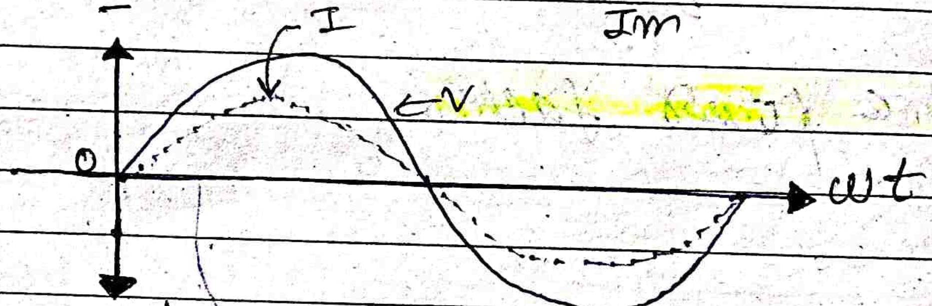
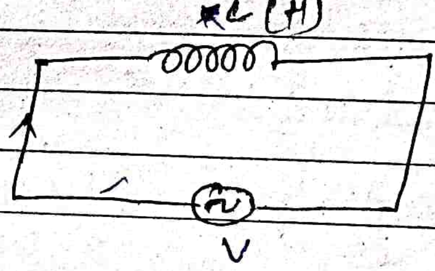


* Ac through pure inductance



L → में current voltage को log करेगा with 90° mean (current -90 से)

$V = V_m \sin\omega t$

$I = I_m \sin(\omega t - 90^\circ)$

$$\boxed{I_m = \frac{V_m}{X_L}}$$

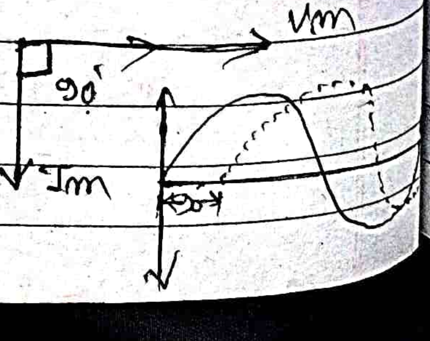
$V = (V_m \angle 0)\ V$

$I = (I_m \angle -90)\ A$

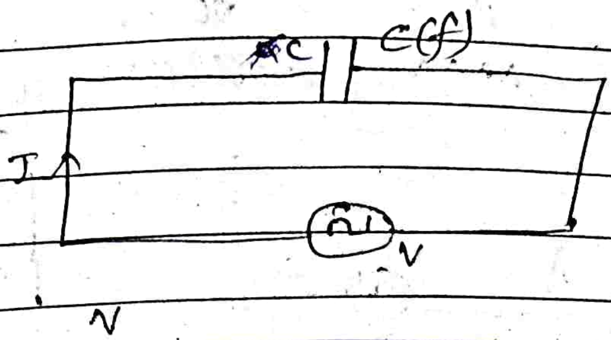
$\boxed{X_L = \omega L}$ $\boxed{\omega = 2\pi f}$

$\boxed{X_L = 2\pi f L}$

$$\boxed{I_m = \frac{V_m}{2\pi f L}}$$



* AC through pure capacitance



C में current voltage को lead करेगा with 90 means (current +90)

$$\boxed{V = V_m \sin \omega t}$$

$$\boxed{I = I_m \sin(\omega t + 90)}$$

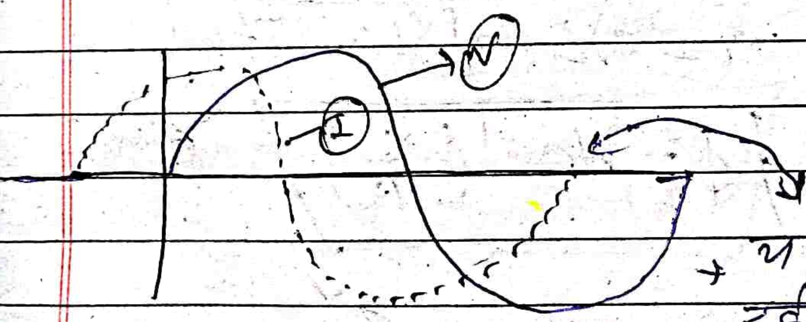
$V = (V_m \angle 0)$

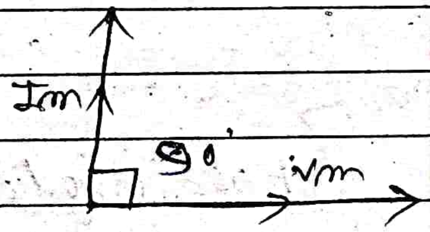
$I = (I_m \angle +90)$

$$I_m = \frac{V_m}{X_C} \qquad I_m = \frac{V_m}{\frac{1}{2\pi f C}} \qquad \boxed{I_a = 2\pi f C \cdot V_m}$$

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

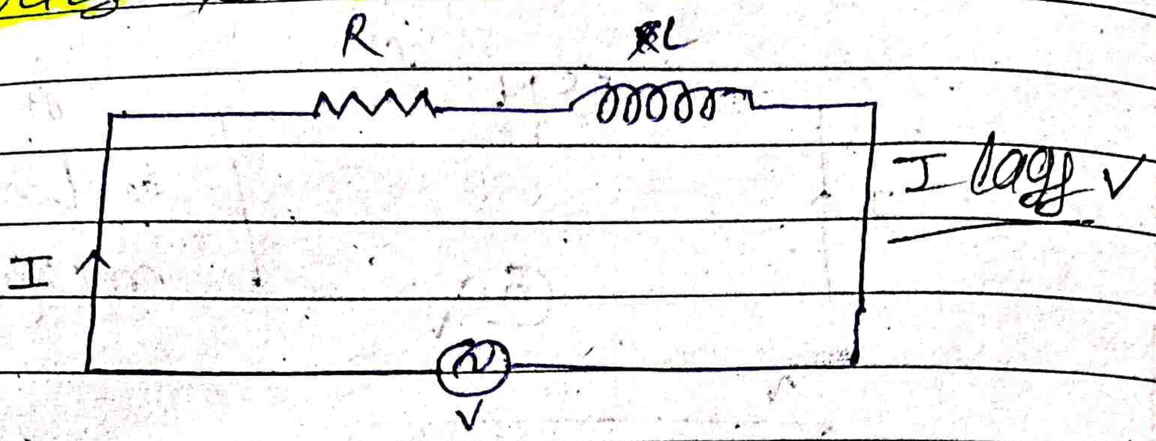
$$\boxed{X_C = \frac{1}{2\pi f C}} \qquad \boxed{I_m = \frac{V_m}{\frac{1}{\omega C}}}$$





यहाँ पर current पहले पहुंच रही है, voltage बाद में पहुंच रही है यानी I, V को lead कर रही है।

* Series R-L circuit



$$v = V_m \sin \omega t$$
$$I = I_m \sin(\omega t - \phi)$$

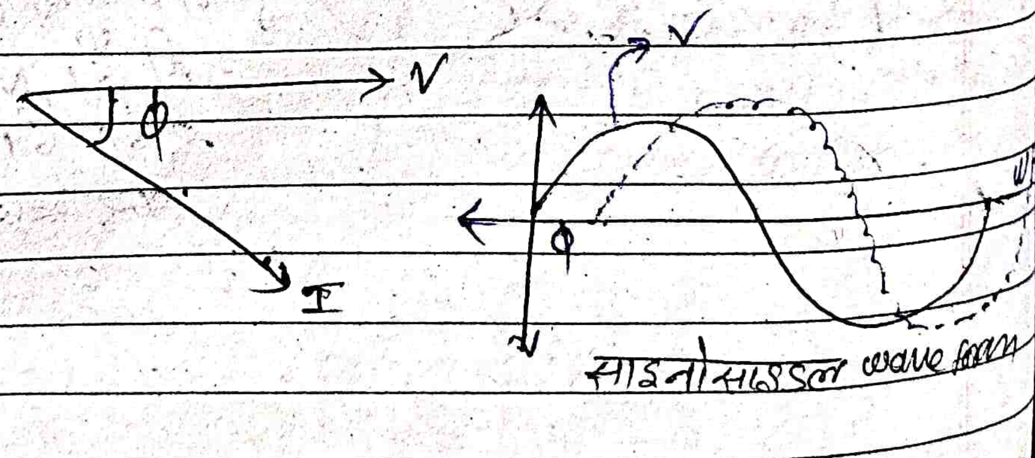
$v = (V_m \angle 0^\circ)$
$I = (I_m \angle -\phi)$

$\therefore \quad I = \frac{V}{Z} \rightarrow Z = \text{impedance}(\Omega)$

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

$X_L = \omega L \Rightarrow \boxed{X_L = 2\pi f L}$

phase angle $\boxed{\phi = \tan^{-1}\left(\frac{X_L}{R}\right)}$



साइनोसाइडल wave form

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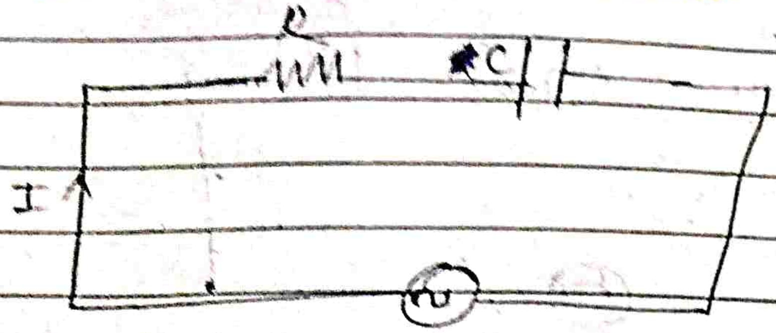
Series R-C circuit



$V = V_m \sin \omega t$ | $V = (V_m = 0)$

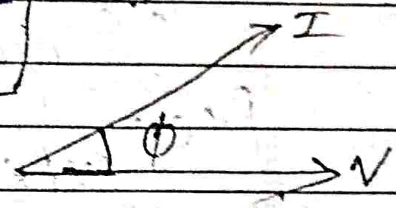
$I = I_m \sin(\omega t + \phi)$ | $I = (I_m = +\phi)$

$I = \frac{V_m}{Z} \longrightarrow$ Impedence

$Z = R + X_C$

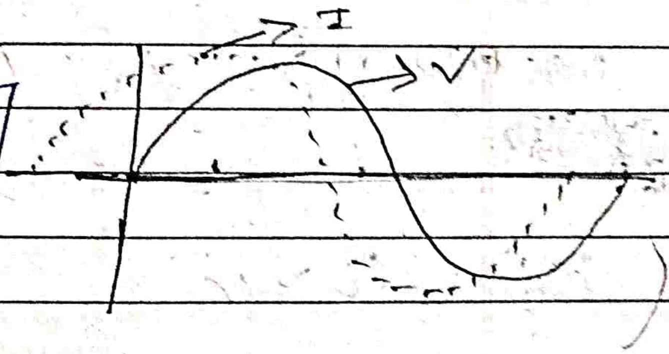
$\boxed{Z = \sqrt{R^2 + (X_C)^2}}$

I leads V

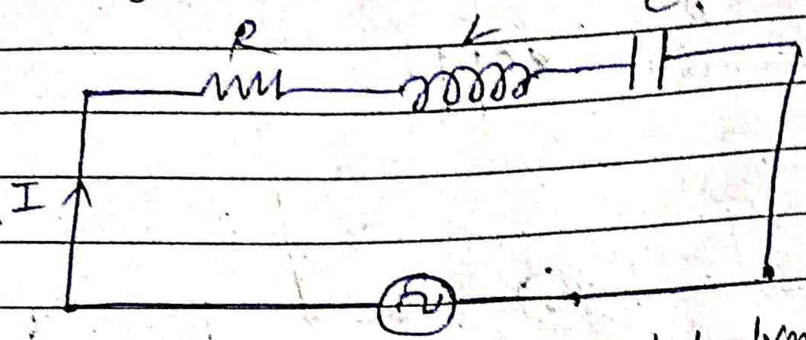


$X_C = \frac{1}{\omega C}$ $\boxed{X_C = \frac{1}{2\pi f C}}$

phase angle $\boxed{\phi = \tan^{-1}\left(\frac{-X_C}{R}\right)}$



* Series RLC circuit & resonance in RLC(ac)



$V = V_m \sin \omega t$ | $V = (V_m \angle 0)$

$I = I_m \sin(\omega t \pm \phi)$ | $I = (I_m \angle \pm \phi)$

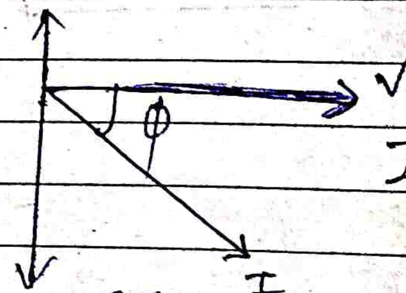
$\boxed{I = \frac{V}{Z}}$ $\boxed{Z = \sqrt{R^2 + (X_L - X_C)^2}}$

$X_C = \frac{1}{\omega C}$, $X_L = \omega L$

$\boxed{X_C = \frac{1}{2\pi f C}}$, $\boxed{X_L = 2\pi f L}$

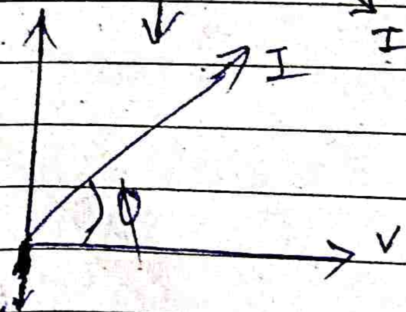
phase angle → $\boxed{\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)}$

Case (i) $X_L > X_C$



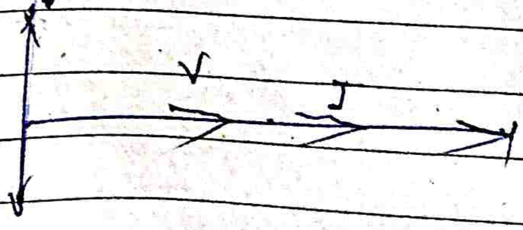
I lags V

Case (ii) $X_C > X_L$



I leads V

Case (iii) $X_L = X_C$



pure R circuit

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(*) Define apparent power, active power and reactive power.

