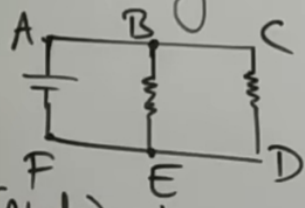
Kirchhoff's First Law / Junction Rule / Kirchhoff's Current Law (KCL)

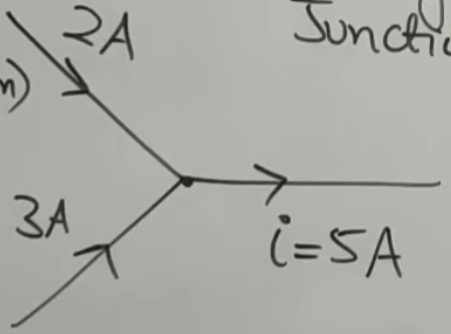
At any Junction, → where 3 or more wire/conductor meets.

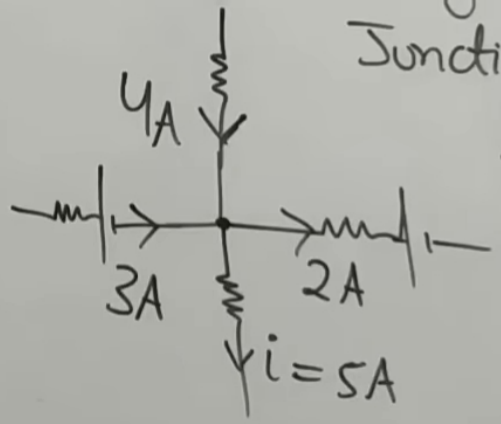


(Node) ↓ (Junction)

B, E

the sum of current entering the Junction = Sum of current Leaving the Junction





$3+4=2+i$

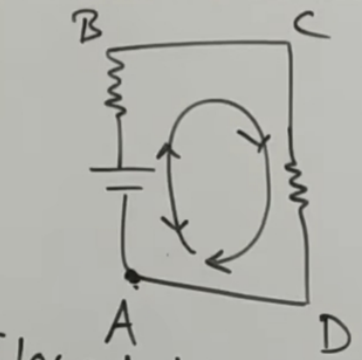
$7=2+i$

$\boxed{i=5A}$

Kirchhoff's 2nd Law / Loop Rule / Kirchhoof's Voltage Law (KVL)

"The algebric sum of change in Potential around a CLOSED Loop is Zero."

$$\sum \Delta V = 0 \quad \text{Closed Loop.}$$



Closed Loop
ABC D A

$V_A - V_A = 0$

Potential gain $\rightarrow +V$ Potential drop $\rightarrow -V$

Closed loop $\oint \pm V_1 \pm V_2 \pm V_3 \pm \text{---} - V_n = 0$

Principle of Conservation of Energy.

KCL(Kirchoff's Current Law) is based on **"Conservation of Charge"**

⇩

Charge can neither be created nor be destroyed

Current is basically Charge per unit time

$$\mathbf{I = Q / t}$$

KVL (Kirchoff's Voltage Law) is based on **"Conservation of Energy"**

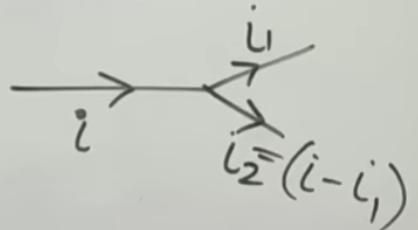
Basically, $\mathbf{V = \frac{W_{ext}}{q}}$

Work - joules / second

Thus, energy can neither be created nor be destroyed

How To Apply Kirchhoff's Law.

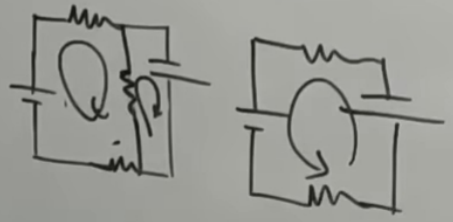
① Draw current from one/more cell → Svadanusar.
follow KCL for distribution of current.