(i) active power : That power which is conformed or utillized in ac circuit is called active power, it is denoted by P. its unit is (KW)

$\boxed{P = VI\cos\phi}$ $\boxed{P = I^2R}$
power

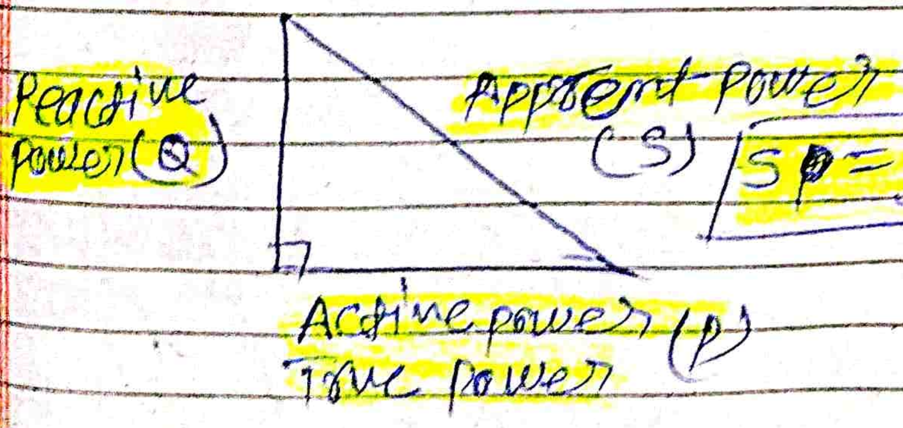
* reactive power : Reactive is the useless power which is moves between source and load in the circuit. it is denoted by Q
It is known of imagenary power or wattless power. reactive power is the sin angle between voltage and current, it's unit is (VAR)

$Q = VI\sin\phi$

* Apparent power : Apparent power is the Combination of Active and reactive power is called apparent power. it is denoted by S.

$\boxed{S = \sqrt{P^2 + Q^2}}$ $S = VI$ (KVA) unit

* Draw the power triangle



$\boxed{S = \sqrt{P^2 + Q^2}}$

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z = impemdance ; x = Reactance
x_L = inductive reactance
x_C = capacitive reactance
ω = angular velocity
t = time f = frequency

$\boxed{\text{Power factor} = \cos\phi}$ (leading or lagging)

Active power → $P = I^2R$

Reactive power → find the True power, power, Power lost, pow absorb, power consumed → Active power

Same power: $\boxed{P = I^2R}$ (W or kW) $\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$ $\boxed{I_{rms} = \frac{I_m}{\sqrt{2}}}$

$\boxed{P = |V||I|\cos\phi}$ (kW) φ → power factor angle

Reactive power / imaginary power / watless power: $\boxed{Q = |V||I|\sin\phi}$ (VAR) (kVAR)

cos / sin φ → यानि V and I के बीच का phase angle

* What is active and reactive power.
* power factor :- power factor is cosine of angle between voltage and current so it the ration of resistance to impedance
power factor in never be greater than unity
among → (1)

$\boxed{\text{Apparant power} \Rightarrow VI}$, $\boxed{S = \sqrt{P^2+Q^2}}$ VA or kVA
VI → Vrms value

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* The sinusoidal voltage applied to a circuit of unknown impedance is $v = 325 \sin \omega t$ and the current ($i = 7 \sin(\omega t + 63°)$) Hence find (i) RMS value of voltage and current (ii) unknown impedance (3) power factor (4) comment wheather the current is lagging or leading w.r.t voltage

(i) $V_{rms} = ?$ (ii) $I_{rms} = ?$ $Z = ?$, $\phi = ?$

given $v = 325 \sin \omega t$

$\boxed{\phi = 63°}$ $I = 7 \sin(\omega t + 63°)$

$V_m = 325$, $I_m = 7$

(i) $V_{rms} = \frac{V_m}{\sqrt{2}}$, $V_{rms} = \frac{325}{\sqrt{2}}$

$\boxed{V_{rms} = 229.80\,V}$

$I_{rms} = \frac{7}{\sqrt{2}}$ $\boxed{I_{rms} = 4.94\,A}$

$\boxed{I = \frac{V_m}{Z}}$ $Z = \frac{V_m}{I}$

$Z = \frac{325}{7}$ $\boxed{Z = 46.42\,\Omega}$

$\boxed{\phi = 63}$ ✓

Current is leading w.r.to voltage with 63° angle

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*) $E(t) = 150 \sin(2\pi f)t$, 50 Hz, 10Ω, 0.0318 Henry for R-L circuit

(i) Expression for I
(ii) Phase angle b/w V & I
(iii) Power factor

given $E = 150 \sin(2\pi f)t$

$V_m = 150$, $\omega = 2\pi f$, $\boxed{L = 0.0318}$, $X_L = \omega L$

$\boxed{R = 10\Omega}$, $\boxed{\omega = 2\pi \cdot 50}$, $X_L = 100\pi \times 0.0318$

$\cancel{2\pi f = \omega}$

$\boxed{I = \frac{V_m}{Z}}$, $I = \frac{V_m}{\sqrt{R^2 + (X_L)^2}}$, $X_L =$

$X_L = \omega L$, $X_L = 2 \times \pi \times 50 \times 0.0318$, $Z = \sqrt{R^2 + (X_L)^2}$

$\boxed{X_L = 9.99}\,\Omega$, $\boxed{X_L^2 = 99.80}$

$I = \frac{150}{\sqrt{100 + 99.80}}$, $I = \frac{150}{14.13}$, $\boxed{I = 10.61\,A}$

(ii) $\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$, $\phi = \frac{9.99}{10}$, $\boxed{\phi = 0.999}$

$\phi = \tan^{-1}(0.999)$

$\boxed{\phi = 0.78}$

(iii) power factor $\cos\phi \Rightarrow \cos(0.78)$ I

$\boxed{pf = 0.71}$ leading I >> V

$\boxed{I \text{ leading } V}$

* The current $I = 35.36 \sin 314t$ is flowing through R-L series circuit having $R = 15\,\Omega$ and $X_L = 12\,\Omega$ find (i) RMS value of current (ii) Average value of current (iii) impedance (iv) power factor

ans ⇒ given $I = 35.36 \sin 314t$

$R = 15\,\Omega$ $\quad I_m = 35.36$

$X_L = 12\,\Omega$

(i) $I_{rms} = \frac{35.36}{\sqrt{2}}$ $\quad \boxed{I_{rms} = 25.00\,A}$

(ii) $I_{avg} = 0.637 \times I_{max}$

~~$I_{avg} = 0.637 \times 35.36$~~

$= 0.637 \times 35.36$

$\boxed{I_{avg} = 22.52\,A}$ $\quad \boxed{Z = \sqrt{R^2 + (X_L)^2}}$

19.2

(iii) $Z = ?$ $\quad I = \frac{V}{Z}$ $\quad Z = \frac{V}{I}$

$I = 35.36$ $\quad V = 35.36 \times 15$

$R = 15$ $\quad \boxed{V = 530.4\,V}$

$Z = \frac{530.4}{35.36}$ $\quad \boxed{Z = 15\,\Omega}$

(iv) power factor $\cos\phi$

$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$ $\quad \phi = \tan^{-1}\left(\frac{12}{15}\right)$

$\phi = 0.099$

$Pf = \cos(0.099)$

$\boxed{PF = 0.9951}$

* $v = 200 \sin 377t$ volts.

$i = 8\sin(377t - 30°)\,A$

Determine p.f, true p, apparent p, Reactive p also the pow △

* A voltage $e = 200 \sin(100\pi t)$ is applied to a coil having $R = 200\,\Omega$ and $L = 0.38H$. Determine the expression of current and power taken by coil.

ans ⇒

given $e = 200 \sin(100\pi t)$

$R = 200\,\Omega$; $L = 0.38H$

$I = ?$, $P = ?$

$V_m = 200$

$I = \frac{V_m}{Z}$, $Z = \sqrt{R^2 + (X_L)^2}$

$\boxed{X_L = 2\pi f L}$

$\omega = 100\pi$

$2\pi f = 100\pi$

$\boxed{f = 50\,Hz}$

$X_L = 2 \times \pi \times 50 \times 0.38H$

$X_L = 119.38\ H$

$Z = \sqrt{40000 + 14251.58}$

$Z = \sqrt{54251.58}$

$\boxed{Z = 232.91}$

$I = \frac{200}{232.91}$

$\boxed{I = 0.858A}$

$P = I^2R$

$P = 0.73736 \times 200$

$\boxed{P = 147.47\ \text{watt}}$

~~$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$ $\phi = \tan^{-1}\left(\frac{16.71}{2.5}\right)$ $\phi = 1.42$~~

Q. A 230V, 50Hz AC supply is applied to a coil of 0.06 H (inductance) and 2.5 Ω (resistance) connected in series with a 6.8 μf capacitor. Calculate (a) Impedance (z) (b) current (I) (c) Phase Angle (φ) (d) Power factor (e) power consumed

→ given $V = 230$, $f = 50Hz$, $L = 0.06H$
$R = 2.5\,\Omega$, $C = 6.8\,\mu f$, $C = 6.8 \times 10^{-6} f$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$ $\quad X_L = 2\pi f L$ $\quad \boxed{X_L = 18.84}$

$X_C = \frac{1}{2\pi f C}$ $\quad \boxed{X_C = 2.13}$ $\quad Z = \sqrt{6.25 + 16.71}$

$\boxed{Z = 4.79}$ $\quad I = \frac{V_m}{Z}$ $\quad I = \frac{230}{4.79}$

$\boxed{I = 48A}$

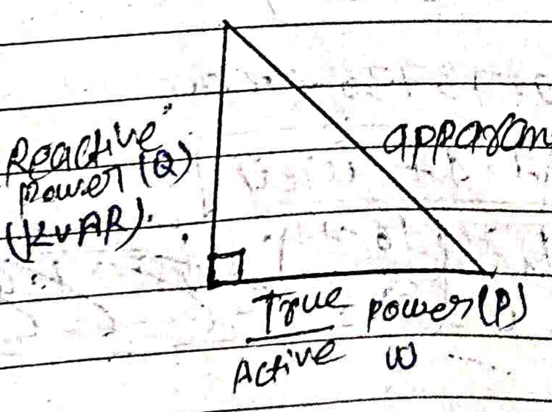
$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$ $\quad \phi = \tan^{-1}\left(\frac{16.71}{2.5}\right)$

$\phi = \tan^{-1}(6.684)$ $\quad \phi = 81.49$

$pf = \cos\phi$ $\quad \boxed{pf = 0.147}$

Power consumed $= I^2R = 5760$ watt

Draw the power triangle



$\boxed{S = \sqrt{P^2 + Q^2}}$

* $v = 200 \sin 377t$ volts, $i = 8 \sin(377t - 30°)$ A
Determine (i) p.f, (ii) True power (iii) apparant p (iv) Reactive p (v) pow △

Ans
$i_m = 8$
$V_m = 200$
$\omega = 377$
$\phi = 30°$

$p.f = \cos\phi$
$pf = \frac{\sqrt{3}}{2}$ $\boxed{pf = 0.15}$

(ii) True power → $VI\cos\phi$
$TP = 200 \times 8 \times 0.15$
$TP = 240$ watt

(iv) $RP = VI\sin\phi$
$RP = 200 \times 8 \times \frac{1}{2}$
$RP = \cancel{800}$
$\boxed{RP = 800}$ VAR
$Q = 800$

(iii) apparant p → $S =$

$S = \sqrt{P^2 + Q^2}$
$S = \sqrt{57600 + 640000} \Rightarrow S = \sqrt{697600}$

$\boxed{S = 835.22 \text{ VA}}$

* $v = 100 \sin 314t$, $R = 25\Omega$, $C = 80\mu f$ determine
(i) peak value of I (ii) pf (3) Total power confumed

Ans Peak val of I $= \frac{\text{Max } I}{\cancel{I_{rms}}}$

given
$V_m = 100$
$\omega = 314$
$R = 25\Omega$
$C = 80 \times 10^{-6} f$

$314 = 2\pi f$
$f = \frac{314}{2\pi}$
$f = 49.97$

$\cancel{I_{m}} = \frac{V_m}{R}$
$I_m = \frac{100}{25}$ $I_m = 4A$

(ii) $\cos\phi$

$\omega C = \frac{1}{2\pi f C}$
$\boxed{\omega C = 40}$

$P.V = \frac{4A}{2.82}$
$\boxed{P.V = 1.41}$

$\phi = \tan^{-1}\left(-\frac{\omega C}{R}\right)$
$\phi = \tan^{-1}\left(-\frac{40}{25}\right)$
$\phi = \tan^{-1}(-1.6)$
$\boxed{\phi = -1.01}$

$\boxed{\text{(ii) } \cos\phi = 0.53}$

$P = I^2R$ $P = 16 \times 25 = 400$ Watt

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Q. $R = 10\Omega$ $L = 50mH$ $C = 100\mu f$, $V = 200V$
$f = 50Hz$ (i) Z (ii) Pf (iii) I (iv) P
(v) voltage drop accross each element.

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

$X_L = 2\pi f L$ $X_L = 2 \times \pi \times 50 \times 50 \times 10^{-3}$

$$\boxed{X_L = 15.70\,\Omega}$$

$X_C = \frac{1}{2\pi f C}$ $X_C = \frac{1}{2 \times \pi \times 50 \times 100 \times 10^{-6}}$

$$\boxed{X_C = 32.25}$$

$Z = \sqrt{100 + 273.90}$

$Z = \sqrt{373.90}$ $\boxed{Z = 19.33\,\Omega}$

$I = \frac{V_{rm}}{Z}$ $I = \frac{200}{19.33}$ $\boxed{I = 10.34A}$

$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$ $\phi = \tan^{-1}\left(\frac{-16.55}{10}\right)$

$\phi = \tan^{-1}(-1.65)$

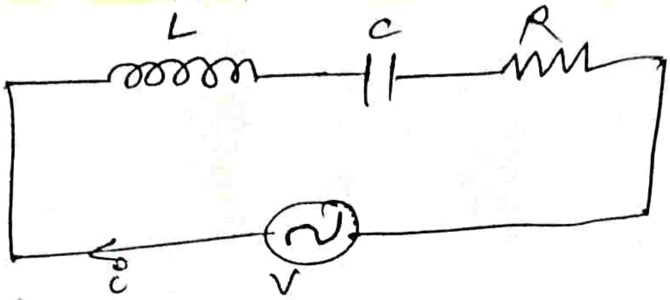
$$\boxed{\phi = -1.025}$$

$\boxed{pf = 0.51}$ $P = I^2 R$

$\boxed{P = 1069.15}$ watt

* what is resonance :- when the value of inductive and capacitive reactances have equal magnitude but phase difference is 180° is called resonance.

* Resonance in RLC circuit



∴ Resonance $X_L = X_C$

① $Z = \sqrt{R^2 + (X_L - X_C)^2} \Rightarrow Z = \sqrt{R^2 + (\cancel{X_L - X_C})^2} \Rightarrow \boxed{Z = R}$

② $Z = R$ · impedance minimum

③ $V = \frac{I}{Z}$ $\quad V = \frac{I}{R}$ ④ I = maximum

⑤ $\xrightarrow{I \quad V}$ pure resistive circuit
in phase

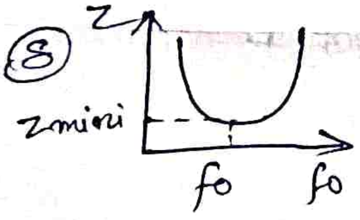
⑥ power factor $\cos 0° = 1$ $\quad X_L = X_C$

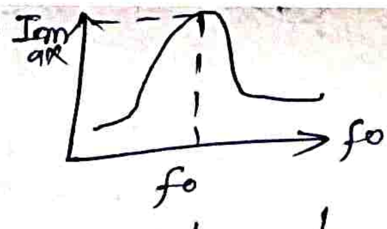
⑦ resonance frequency $\Rightarrow \omega_0 L = \frac{1}{\omega_0 C}$

$\omega_0^2 = \frac{1}{LC} \quad \omega_0 = \frac{1}{\sqrt{LC}}$

$\omega_0 = 2\pi f_0$

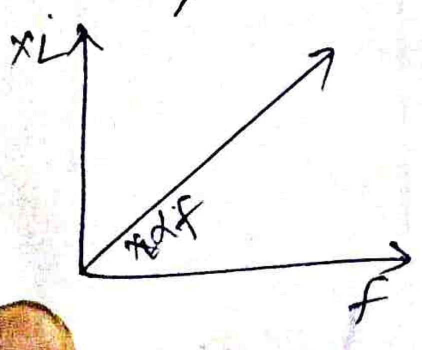
$2\pi f_0 = \frac{1}{\sqrt{LC}}$ $\quad \boxed{f_0 = \frac{1}{2\pi\sqrt{LC}}}$ resonance frequency

⑧


⑨


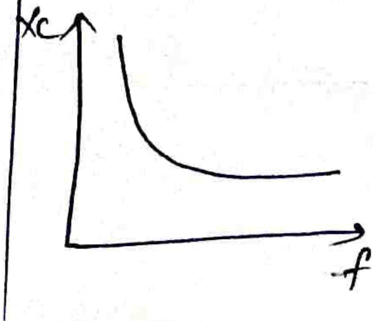
$X_L = \omega L = 2\pi f L$

$X_L \propto f$

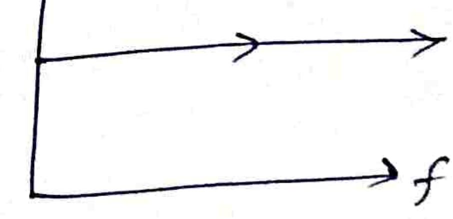


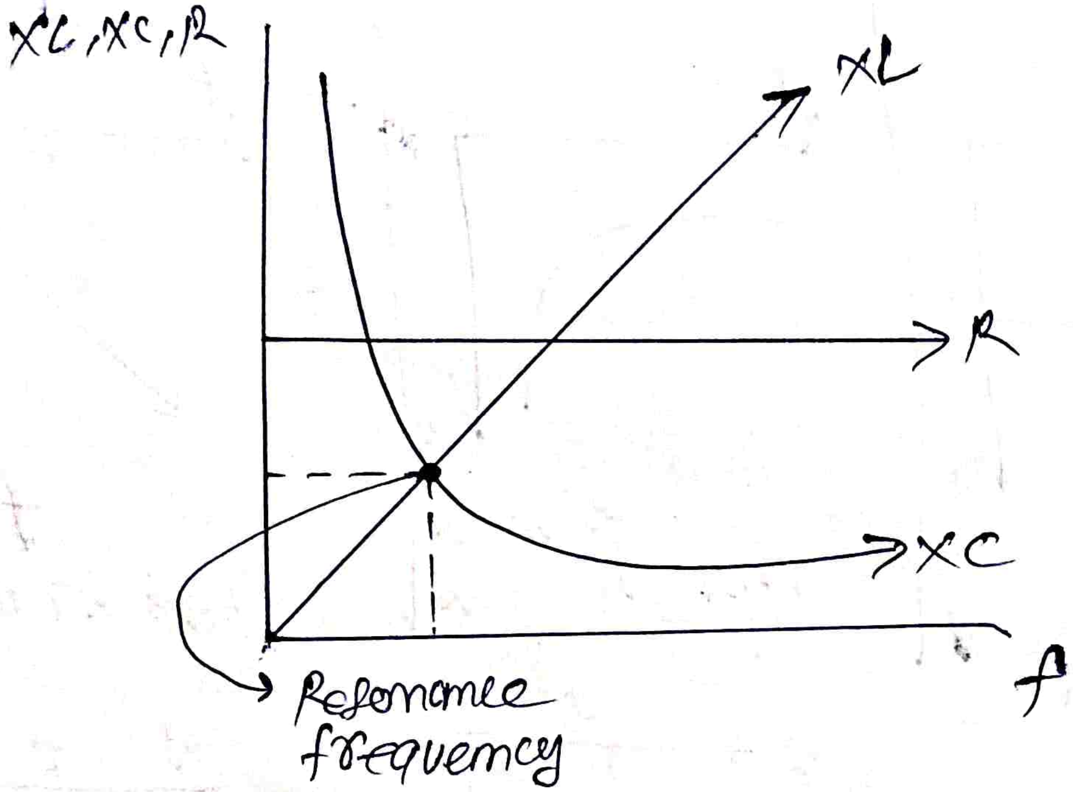
$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

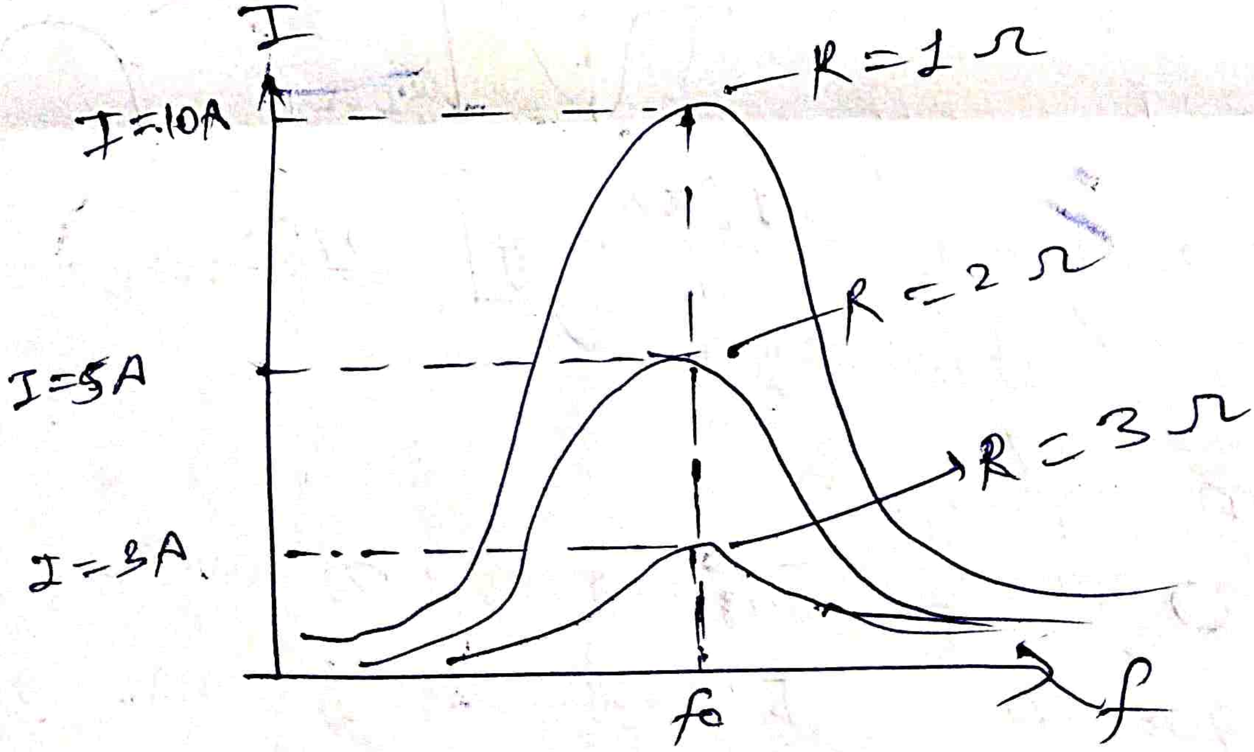
$X_C \propto \frac{1}{f}$



R → constant



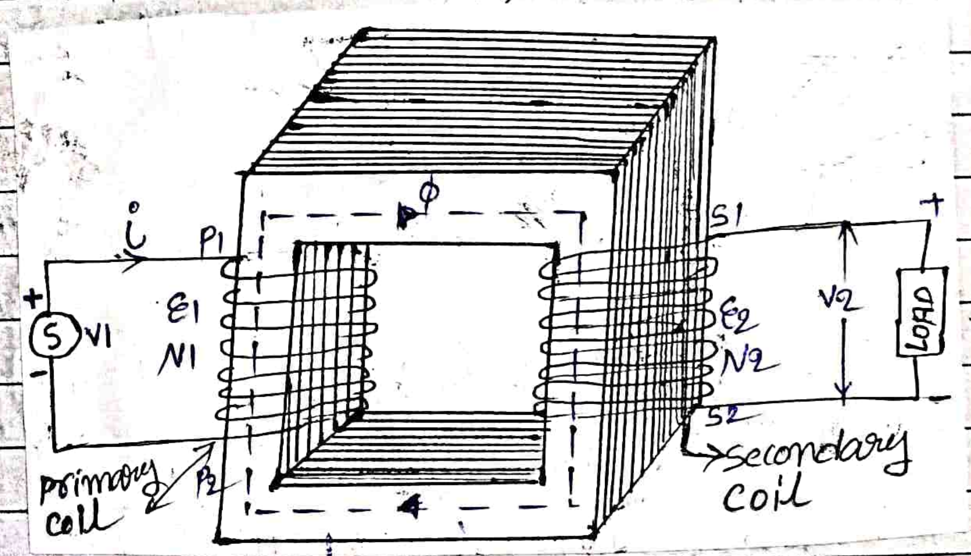

XL, XC, R
XL
R
XC
f
Resonance frequency


I
R = 1 Ω
I = 10A
R = 2 Ω
I = 5A
R = 3 Ω
I = 3A
fo
f

Transformer

(PYQ) Describe the constructional details of transformer and working principle and E.M.f equation. Effeciency of a transformer & condition for maximum value of efficiency.

Introduction :- Transformer is a device which is used to step-up and step-down the input voltage is called transformer



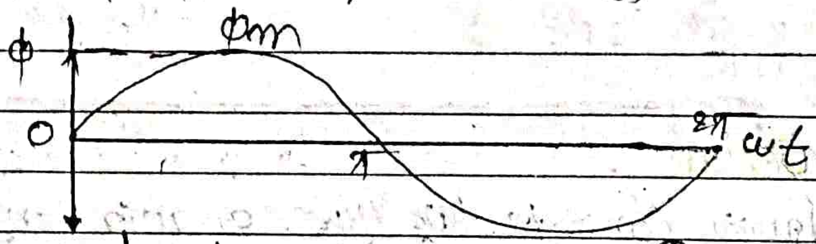
core (magnetic material)

Construction :- Transformer consists two types of windings and a laminated steel core, two windings are placed on a magnetic core insulated from each-other and ~~thin~~ stell core is ~~insulate~~ laminated and made of thin sheets of silicon. This arrangement of of core diminishes the eddy current loss. There are two types of winding one is called primary winding (P1 & P2) and other is called secondary winding (S1 & S2) placed on core. N_1 and N_2 be the no of turns in primary & secondary winding. Ac input is given to primary winding & Ac output taken by secondary winding

Working principle of transformer

÷ A transformer works on the principle of mutual ~~electromagnetic~~ induction, When an alternative Voltage (V1) is applied to the primary winding than current (i) flows through it and this current produces flux (ϕ) in the core which links with primary and secondary windings. The flux self-induces emf (E_1) in primary winding and the flux mutually induces emf (E_2) in secondary winding according to the faraday's laws of electromagnetic induction. After this current will start flowing in the secondary winding.