② Choosing a Loop.

i) Should be closed loop/Loops.
Can involve any number of cells, resistors, capacitors etc.

③ Direction of Loop → path



Clockwise / Anticlockwise.
2 loops in same questions → take CW or ACW one/both

How To Apply Kirchhoff's Law.

(4) Potential drop or Potential gain.

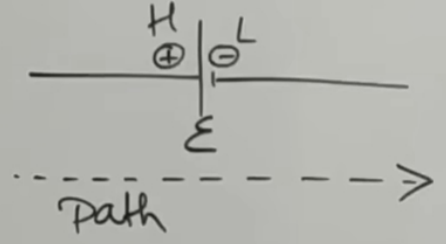
Higher Potential ⟶ lower Potential

Potential drop

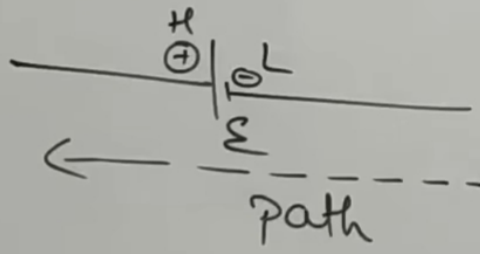
$\Delta V = -ve$

H ⟶ L

Cells:



$\Delta V = -\varepsilon$



$\Delta V = +\varepsilon$

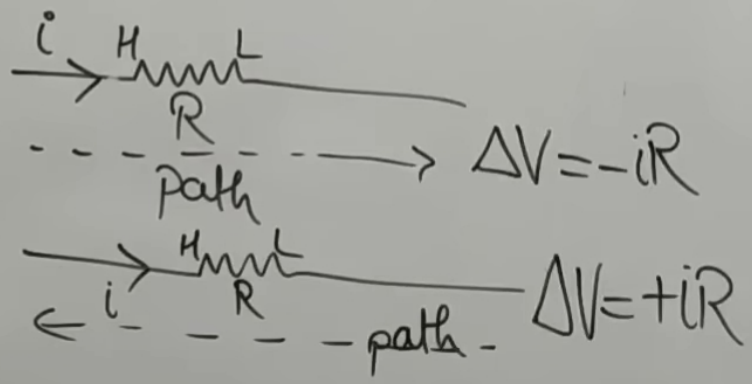
Lower Potential ⟶ Higher Potential

Potential gain

$\Delta V = +ve$

L ⟶ H

Resistor.



$\Delta V = -iR$

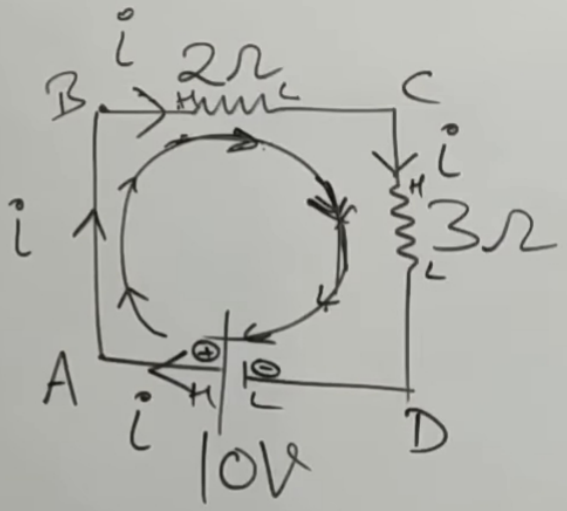
$\Delta V = +iR$

*** Remember for KVL ***

In Cell, If Path follows from - to +, Take Δv = +ve

In resistors, If Current (i) and path are in opposite direction, take ΔV = +ve

Q1)



Loop ABCDA (Clockwise)