EMf Equation of A Transformer ÷



$$\phi = \phi m \sin \omega t \quad \text{——— (1)}$$

by faraday's law of electromagnetic induction

$$E = N \frac{d\phi}{dt}$$

by lenz law

$$E = -N \frac{d\phi}{dt} \quad \text{——— (2)}$$

so, Emf induced in primary winding
Put (1) eqn in 2

$$E_1 = -N \frac{d(\phi m \sin \omega t)}{dt}$$

$\varepsilon_1 = -N \cdot \phi m \cdot \omega \cos \omega t$ $\quad \omega t = 0$

$\varepsilon_1 = N \phi m \cdot \omega(-\cos \omega t)$ — (4)

$\because \cos\theta = \sin(\frac{\pi}{2} - \theta)$

mul (-) both side $\quad \left\{ -\sin\theta = \sin(-\theta) \right.$

$-\cos\theta = -\sin(\frac{\pi}{2} - \theta)$

$\boxed{-\cos \omega t = \sin(\omega t - 90^\circ)}$ — (3) put in (4)

$\varepsilon_1 = N \phi m \cdot \omega(\sin(\omega t - 90^\circ))$

$\varepsilon_1 = N \cdot \phi m \cdot 2\pi f \sin(\omega t - 90^\circ)$

comparing with

$\varepsilon_1 = em \sin(\omega t + 0)$

$Em_1 = N \phi m \cdot 2\pi f$

so RMS value of emf $= \frac{\text{Emax value}}{\sqrt{2}}$

$\varepsilon_1 = \frac{N \phi m \cdot 2\pi f}{\sqrt{2}} \Rightarrow \varepsilon_1 = \frac{2\pi}{\sqrt{2}} \cdot N \phi m f \quad \because \left\{ \frac{2\pi}{\sqrt{2}} = 4.44 \right.$

$\boxed{\varepsilon_1 = 4.44 \phi m f \cdot N_1}$

similaarly for secondary winding

$\boxed{\varepsilon_2 = 4.44 \phi m f N_2}$

Transformation ratio $\boxed{K = \frac{V_2}{V_1} = \frac{\varepsilon_2}{\varepsilon_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}}$

(*) Losses in a Transformer :-

(1) Core loss or iron loss

(i) hysteresis loss

(ii) eddy current loss

(2) copper loss

(1) Core loss or iron loss:- Core loss or iron loss Consists both of the losses hysteresis loss and eddy current loss

(i) Eddy current loss:- Due to apply Alternative current in core of transformer there are produced eddy currents in core by which energy losses in the form of heat is Called eddy Current loss in order to diminish the losses we should use ~~...~~ thin sheets of silicon for core so we can diminish the energy loss.

$$\boxed{P_e = K B^2 f^2 t^2 W}$$

(ii) Hysteresis loss:- Due to apply Alternative current in core of transformer, Core getting frequently magnetized and de-magnetized so energy gets loss is called hysteresis loss. $P_h = \eta B^n f V W$ $\rightarrow$ $\eta \rightarrow$ constant of the core, $B \rightarrow$ flux density

(2) Copper loss:- The winding of the transformer is made of Copper wire, so it has some resistance due to this resistance electrical energy is Converted into heat energy this is called copper loss.

$$\boxed{P_{cu} = I_1^2 R1 + I_2^2 R2}$$

EFFICIENCY of a Transformer: efficiency of a transformer is the ratio of input power and output power. It is denoted by η.

$$\eta = \frac{\text{output power}}{\text{input power}} \Rightarrow \eta = \frac{\text{output power}}{\text{output power + losses}}$$

$$\eta = \frac{\text{output power}}{\text{output po + iron loss + copper loss}}$$

$$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + I_2^2 R_2 + P_i} \quad \text{--- (A)}$$

Condition for maximum value of efficiency

diff eq (A) w.r.t. I_2 Note: [P_i → constant, and I_2 variable and all are constant]

$$\frac{d\eta}{dI_2} = \frac{(V_2 I_2 \cos\phi_2 + I_2^2 R_2 + P_i)(V_2 \cos\phi_2) - V_2 I_2 \cos\phi_2 (V_2 \cos\phi_2 + 2 I_2 R_2 + 0)}{(V_2 I_2 \cos\phi_2 + I_2^2 R_2 + P_i)^2}$$

To get max efficiency put $\frac{d\eta}{dI_2} = 0$

$$(V_2 I_2 \cos\phi_2 + I_2^2 R_2 + P_i) V_2 \cos\phi_2 - V_2 I_2 \cos\phi_2 (V_2 \cos\phi_2 + 2 I_2 R_2) = 0$$

$$V_2 \cos\phi_2 (V_2 I_2 \cos\phi_2 + I_2^2 R_2 + P_i) - V_2 I_2 \cos\phi_2 (V_2 \cos\phi_2 + 2 I_2 R_2) = 0$$

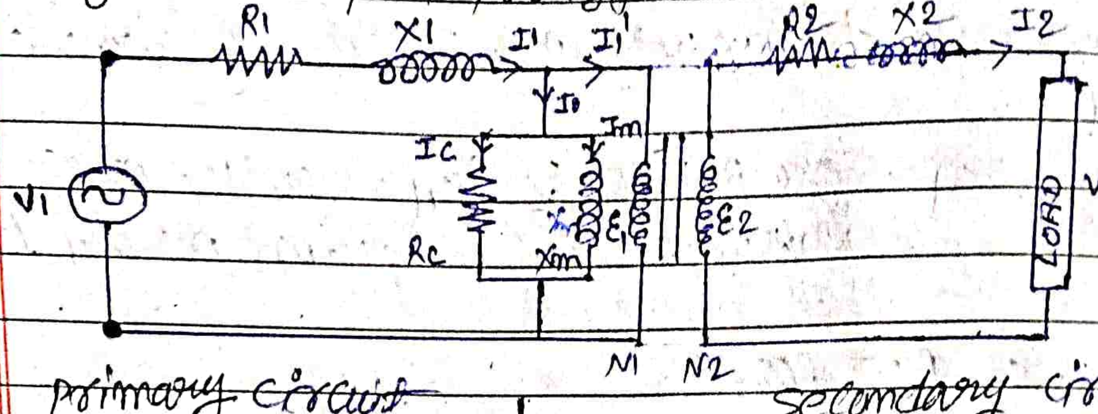
$$V_2 \cos\phi_2 (\cancel{V_2 I_2 \cos\phi_2} + I_2^2 R_2 + P_i - \cancel{I_2 V_2 \cos\phi_2} - 2 I_2^2 R_2) = 0$$

$$P_i - I_2^2 R_2 = 0$$

$$\boxed{P_i = I_2^2 R_2}$$ {(P_i = iron losses & $I_2^2 R_2$ → copper losses)}

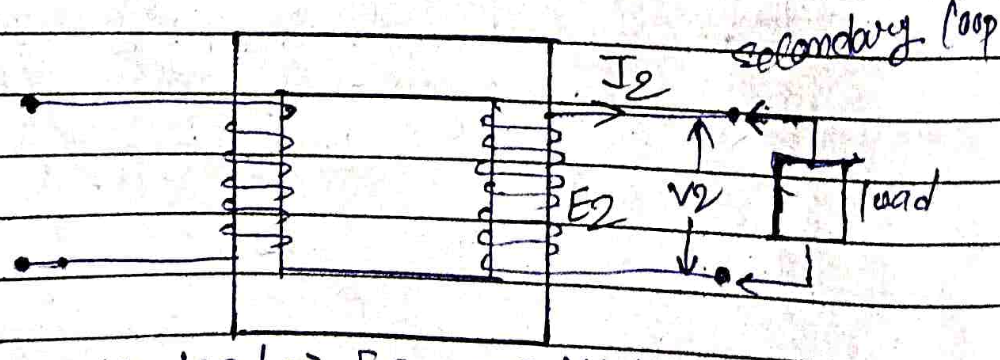
∴ copper losses & iron losses is equal so we can say that from the above expression (maximum value of efficiency).

PYQ Draw equivalent circuit of a transformer and regulation of a transformer:



primary circuit	secondary circuit
V_1 → Ac V supply	R_2 → resistance of secondary winding
I_1 → primary current	X_2 → Leakage reactance of secondary winding
R_1 → resistance of primary winding	I_2 → load current
X_1 → leakage reactance of primary winding	V_2 → load voltage
I_0 → No load current	E_2 → secondary induced emf
I_m → magnetision current	
X_m → magnetision reactance	
I_c → core loss current	
R_c → core ~~current~~ resistance	
e_1 → primary induced emf	~~secondary induced emf~~

* regulation of a transformer:



No load → E2 या V2 NL

on load → V2

V2 ≠ VNL

regulation of a transformer :- The change in Secondary terminal voltage from No load to full load with respect to No load ~~voltage~~ to full load with respect to No load voltage, when primary voltage is kept constant.

$V_2 \rightarrow$ Secondary terminal voltage at any load
$E_2 \rightarrow$ Secondary terminal voltage at No load

Voltage regulation $= \dfrac{E_2 - V_2}{E_2} \times 100$ — (B)

apply KVL in Secondary loop

$$V_2 = E_2 - I_2 Z_2$$

$$E_2 - V_2 = I_2 Z_2$$

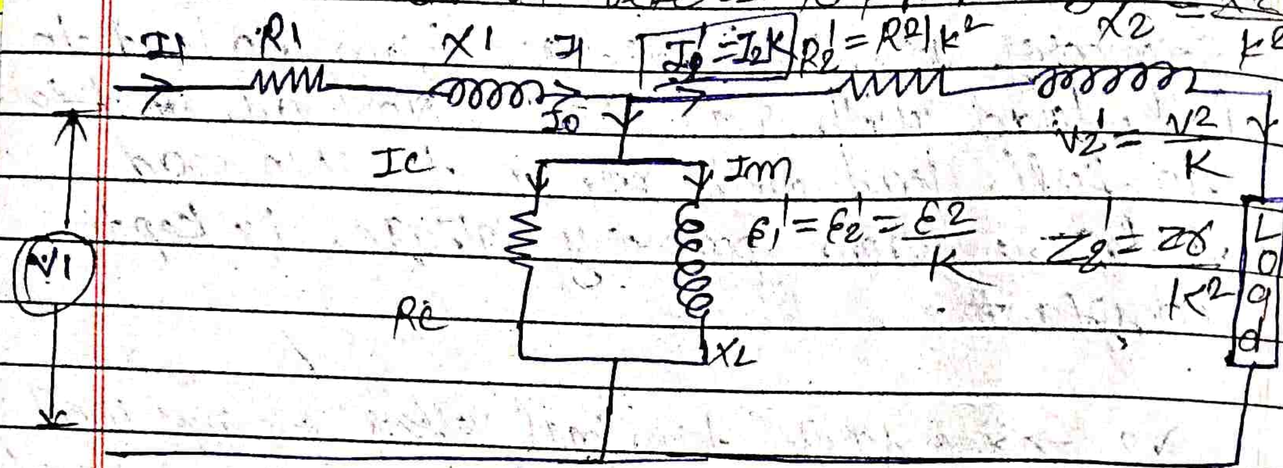
$$E_2 - V_2 = I_2 (R_2 \cos\theta_2 \mp X_2 \sin\theta_2) \quad \text{— (A)}$$

eqn (A) put in (B)

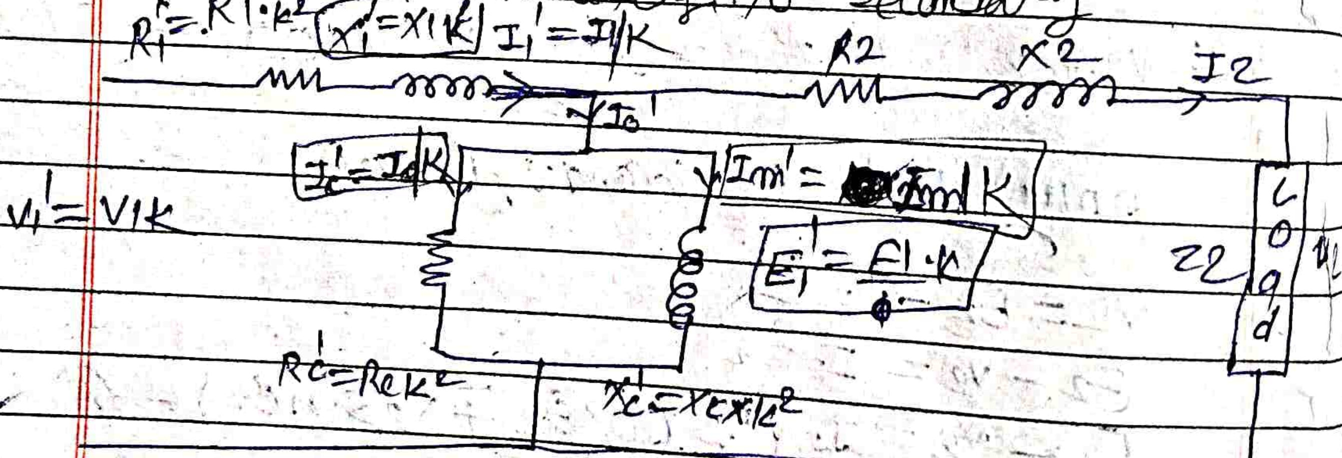
$$VR = \frac{I_2 R_2 \cos\theta_2 \pm I_2 X_2 \sin\theta_2}{E_2} \times 100$$

$$V_R = \left[\frac{I_2 R_2 \cos\theta_2}{E_2} \pm \frac{I_2 X_2 \sin\theta_2}{E_2}\right] \times 100$$

* Equivalent circuit refers to primary



* Equivalent circuit refers to Secondary



T.r → $\frac{V1}{V2} = \frac{E1}{E2} = \frac{N1}{N2} = \frac{I2}{I1} = K$

~~Capacity KVA rating~~

Note ⇒ Connected होती 300 V1 या E1 होगा
load voltage होती E2 या V2 होगा

$$\text{full load current} = \frac{\text{KVA rating} \times 1000}{E1 \text{ or } V1}$$

KVA rating means → capacity

* A 25 KVA loss ~~loss~~ transformer has 500 turns on primary and 40 turns on secondary the primary is connected to 3000V, 50 Hz mains. determine
(i) primary and secondary current at full load. (ii) The secondary emf (iii) The maximum flux in the core

ans → given
$N1 = 500$
$N2 = 40$
$V_1 = 3000\,V$
$f = 50\,Hz$

load current for primary $= \frac{KVA \times 1000}{V1} = \frac{25 \times 1000}{3000} = 8.3\,A$

current ∴ $\frac{N1}{N2} = \frac{V1}{V2}$

$\frac{500}{40} = \frac{3000}{V2} = V_2 = \frac{120000}{500}$

$\boxed{N2 = 240V}$

primary load current $= 8.3A$
and secondary $- 103.75$

load current for secondary current =

$\frac{V1}{V2} = \frac{I2}{I1}$

$I2 = \frac{V1 I1}{V2}$

$I_2 = \frac{3000 \times 8.3}{240}$ $\boxed{I_2 = 103.75}$

(ii) $E_2 = ?$ $\because \frac{N_1}{N_2} = \frac{E_1}{E_2}$

$\because V_1 = E_1 = 3000$

$$\frac{500}{40} = \frac{3000}{E_2}$$

$$E_2 = \frac{3000 \times 40}{500} \quad E_2 = 60 \times 4$$

$$\boxed{E_2 = 240V}$$

(iii) Maximum flux $\rightarrow$

$$E_1 = 4.44\ \phi_m f N_1$$

$$3000 = 4.44\ \phi_m \times 50 \times 500$$

$$\phi_m = \frac{3000}{4.44 \times 25000} = \frac{3}{111}$$

$$\boxed{\phi_m = 0.027\ wb} \text{ weber}$$

* The emf per turn of a single phase 10VA, 2200/220V, 50Hz, transformer is 10V calculate N1 and N2, net cross sectional area are of core for a maximum flux density of 1.5 T.