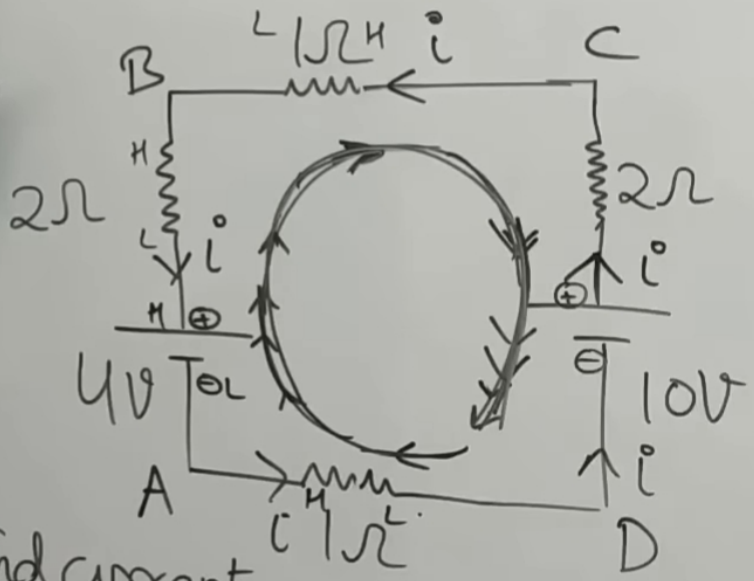
$$\Sigma \Delta V = 0$$

$$+10V - 2i - 3i = 0$$

$$5i = 10$$

$$i = \frac{10}{5} = 2A$$

Q2)



Find current in each resistor.

Loop ABCDA (Clockwise.)