ans $\Rightarrow$

rating $\Rightarrow$ 10 N_1? N_2? $a = ?$

$E_1 = 2200V$

$E_2 = 220\ V$

$f = 50Hz$

$B = 1.5\ T$

$E_1 = 4.44\ \phi_m f \cdot N_1$

$\because B = \frac{\phi}{a} \quad \phi = Ba$

N_1 = emf per turn of a single phase

$N_1 = \frac{2200}{10}$ $\boxed{N_1 = 220}$

$N_2 = \frac{220}{10}$

$\boxed{N_2 = \cancel{22}}$

$\boxed{N_2 = 22}$

$B = \frac{\phi}{a}$ $\boxed{a = \frac{\phi}{B}}$

$E_1 = 4.44\, \phi m \cdot f \cdot N_1$

$2200 = 4.44 \times \phi m \times 50 \times 220$

$\phi m = \frac{2200}{4.44 \times 50 \times 220}$

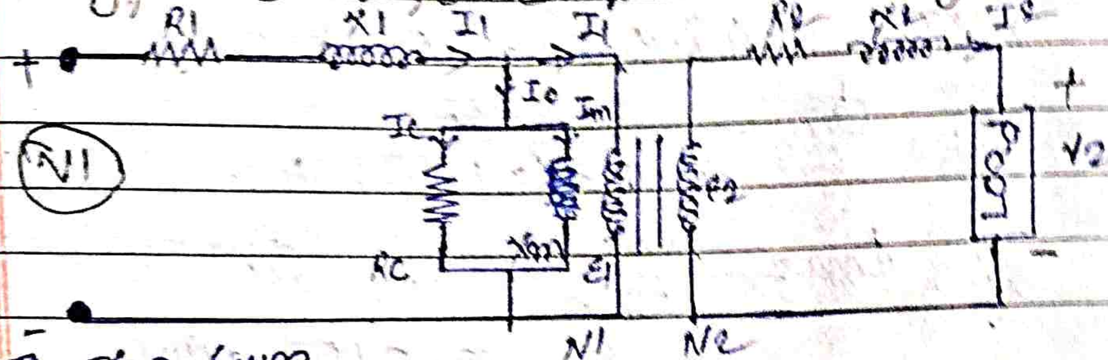
$\phi m = \frac{22}{488.4}$ $\phi m =$

$\phi_m = 0.0450\ wb$

$a = \frac{0.0450}{1.5}$ $\boxed{a = 0.03 m^2}$

आप चाहे तो ये छोड़ भी सकते हैं
चाहे तो कर भी सकते हैं EASY है

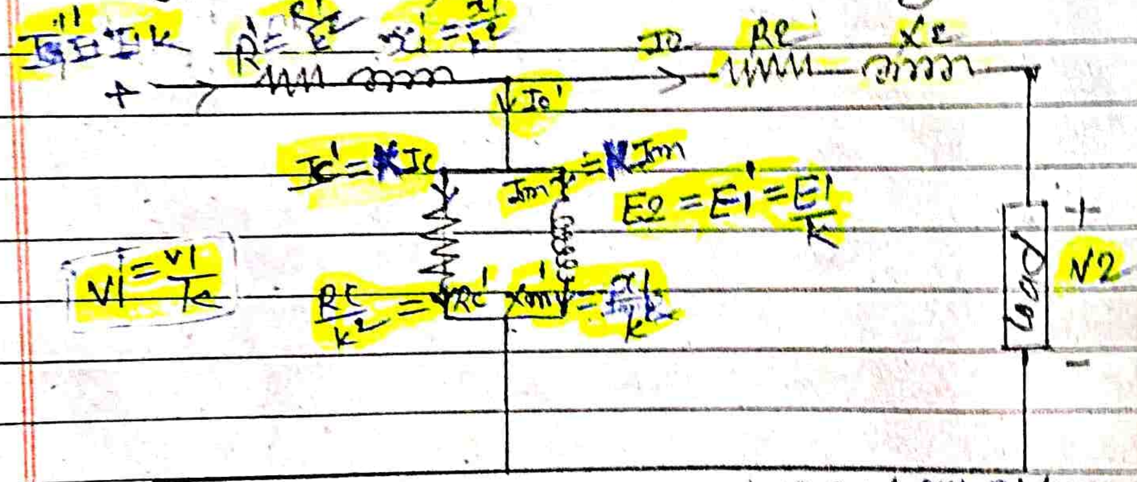
(DYQ) Draw an equivalent circuit and drive circuit parameters of conventional two winding transformer referred to secondary side.



step down

$N1 : N2$

Transformer referred to secondary side



in primary

$\therefore \frac{V1}{V2} = \frac{N1}{N2} = K$

in secondary side

$\frac{V_1}{V_1'} = \frac{N1}{N2}$ $\quad TR = K$

$\boxed{V_1' = \frac{V1}{K}}$

in P.S	
$R1$	in S.S → $\boxed{R_1' = \frac{1}{K^2} R1}$
$X1$	X_1' $\boxed{X_1' = \frac{1}{K^2} X1}$
Xm	Xm' $\quad Xm' = \frac{1}{K^2} Xm$
Rc	Rc' $\boxed{Rc' = \frac{1}{K^2} Rc}$

P.S $\quad I_1 \longrightarrow I_1''$ S.S

$\frac{I_1''}{I_1} = \frac{N1}{N2} = K$

$\boxed{I_1'' = I_1 K}$

P.S — S.S

E_1 — E_1'

$$\frac{E_1}{E_1'} = \frac{N_1}{N_2} = K \qquad \boxed{E_1' = \frac{E_1}{K}}$$

I_m — I_m'

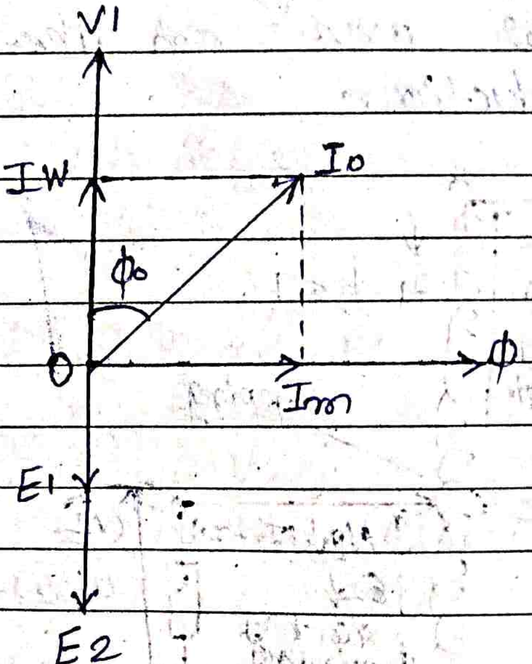
$$\boxed{I_m' = I_m K}$$

I_c → I_c'

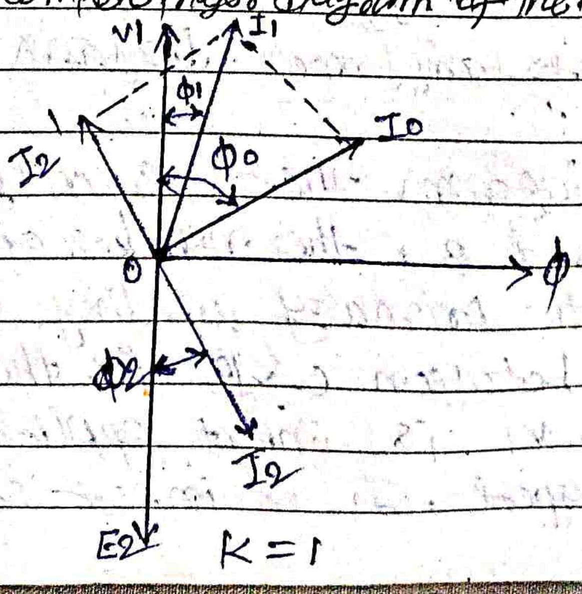
$$\boxed{I_c' = I_c K}$$

PYQ Draw the complete phasor diagram of the transformer under no load conditions.

Sol:-



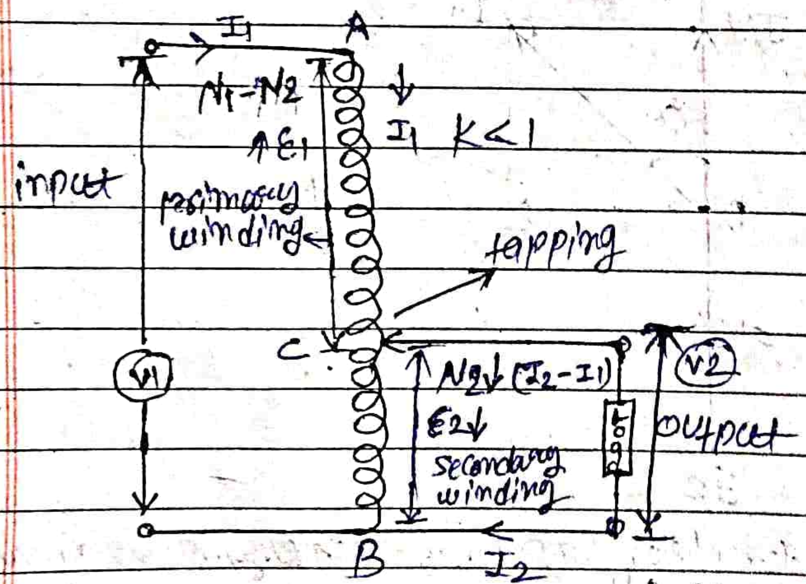
PYQ Draw the complete phasor diagram of the transformer under on load



K = 1

PYQ what do you understand by autotransformer. Explain construction and working principle of an auto transformer. How its different from Conventional two winding transformer.

ans ⇒ An auto transformer is a transformer with only one winding placed on a laminated core. And auto transformer is similar to a two winding transformer but differ in the way the primary and secondary winding are interrelated. Auto transformer works on the principle of self-induction.



Auto transformer - diagram

Construction :-
In the diagram there is only one winding between A and B, the number of turns between A & C is the primary winding and the number of turns between C & B is the secondary winding, V_1 is input applied voltage and V_2 is output, I_1 is input current and I_2

is output current, emf is induced in primary side E1 and secondary side E2 and a tapping is done over c point.

principle :- Auto transformer works on the principle of self - induction.

working :- The working of autotransformer is similar to the conventional transformer. in the autotransformer when current is applied to the input side primary winding of autotransformer it creates magnetic field that induces a emf in the secondary winding and current flows through secondary winding.

advantage :- ① Small in size
② lower weight
③ higher efficiency
④ voltage control as our requirement.

PYQ Difference between auto transformer and Conventional two winding transformer.

	Auto transformer	conventional transformer
(i)	It has only one winding	It have two winding.
(ii)	Voltage is induced due to self induction	voltage is induced due to mutual induction.
(iii)	voltage can be changed as our requirement	voltage cannot change as our ~~requirement~~.
(iv)	losses are very low	losses are very high.
(v)	output voltage is variable.	output voltage is constant.
(vi)	cost is very less	cost is very high

* Transformer efficiency

$$\boxed{\%\eta = \frac{n \times VA\ rating \times \cos\phi}{n \times VA\ rating \times \cos\phi + P_i + n^2 \times P_{cu}} \times 100}$$

(1) 1KVA, single fase transformer has core loss of ~~watt~~ 15 watt and full load cu losses 20watt calculate the efficiency
(i) full load 0.9 pf (lag)
(ii) Half full load unity power factor
(iii) 3/4 full load 0.707 pf (lag or lead)

(i) given VA rating = 1000

p_i = 15 watt

p_{cu} = 20 watt

pf = 0.9 (lag)

η = ?

$$\eta = \frac{1 \times 1000 \times 0.9 \times 100}{1000 \times 0.9 + 15 + 20}$$

$$\cancel{\eta = \frac{90000}{90000 + 300}} \quad \cancel{\eta = \frac{90000}{1200}} \quad \cancel{\eta = \frac{90000}{1200}}$$

$$\eta = \frac{900 \times 100}{900 + 35} \Rightarrow \eta = \frac{900}{935} \times 100$$

$$\eta = \frac{900}{935} \times 100 = 0.9625 \times 100$$

$$\boxed{\eta\% = 96.25\%}$$

(ii)
$$\eta = \frac{0.5 \times 1000 \times 1 \times 100}{0.5 \times 1000 \times 1 + 15 + 20 \times (0.5)^2}$$

$$\eta = \frac{500 \times 100}{520} \Rightarrow \eta = 0.9615 \times 100$$

$$\boxed{\eta\% = 96.15\%}$$

(iii)
$$\eta = \frac{0.75 \times 1000 \times 0.707 \times 100}{0.75 \times 1000 \times 0.707 + 15 + 20 \times 0.5625}$$

$$\eta = \frac{530.25}{530.25 + 26.25} \times 100 \Rightarrow \eta = \frac{530.25}{566.5} \times 100$$

$$\eta = 0.9360 \times 100$$

$$\boxed{\eta = 93.60\%}$$ lead

Q(2) 3300/110V, 50Hz, 60KVA single phase transformer has iron losses of 600 watts. primary and secondary winding resistances are 3.3 ohms and 0.011 ohms respectively. Determine the efficiency of the transformer on full load at 0.8 lag pf load.

Sol:- given:- $V_1 = 3300V$, $KVA = 60$, $f = 50\,Hz$, $R_1 = 3.3\Omega$
$V_2 = 110V$, $R_2 = 0.011\Omega$
$P_i = 600W$, $\cos\phi\,(pf) = 0.8$ lag

$\because$ $\%\eta = \dfrac{n \times VA\ rating \times P.f}{n \times VA\ rating \times pf + P_i + P_{cu} \times n^2}$

P_{cu} = primary copper loss + secondary copper loss

$\boxed{P_{cu} = I_1^2 R_1 + I_2^2 R_2}$

$\because$ full load current = $\dfrac{KVA\ rating \times 1000}{V_1}$

$I_1 = \dfrac{60 \times 1000}{3300} \Rightarrow \boxed{I_1 = 18.18A}$

$I_2 = \dfrac{60 \times 1000}{110} \Rightarrow \boxed{I_2 = 545.45A}$

$P_{cuT} = (18.18)^2 \times 3.3 + (545.45)^2 \times 0.011$

$P_{cuT} = 3272.72 + 330.51 \times 3.3$

$P_{cu} = 3272.72 + 1090.62092$

$\boxed{P_{cu} = 4363.41\ watt}$ on full load

$\%\eta = \dfrac{1 \times 60 \times 1000 \times 0.8}{60 \times 1000 \times 0.8 + 600 + 4363.41} \times 100$

$\boxed{\%\eta = 90.62\%}$

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(Q) In a 50KVA transformer, the iron loss is 500w and full load copper loss is 800w find the efficiency at full load on half load at 0.8 pf lag.

ans → given VA rating = 50×1000
P_i = 500 W $n_1 = 1$
P_{cu} = 800 W $n_2 = 1/2 = 0.5$
pf = 0.8

(i)

$$\%\eta = \frac{1 \times 50000 \times 0.8}{50000 \times 0.8 + 500 + 800 \times 1^2} \times 100$$

$$\%\eta = \frac{4000}{4000 + 1300} \times 100 \Rightarrow \frac{4000}{5300} \times 100$$

$$\%\eta = 0.7547 \times 100$$

$$\boxed{\%\eta = 75.47\%}$$

(ii) at half load

$$\%\eta = \frac{0.5 \times 50000 \times 0.8}{0.5 \times 50{,}000 \times 0.8 + 500 + 800 \times (0.5)^2} \times 100$$

$$\%\eta = \frac{20000}{20{,}000 + 500 + 200} \times 100$$

$$\%\eta = \frac{20000}{20{,}700} \times 1000 \Rightarrow \%\eta = 0.9661 \times 100$$

$$\boxed{\%\eta = 96.61\%}$$

Numericle on refers to primary & secondary.

for primary →

equivalent resistance → R_{1eq}
equivalent reactance → X_{1eq}

$R_{1eq} = R_1 + R_2'$ total equivalent

$\boxed{R_{1eq} = R_1 + R_2/k^2}$ where

$\boxed{R_{01} = \cancel{R_1} + R_2/k^2}$ $\boxed{K = \frac{V_2}{V_1}}$

K transformer ratio

$X_{eq} = X_1 + X_2'$ total equivalent

$\boxed{X_{01} = \cancel{X_1} + X_2/k^2}$

for secondary →

equivalent resistance total equivalent

$R_{eq} = R_2 + R_1'$

$\boxed{R_{02} = \cancel{R_2} + R_1 \times k^2}$ $\boxed{K = \frac{V_2}{V_1}}$

$\boxed{X_{02} = \cancel{X_2} + X_1 \times k^2}$

PYQ A 400/200, 50Hz, 10KVA transformer has primary and secondary winding resistance of 2.5 Ω and 0.5 Ω and winding leakage reactance of 5 Ω and 1 Ω respectively. find the equivalent resistance and reactance refered to secondary side

given ⇒ $V1 = 400V$, $R1 = 2.5\Omega$
$V2 = 200V$ $R2 = 0.5\Omega$
$X1 = 5\Omega$
$X2 = 1\Omega$

$Req = R2 + R1'$

$R02 = R2 + R1/K^2$

$K = \frac{V2}{V1}$ $K = \frac{200}{400}$ $K = \frac{1}{2}$ $\boxed{K = 0.5}$

$R02 = 0.5 + 2.5/0.25$

$R02 = 0.5 + 10$ $\boxed{R02 = 10.5\,\Omega}$

$\boxed{Req = 10.5\,\Omega}$

$X_{2equ} = X2 + X1'$

$X02 = X2 + X1/K^2$ $\boxed{K = 0.5}$

$X02 = 1 + 5/0.25$

$X02 = 1 + 20$

$\boxed{X_{02\,eq} = 21\,\Omega}$

Q7 A 100 KVA, 1100/200 volt single phase transformer has the following parameters $R1 = 0.1\Omega$, $X1 = 0.3\Omega$, $R2 = 0.004\Omega$, $X2 = 0.012\Omega$ find equivalent resistance and leakage reactance as referred to primary side.

ans ⇒ give ⇒ $R1 = 0.1\Omega$, $X1 = 0.3\Omega$, $V1 = 1100V$
$R2 = 0.004\Omega$, $X2 = 0.012\Omega$, $V2 = 200V$

$R01 = R1 + R2/K^2$, $X01 = X1 + X2/K^2$

$K = V2/V1$ $K = \frac{200}{1100}$ $\boxed{K = 0.1818}$ $K^2 = 0.033$

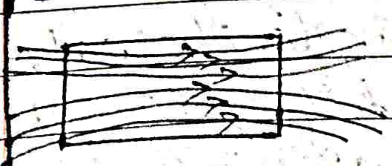
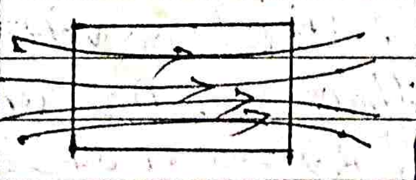
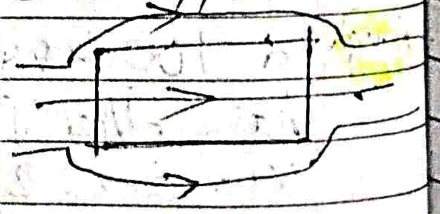
$R01 = 0.1 + 0.004/0.033$, $X01 = 0.3 + 0.012/0.033$

$\boxed{R01 = 0.221\,\Omega}$ $\boxed{X01 = 0.666\,\Omega}$

* What is magnetic material?

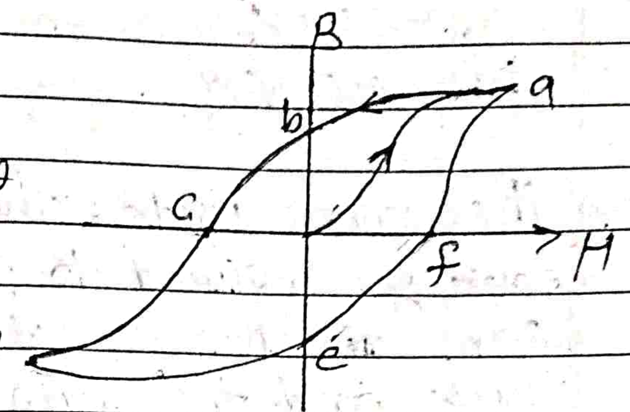
ans ⇒ It is a substance that can be magnetic & produces a magnetic field, they are used in many applications like → electric motors, generators. For ex → iron, nickel

Types of magnetic material

	ferromagnetic	paramagnetic	diamagnetic
(i)	They are solid.	They can be solid, liquid or gas.	They can be solid liquid or gas.
(ii)	They strongly attracted by a magnet.	They weakly attracted by a magnet.	They weakly repelled by a magnet.
(iii)	They tend to move from low to hight field region.	They tend to move from low to high field region.	They tend to move from high to low field region.
(iv)	Ex ⇒ Iron	Ex ⇒ Lithium	Ex ⇒ copper
(v)			
(vi)	after remove external magnetic field it retains it's magnetic property	after remove external magnetic field it does not retain it's magnetic property	after remove external magnetic field it does not retain it's magnetic property.

Explain the BH characteristics of magnetic material.

a → saturation
b → $H=0$, $B\neq 0$ Retentivity
c → $H=-ve$, $B=0$
coercivity
Hysteresis loop



BH characteristic describe the relationship between magnetic flux density (B) and applied external magnetic field.

(i) Saturation :- At high value of external magnetic field, the magnetic flux density of a material reaches a maximum value known as saturation.

(ii) Rentemtivity :- When external magnetic field reduced to zero but magnetic flux density does not return to zero known as rentemtivity.

(iii) Hysteresis :- When external magnetic field increased and decreased than magnetic flux density does not follow the same path.

(iv) Coercivity :- It is the amount of external magnetic field required to demagnitise a material.

(v) Permeability :- It is the ratio of magnetic flux density and external magnetic field

$$\boxed{\mu = \frac{B}{H}}$$

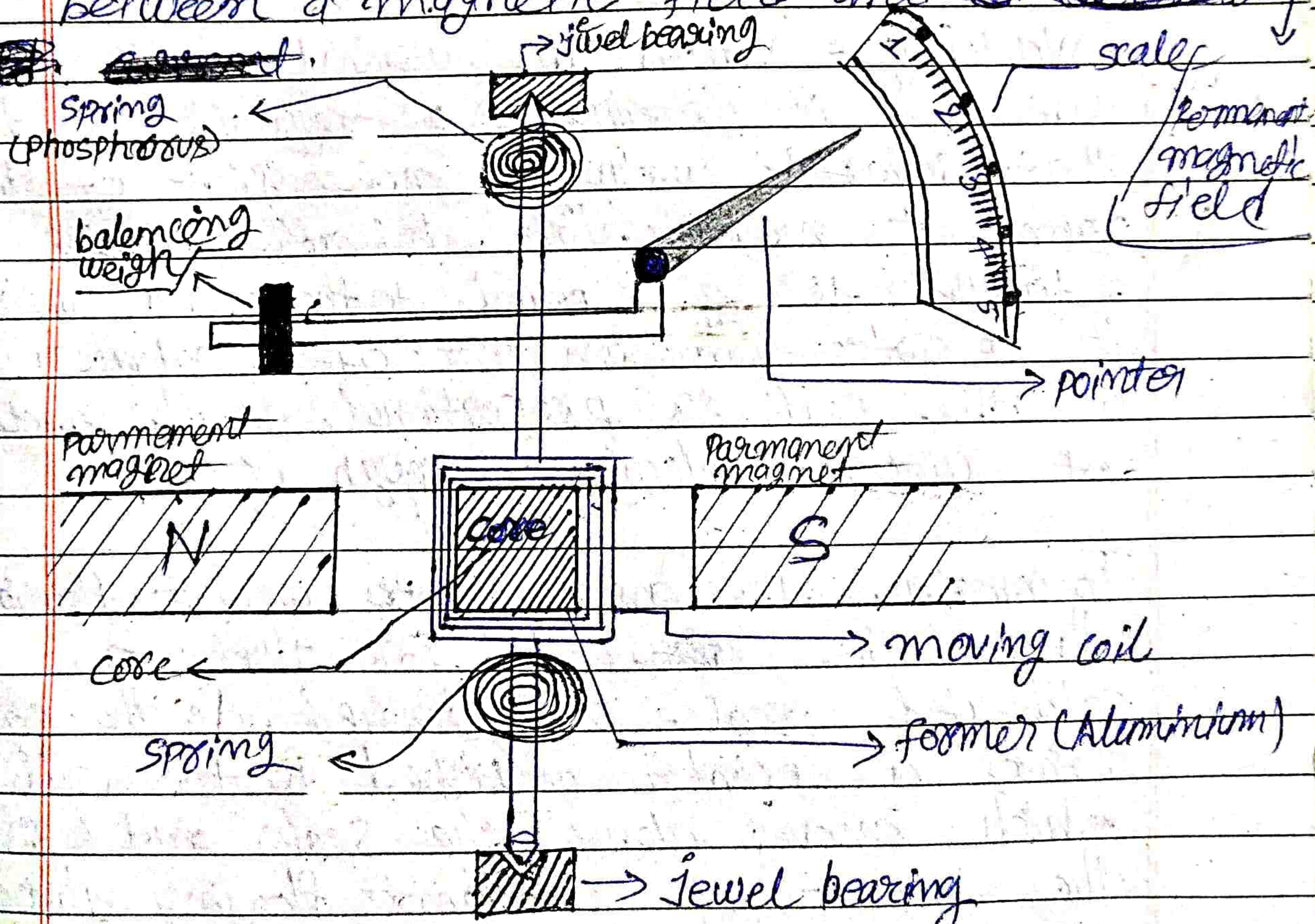
PYQ What can you infer regarding magnetic properties of a material from area under BH curve?

ans ⇒ The area under the BH curve represents the energy required to magnetize the material from unmagnetized to a fully magnetized state and the demagnetize it back to its original state.

Electrical instrument

Q) Explain construction and working of permanent magnet moving coil instrument. Give its merits and demerits and operating principle of a PMMC.

PMMC- stands for parmanent magnet moving coil. PMMC is a type of instrument which is used as voltmeter or ammeter to measure the voltage & current it is works on the principle of interaction between a magnetic field and ~~electrical~~ ~~current~~.



Construction:

Parmanent magnet moving coil consists two parmanent magnet N & S, and a core on which moving coils are placed and core is made of former which is made of Aluminium and core is connected to spring and jewel bearing, spring is made of Phosphorous

A pointer is connected to core with the help of blancing weight and there is a calibrated scale placed over pointer to point magnitude of measurement.

operating principle :- The operating principle of a permanent magnet moving coil is based on the interaction between a ~~mag~~ magnetic field and ~~an electric field~~ permanent magnetic field.

Working :- When dc current flows through wire coil it produces a magnetic field that interacts with magnetic field of the permanent magnet. This interaction causes a torque to be applied to the coil causing it to rotate. The amount of rotation of the coil is proportional to the amount of current flowing through it.

and this torque is

To measure the amount of current flowing through the coil for that a calibrated scale is attached. As the coil rotates a pointer attached to the coil which moves along the scale and indicating the amount of current flowing through the coil.

Applications :- (i) Ammeter
(ii) Voltmeter.
(iii) Galvanometer.
(iv) Ohm meter.

Merits or advantages :

(i) PMMC consumes less power and has great accuracy.

(ii) It's scale can cover arc of 270°.

(iii) It produces no losses due to hysteresis.