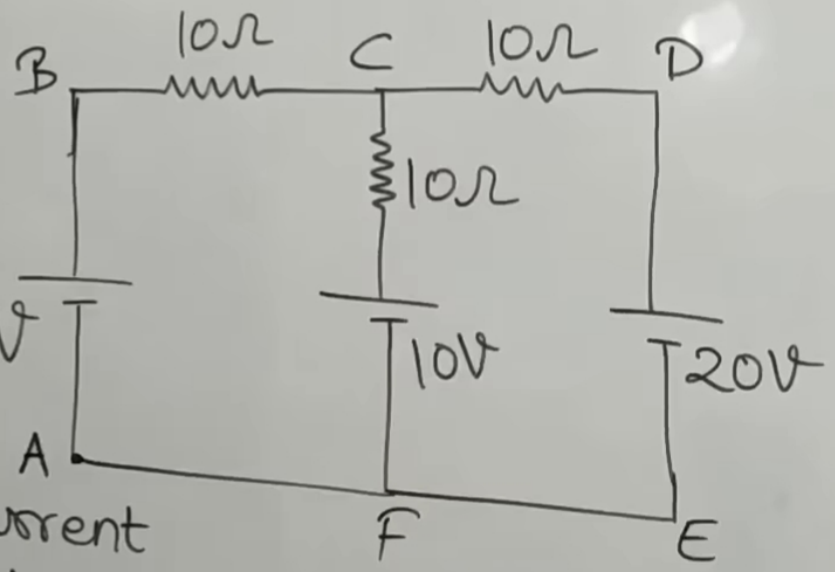
$$\Sigma \Delta V = 0$$

$$+4V + 2i + i + 2i - 10V + i = 0$$

$$6i = 6$$

$$\boxed{i = 1A}$$

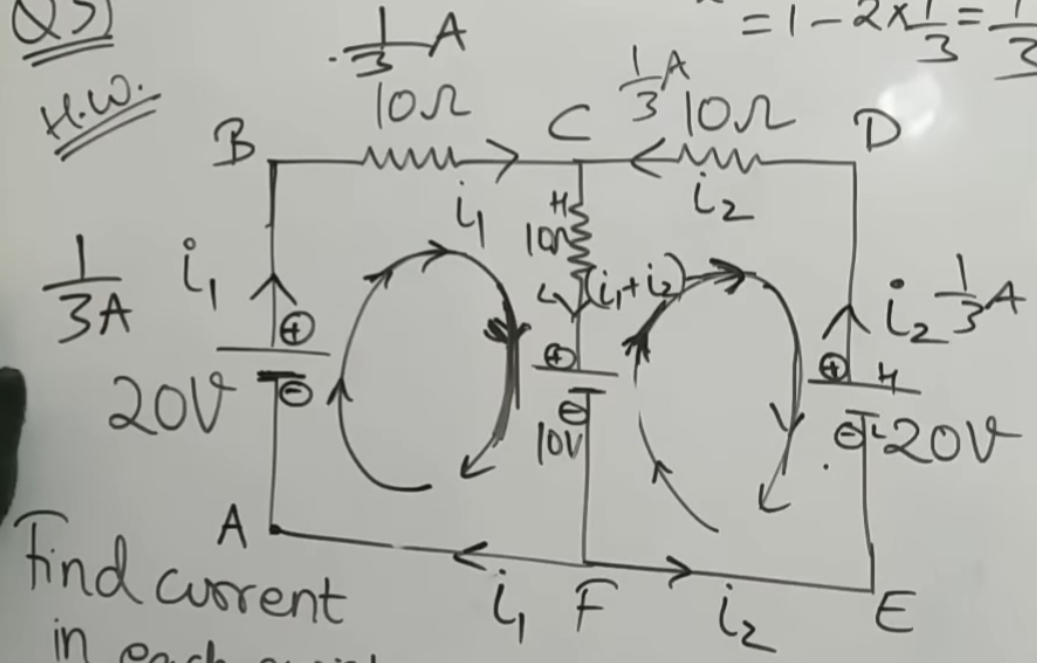
Q3)



Find current in each resistor.

Q3)

H.W.



Find current in each resistor.

Loop ABCFA

$$+20 - 10i_1 - 10(i_1+i_2) - 10 = 0$$

$i_2 = 1 - 2i_1$

$= 1 - 2\times\frac{1}{3} = \frac{1}{3}A$

$20i_1 + 10i_2 = 10$

$2i_1 + i_2 = 1$ —(i)

Loop CDEFC

$+10 + 10(i_1+i_2)$

$+10i_2 - 20 = 0$

$20i_2 + 10i_1 = 10$

$2i_2 + i_1 = 1$ —(ii)

$2i_1 + i_2 = 1 \times 2$

$\ominus\ 2i_2 + i_1 = 1$

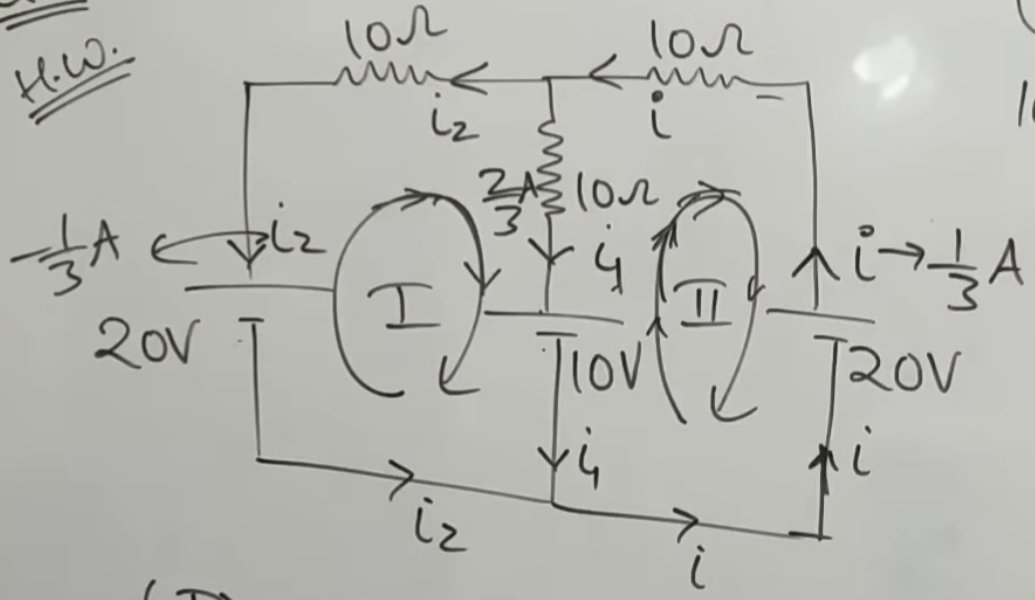
$3i_1 + 0 = 1$

$3i_1 = 1$

$\boxed{i_1 = \frac{1}{3}}$

Q3) $i = i_1 + i_2 = \frac{2}{3} - \frac{1}{3} = \frac{1}{3}A$

H.W.