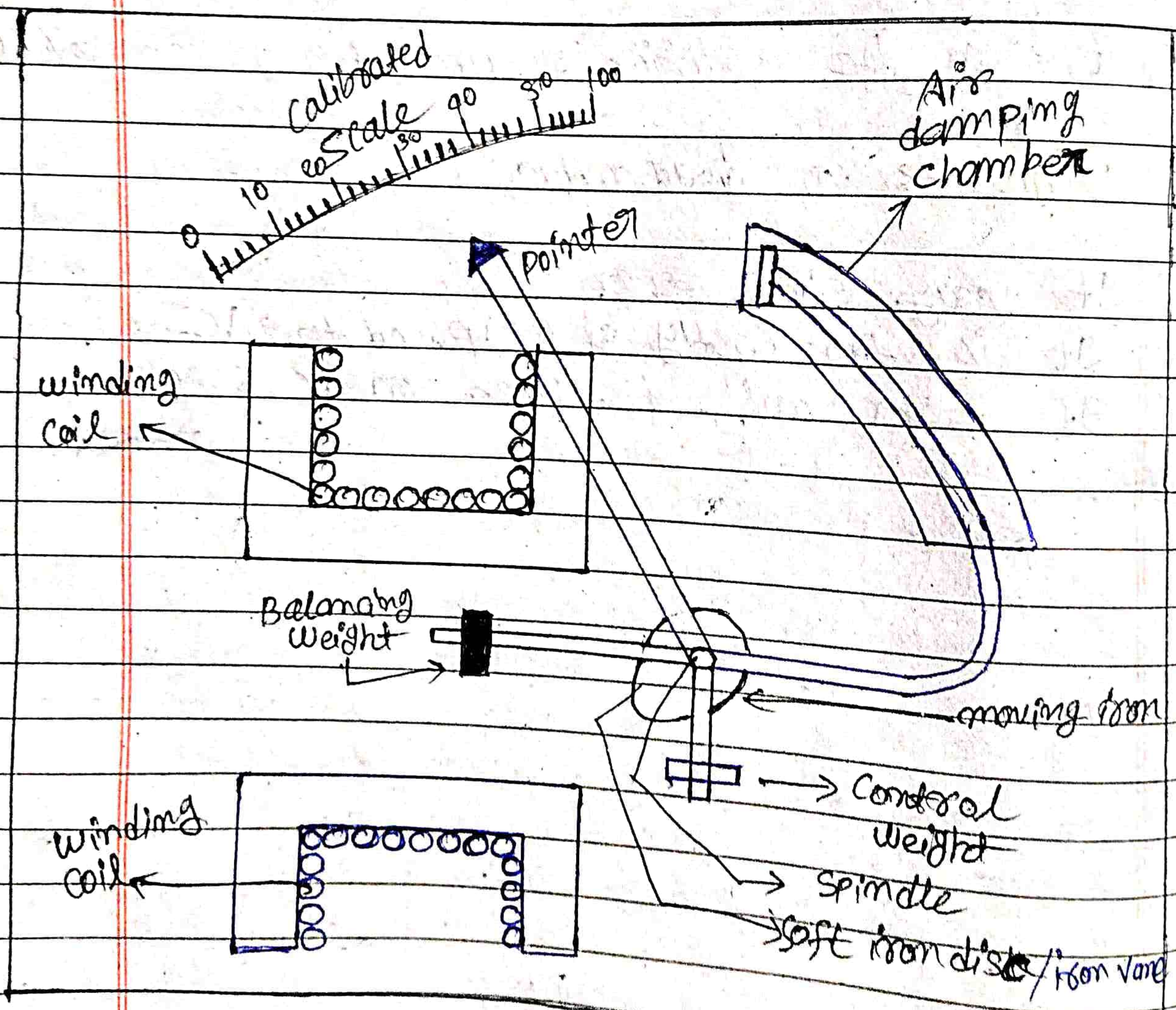
(iv) It can be modified as ammeter or voltmeter.

Demerits or disadvantages :

(i) It may show error
(ii) It is too costly as compared to MCI.
(iii) It can only be used on dc supply.

(PYQ) Explain the construction and working principle of Moving Iron instrument. Give applications ~~principle~~, merits & demerits.

ans ⇒ Moving iron instrument is a type of analog electrical measuring instrument used to measure Ac or Dc electrical quantities such as voltage, current, power.



Construction ÷ MII - Stands for Moving iron instrument, Iron instrument consists two winding coil and a spindle on which calibrated scale, Air damping chamber and Soft iron disc and pointer attached with the help of control weight & Blancing weight, here in moving Iron winding coil is the temporary magnet whose magnetic field strength increases or decreases with current passing through it.

Working ÷ When a current flows through coil, it creates a magnetic field around it which interacts with the electromagnet. The interaction of the magnetic fields causes the iron vane to move, which is connected to a pointer that moves along the calibrated scale and indicating the amount of current or voltage [redacted] flowing through [redacted] coil.

[redacted]

The amount of deflection of the iron vane depends on the strength of the magnetic field produced by current flowing through the coil, deflection of iron vane is proportional to current flowing in the coil.

Applications ÷ (i) power measurement
① voltmeter (ii) Energy metering (iv) electrical system ~~testing~~ testing
② Ammeter (iii) Load monitoring ③ speed meter.

Advantages ÷ It does not show any error.
(ii) It is too cheaper than PMMC.
(iii) It can be used DC along with AC supply.

disadvantage ÷ it does not have great accuracy.
(ii) It can't modified as ammeter or voltmeter

* **Deflection torque** ÷ Deflection torque used for ~~[illegible]~~ deflecting the pointer by measuring quantity.

* **Controlling torque** ÷ Controlling stops torque stops the pointer at its final position and it brings back the pointer at initial position..

* **Damping torque** ÷ Damping torque eliminate the oscilation of pointer near its ~~[illegible]~~ final position.

Classification of electrical instrument

- Abosolute instrument (Primary instrument)
- Secondary instrument
  1. Indicating ins
  2. Recording ins
  3. Integrating ins
- According to type of current
  1. AC instrument
  2. DC instrument
  3. AC/DC instrument

* **Abosolute instrument** ÷ Absolute instrument also known as primary instrument, it measures a physical quantity and provides reading. It does not require calibration against any other instrument.
  Ex→ thermocouples.

~~① Indicating instrument~~ ÷

* **Secondary instrument** ÷ Secondary instrument is an that instrument that requires to calibration against a primary or standard instrument to ensure the accuracy Ex→ multimeter

(i) Indicating instrument :- Indicating instrument indicates the magnitude of quantity being measured.
Ex ⇒ Ammeter, voltmeter etc

(ii) Recording Instrument :- Recording instrument records the magnitude of quantity being measured.
Ex ⇒ ECG, EEG etc.

(iii) Integrating instruments :- Integrating instrument add up the total physical quantities that have been measured such as volume, mass, temperature, pressure etc.

(1) Dc instrument :- The instrument whose deflections are proportional to current or voltage, which is used for dc measurement only. Ex ⇒ PMMC.

(ii) Ac instrument :- Ac instrument measures quantities such as voltage current, frequency and power in Ac circuit only.
Ex ⇒ Induction motor

(iii) Ac/dc instrument :- The instrument having deflection proportional to the square of current or voltage, It can be used for 'dc' as well as 'ac' measurement.
Ex ⇒ Moving iron instrument.

PYQ classify various measuring instruments

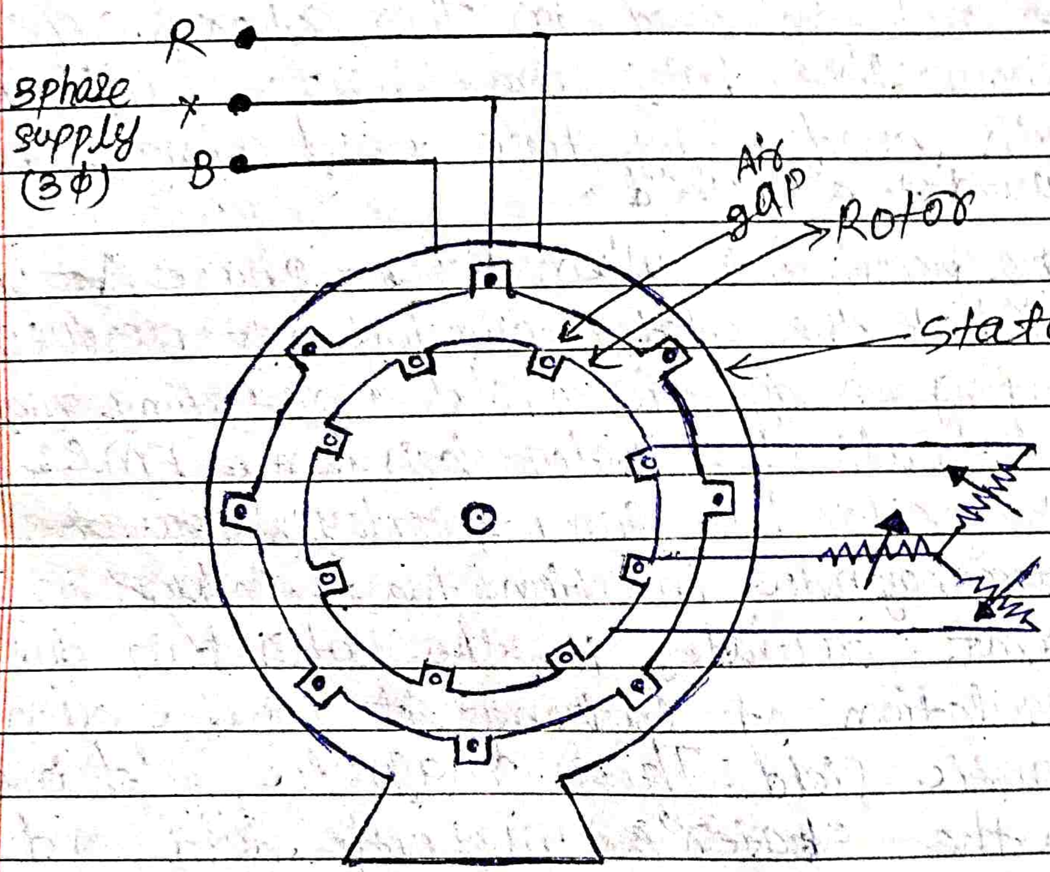
Measuring instrument
- Mechanical instrument
- Electrical instrument
  - Absolute ~~Fixed~~ instrument
  - Secondary instrument
    - Analog instrument
      - Deflecting instrument
        - → indicating instrument
        - → integrating instrument
        - → Recording instrument
      - null deflection instrument
    - digital instrument
- Electronic instrument

PYQ which type of instruments are used for measuring DC quantities only?

Ans ⇒
1. DC Ammeter
2. DC voltmeter
3. DC ohm meter
4. DC whatt meter

PYQ) Explain the construction and working principle of 3ϕ induction motor. why induction motor need stator?

A three phase induction motor is a type of Ac motor that converts electrical energy into mechanical energy throught electromagnetic induction.



Construction ÷ A three phase induction motor has two parts : first stator and second rotor

Stator ÷ stator is the stationary part of the motor and it made up of a cylinder frame made of steel laminations, There are three windings inside cylinder apart from 120° degree.

These windings are connected to three-phase AC supply and produce a rotating magnetic field, in the stator, field winding are used.

Rotor ÷ The rotor is the rotating part of the motor and consists of a cylindrical core made of steel laminations. It has a series of conductive bars, made of copper or aluminium that are arranged in a cylindrical shape and embedded in the rotor's core. The conductive bars are short-circuited at both ends by two end rings. there armature winding are used.

Working principle ÷ when three-phase AC voltage applied to the stator winding, it produces a rotating magnetic field, rotating magnetic fields cuts the rotor bar hence EMF induces in the rotor bar from faraday's law of electromagnetic induction due to induced emf current circulates in the rotor bar, due to circulation of current it creates own magnetic field. This magnetic field interacts with the stator's magnetic field and produces a torque that rotates the rotator.

PYQ

induction motor needs a ~~stator~~ starter to limit the starting current drawn by the motor during its starting period and provide ~~[illegible]~~ protection to the motor against overloading and low voltage condition.

Q10) Discuss the various speed control method of three phase induction motor.

Ans → ∵ running speed of induction motor is

$$N = \frac{120f}{P}$$

from this equation speed of IM can be controlled.

① changing the number of poles method :- Changing the number of poles in the motor by rewinding the stator. This method is not used generally.

② frequency method :- The speed of induction motor is directly proportional to the frequency of the power supply, therefore by changing the frequency the speed of IM can be controlled.

③ Slip control method :- In this method, the slip of the motor is controlled by varying the rotor resistance. This method is commonly used.

④ voltage control method :- The speed of induction motor is directly proportional to the voltage applied to the stator winding. therefore by changing the voltage of stator winding the speed of IM can be controlled.

⑤ External resistance method :- In this method By adding external resistance to rotor the speed of the IM can be controlled.

(PYQ) What are the various types of starters? Explain any two starters in detail.

ans→ Here are various types of staters
(i) D.O.L ~~stator~~ starter
(ii) Star - Delta ~~stator~~ starter
(iii) Auto-transformer ~~stator~~ starter

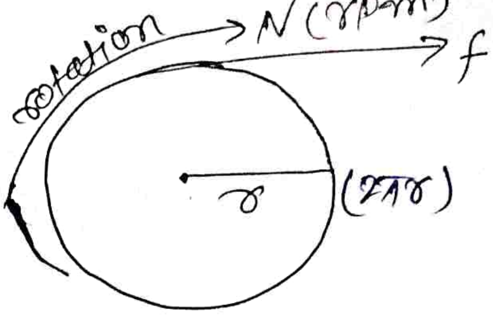
① (D.O.L) Direct - On-line starter ÷ This is the simplest and most common type of starter used with small and medium-sized motors. It connects the motor directly to the supply.

② Star - Delta starter ÷ This starter is used for ~~with~~ larger motors, It connects the motor in a star configuration for starting, and then switches the motor in ~~star~~ delta configuration for normal operation.

③ Auto-transformer starter ÷ This starter is used for larger motors and It provides a variable voltage ~~to the motor~~ by using an autotransformer to step down voltage to the motor. It provides at starting

④ Variable frequency Drive (VFD) Starter ÷ This starter is used for larger motors It provides a variable frequency and voltage to the motor.

Torque equation of dc machine



Power develop

$$P = \frac{\text{worke done}}{\text{time}}$$

$$P = \frac{f \times \text{distance moved}}{\text{time req for one revolution}}$$

{ time required for one revolution $\left(\frac{60}{N}\right)$

$$P = \frac{f \times 2\pi r}{\left(\frac{60}{N}\right)}$$

$$\boxed{P = \frac{2\pi r f N}{60}} \text{ watt}$$

$\because$ Torque $= f \times r$ (distance moved)

$$\boxed{T = f \times r}$$

$$\boxed{P = \frac{2\pi T \cdot N}{60}}$$

Power developed in armature = power at output

$$E_b \cdot I_a = \frac{2\pi T N}{60}$$

$$\because E_b = \frac{\phi P N Z}{60 A}$$

$$\frac{\phi P \cancel{N} Z}{\cancel{60} A} \times I_a = \frac{2\pi \times T \times \cancel{N}}{\cancel{60}}$$

$$\frac{\phi P Z}{A} \times I_a = 2\pi \times T$$

$$T = \frac{\phi P Z \cdot I_a}{2\pi A} \qquad \left\{ \because \frac{1}{2\pi} = 0.159 \right\}$$

$$\boxed{T = \frac{0.159 \cdot I_a \cdot \phi P \cdot Z}{A}} \text{ (N-m) (Torque equation)}$$

* Derive Emf & Torque equation of DC machine.