(I)

$+20 + 10i_2 - 10i_1 - 10 = 0$

$10i_1 - 10i_2 = 10$

$i_1 - i_2 = 1$

$\frac{2}{3} - i_2 = 1$

$i_2 = \frac{2}{3} - 1 = -\frac{1}{3}A$

(II)

$10 + 10i_1 + 10i - 20 = 0$

$10i_1 + 10i = 10$

$i_1 + i = 1$

$i_1 + i_1 + i_2 = 1$

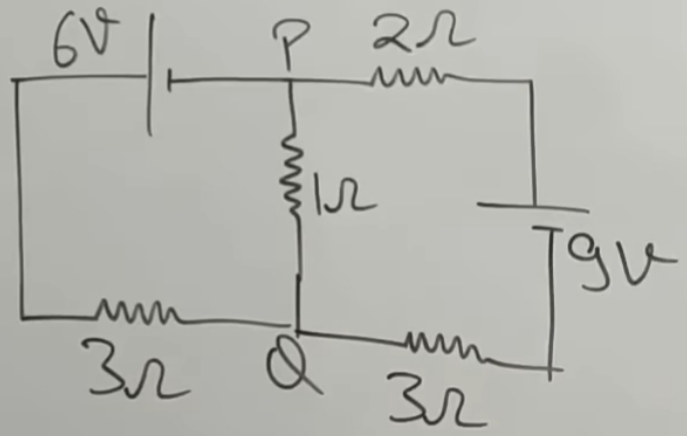
$2i_1 + i_2 = 1$

$+ \quad i_1 - i_2 = 1$

$3i_1 = 2$

$i_1 = \frac{2}{3}A$

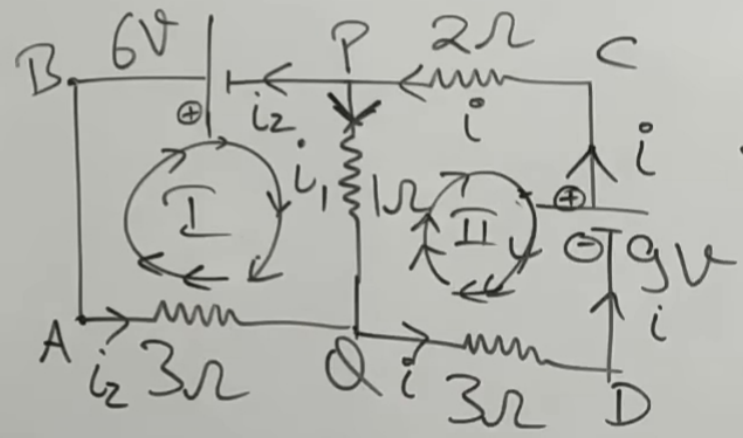
Q4) IIT 2015 Mains



Find the current in 1Ω resistor.

a) 1.13A P → Q
b) 1.13A Q → P
c) 0.13A Q → P
d) 0.13A P → Q

Q4) IIT 2015 Mains



Find the current in 1Ω resistor.

a) 1.13A P→Q
b) 1.13A Q→P
c) 0.13A Q→P
d) 0.13A P→Q

$i_1 = \frac{-3}{24} = \pm 0.125A \approx -0.13A$

Loop ABPQA

$-6 - i_1 + 3i_2 = 0$

$3i_2 - i_1 = 6$ —(i)

Loop PCDQP

$-9 + 3i + i_1 + 2i = 0$

$5i + i_1 = 9$

$5(i_1 + i_2) + i_1 = 9$

$5i_1 + 5i_2 + i_1 = 9$

$6i_1 + 5i_2 = 9$ —(ii)