Sol^n :- P = No of poles | Z = no of conductors in armature

ϕ = flux | A = No of parallel paths

N = speed of armature

Now, Emf induced in armature conductor is from faraday's law of electromagnetic induction

$$\boxed{\varepsilon = \frac{d\phi}{dt}} \quad \text{---} \ (1)$$

total flux ($d\phi$) = flux produced by each pole × no of poles.

$$\boxed{d\phi = \phi \times P} \quad \text{---} \ (2)$$

Time required for to complete one revolution

$$\boxed{dt = \frac{60}{N}} \quad \text{---} \ (3)$$

put eq^n (2) & (3) in eq^n (1)

$$\varepsilon = \frac{\phi \times P}{\frac{60}{N}} \Rightarrow \boxed{\varepsilon = \frac{\phi P N}{60}}$$ { This is only for one Conductor }

Now, Z conductors are distributed in A parallel paths $\left(\frac{Z}{A}\right)$.

$$\varepsilon = \frac{\phi P N}{60} \times \frac{Z}{A}$$

$$\boxed{\varepsilon = \frac{\phi P N Z}{60 A}}$$ Emf equation of DC motor

or $$\boxed{\varepsilon = \frac{\phi N P Z}{60 A}}$$

MST

(pyq) Explain squirrel cage induction motor and wound rotor induction motor or Compare types of 3 phase induction motors and give applications of each type.

→ Squirrel Cage induction motor :- A squirrel cage induction motor is a type of motor that uses a squirrel cage rotor which is made up of a cylinderical laminated core with conductive bars with short - circuited.
Application :- pumps and fans, compressors

→ Wound rotor induction motor :- A wound rotor induction motor is a type of motor that uses a wound rotor which is made up of a cylinderical laminated core with three phase winding, which are connected to slip rings that allow external resistors to be connected to the rotor circuit.
Application :- cranes, hoists, conveyor system

* ~~Types of 3 phase induction motor~~
(i) ~~squirrel cage induction motor.~~
(ii) ~~wound rotor induction motor.~~

* Enlist different types of single - phase induction motor. give application.
(1) squirrel cage induction motor
(2) wound rotor induction motor

(pyq) what do you mean by slip?

ans → The difference between the synchronous speed and rotor spe is known as slip.

Note :- The speed of the rotating magnetic field is known as synchronous speed.

(1) Synchronous speed = $\boxed{N_s = \frac{120 f}{P}}$ rpm

(2) $\boxed{\text{Slip speed} = N_s - N_r}$

(3) $\boxed{\text{Slip } (S) = \frac{N_s - N}{N_s} \times 100}$ $\boxed{S = \frac{N_s - N}{N_s} \times 100}$

rotor frequency / slip frequency

(4) $\boxed{f_r = \frac{P \times (N_s - N)}{120}}$

(1) No load speed of Motor ⇒ $N_0 = N_s(1 - S)$ rpm

(2) full load speed of motor ⇒ $N_{fl} = N_s(1 - S)$ rpm

(3) Frequency of rotor at full load ⇒

$\boxed{f = f_r \times S}$

Slip → full load

PYQ If a 4 pole induction motor running at 50Hz frequency and frequency of rotor current f_r is 2Hz find

(1) Synchronous speed

(2) Slip

ans ⇒ $\boxed{N_s = \frac{120 f}{P}}$ $\boxed{\text{Slip} = \frac{N_s - N}{N_s} \times 100}$

given :- $P = 4$ $f = 50Hz$

$f_r = 2Hz$ $N_s = \frac{120 \times 50}{4}$ $\boxed{N_s = 1500 rpm}$

$\text{Slip} = \frac{N_s - N}{N_s} \times 100$

Q A 3ϕ ; 4 pole, 50Hz induction motor is running at 1455 rpm find slip speed & Slip.

$P = 4$
$f = 50Hz$

ans → $\boxed{Slip = \frac{N - NS}{NS} \times 100}$

$NS = \frac{120f}{P}$ $NS = \frac{120 \times 50}{4}$

$NS = 1500$ $Slip = \frac{Ns - Nr}{Ns} \times 100$

$Slip = \frac{1455 - 1500}{1500} \times 100$

$Slip = \frac{45}{1500} \times 100$ $\boxed{Slip = 3\%}$

$$Slip\ speed = \overset{(NS - N)}{(1500 - 1455)}$$

$\boxed{Slip\ speed = 45\ rpm}$

* An 8 pole alternator runs at 750 rpm and supply power to a 4 pole induction motor, frequency of rotor current is 1.5 Hz determine the speed of motor/rotor.

∵ $\boxed{fr = \frac{P \times (Ns - N)}{120}}$

$2 = \frac{4 \times (150 - N)}{120}$ ⇒ $240 = 4 \times (150 - N)$

$\cancel{\frac{240}{4}} = 150 - N$ ⇒ $60 = 150 - N$

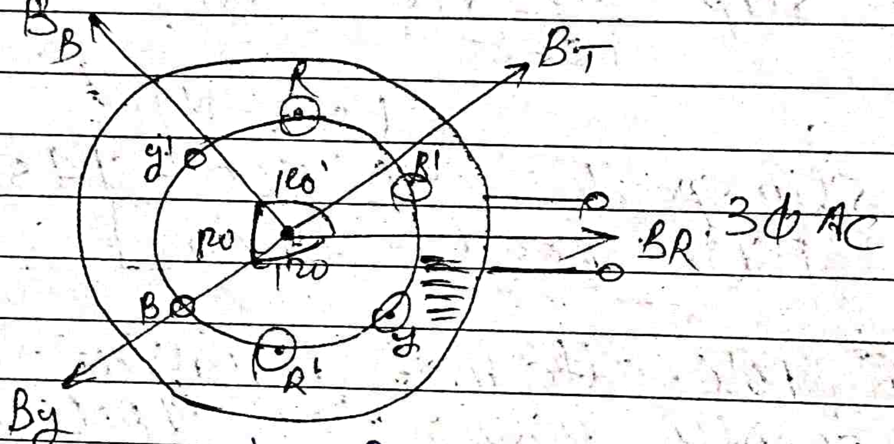
$N = 150 - 60$

$\boxed{N = 90\ rpm}$

$Slip = \frac{150 - 90}{150} \times 100 = \frac{60}{150} \times 100 = 40\%$

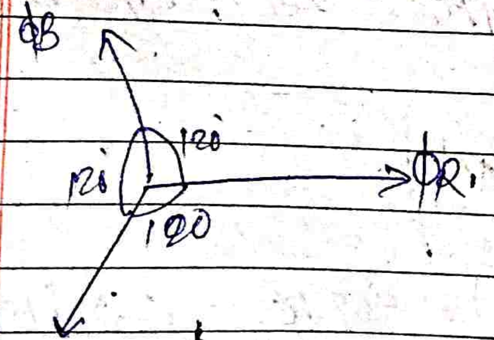
Q19) How rotating magnetic field is produced give mathematical expression.

Sol:- when 3-φ supply applied to the stator winding of 3φ induction motor, a rotating magnetic field is produced. This magnetic field is such that its poles do not remain in a fixed position on the stator but go on shifting their position around the stator. For this reason. It is known as rotating magnetic field.



$\therefore \phi = BA$

$\phi \propto B$



$i = i_m \sin \omega t$

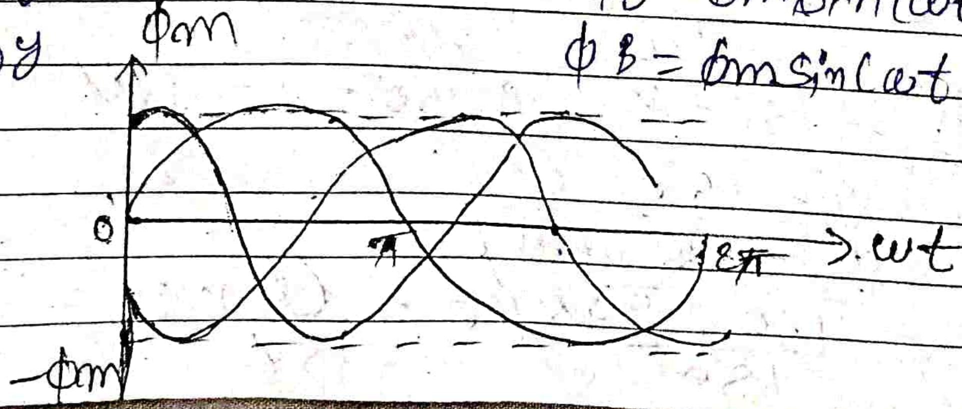
$\phi = \phi_m \sin \omega t$

$\phi_R = \phi_m \sin \omega t$

$\phi_y = \phi_m \sin(\omega t - 120)$

$\phi_B = \phi_m \sin(\omega t - 240)$

graph of eqs



$\theta = 0^\circ$

$\theta = 60^\circ$

$\theta = 180$

Case I → $(\theta = 0^\circ)$

$\phi_R = \phi_m \sin(0^\circ)$

$\boxed{\phi_R = 0}$

$\phi_y = \phi_m \sin(0 - 120^\circ)$

$\phi_y = \phi_m \sin(-120^\circ)$

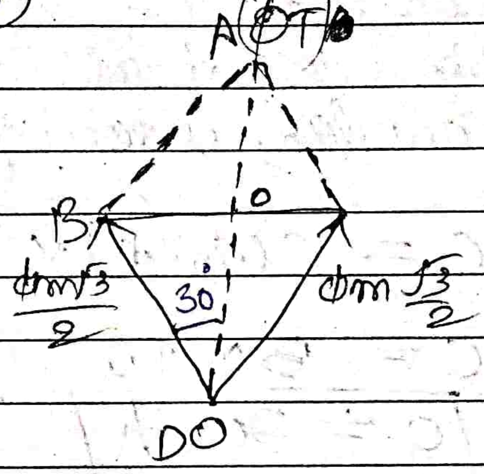
$\phi_y = -\phi_m \frac{\sqrt{3}}{2}$

$\phi_B = \phi_m \sin(0 - 240^\circ)$

$\phi_B = -\phi_m \sin(240^\circ)$

$\phi_B = -\phi_m\left(-\frac{\sqrt{3}}{2}\right)$

$\boxed{\phi_B = \frac{\phi_m\sqrt{3}}{2}}$



$\phi_T = AD$

$\phi_T = 2OD$

$\phi_T = 2 \times OB \cos 30^\circ$

$\phi_T = 2 \times \phi_m \frac{\sqrt{3}}{2} \times \cos 30^\circ$

$\phi_T = 2 \times \phi_m \frac{\sqrt{3}}{2} \times \frac{\sqrt{3}}{2}$

$\phi_T = \cancel{2} \times \phi_m \times \frac{3}{\cancel{4}\,2}$

$\phi_T = \frac{3}{2}\phi_m$

$\boxed{\phi_T = 1.5\,\phi_m}$

* Capacity of the cell =

① current (in A) × time (in hours) Ah
~~② charge (Q) during charging~~ =

Q) A lead acid cell maintains a constant current of 3A for 10 hours before its terminal voltage falls to 1.8V. Calculate the capacity of the cell.

Ans) $C = C(\text{in A}) \times t\ (\text{in H})$

$C = 3 \times 10$

$\boxed{C = 30\ Ah}$

② Charge (Q) during charging

$\boxed{Q = \text{charging current} \times \text{charging time}}$

$\boxed{Q = It}$

③ Energy during charging :

$\boxed{E = \text{charging voltage} \times Q}$

$\boxed{E = V \times Q}$

(4) charge during discharging

Q = discharging current × Discharging time

$\boxed{Q = It}$

(5) Energy during discharging

$\boxed{E = \text{Average discharging voltage} \times Q}$

$\boxed{E = V \times Q}$

(6) Quantity efficiency = Q during discharging

$$\boxed{QE = \frac{Q \text{ during discharging}}{Q \text{ during charging}} \times 100}$$

(7) Energy efficiency

$$\boxed{Ef = \frac{E \text{ during discharging}}{E \text{ during charging}} \times 100}$$

(PYQ) A battery has taken a charging current of 5.2 A for 24 hours at a voltage of 2.25 V, While discharging, it gave a current of 4.5 A for 24 hours at an average voltage of 1.85 V. Calculate the quantity efficiency and energy efficiency of the battery.

Sol^n :- $Q.E = \dfrac{Q \text{ during disc}}{Q \text{ during char}} \times 100$

$Q.d.dis = I.du.dis \times t.du.dis$

$= 4.5 \times 24$

$\boxed{Q = 108\ Ah}$

$Q\ du.ch = I.du.ch \times t.du.char$

$Q = 5.2 \times 24$

$\boxed{Q = 124.8\ Ah}$

$QE = \dfrac{108}{124.8} \times 100$

$\boxed{QE = 86.53\%}$

$\boxed{E.E = \dfrac{E \text{ dur dis}}{E \text{ dur char}} \times 100}$

$E \text{ dur dis} = Q \text{ dur dis} \times V \text{ dur dis}$

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$E = 108 \times 1.85$

$\boxed{E = 199.8}$ Wh

E. dur cha = I dur char × V dur char

$E = 124.8 \times 2.25$

$\boxed{E = 280.8 \text{ Wh}}$

energy efficiency $= \frac{199.8}{280.8} \times 100$

$\boxed{EE = 71.15\%}$

(P40) A 3Φ, 4 pole 50Hz induction motor has a fractional slip = 0.02 at no load and 0.04 at full load. Calculate synchronous speed, No load speed of motor, full load speed of motor, frequency of rotor at full load.

Sol:- $P = 4$ No load slip = 0.02
full load slip = 0.04

$\boxed{NS = ?}$ $\boxed{N_0 = ?}$ $\boxed{N_f = ?}$ $\boxed{f_r = ?}$

$NS = \frac{120f}{P}$ $NS = \frac{120 \times 50}{4}$ $\boxed{NS = 1500 \text{ rpm}}$

$N_0 = NS(1-S)$

$N_0 = 1500(1-0.02)$

$N_0 = 1500 \times 0.98$

$\boxed{N_0 = 1470 \text{ rpm}}$

$\boxed{N_f = NS(1-S)}$

$N_f = 1500(1-0.04)$

$N_f = 1500(0.96)$

$\boxed{N_f = 1440 \text{ rpm}}$

$f_r = f \times S$

$f_r = 50 \times 0.04$

$\boxed{f_r = 2 \text{ Hz}}$