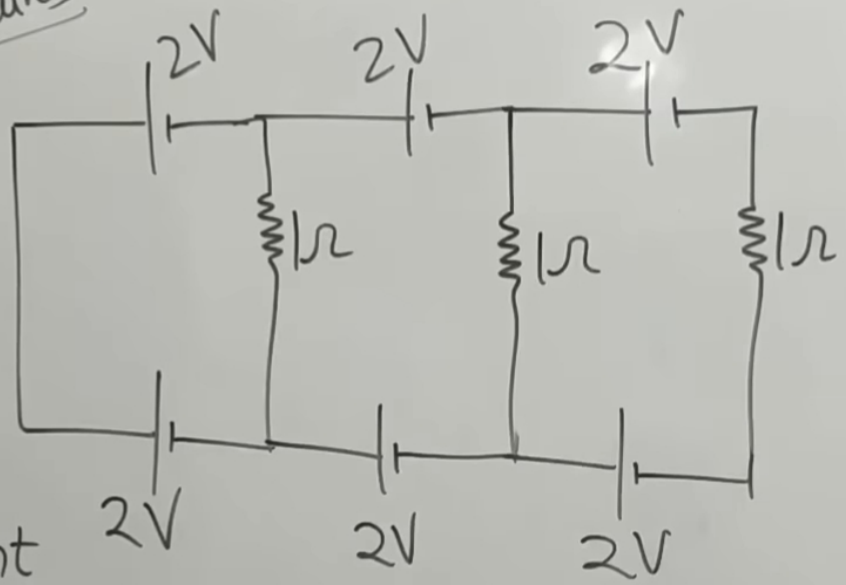
$i = i_1 + i_2$

$3i_2 - i_1 = 6 \times 5$

$6i_1 + 5i_2 = 9 \times 3$

$-23i_1 = 3$

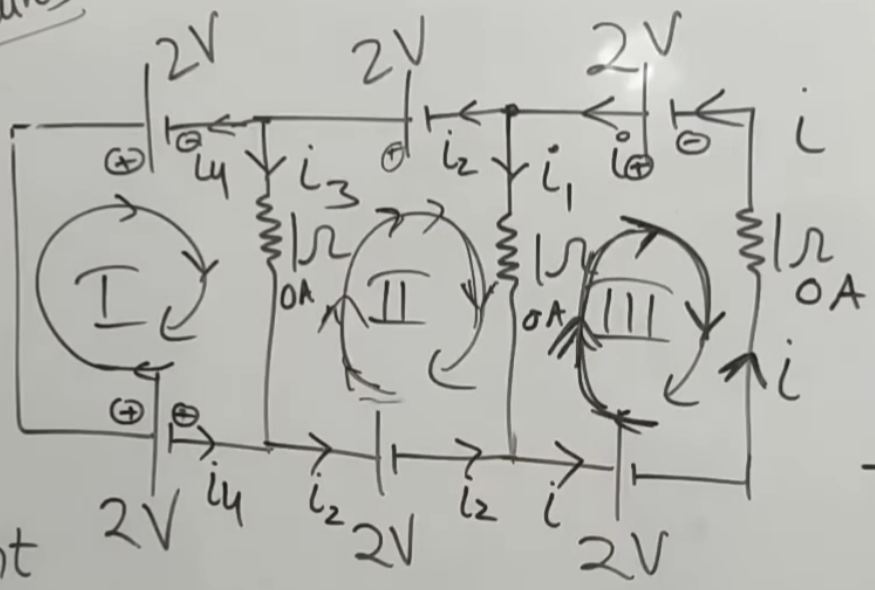
Q6) IIT JEE 2017 Mains



Find current in each resistor

a) 0.25A
b) 0.5A
c) 0A
d) 0.75A.

Q6) IIT JEE 2017 Mains



Find current in each resistor

a) 0.25A
b) 0.5A
c) 0A
d) 0.75A.

Loop I

$+2V-2V-i_3\times1=0$

$\boxed{i_3=0}$

Loop II

$+2V+i_3-2V-i_1=0$

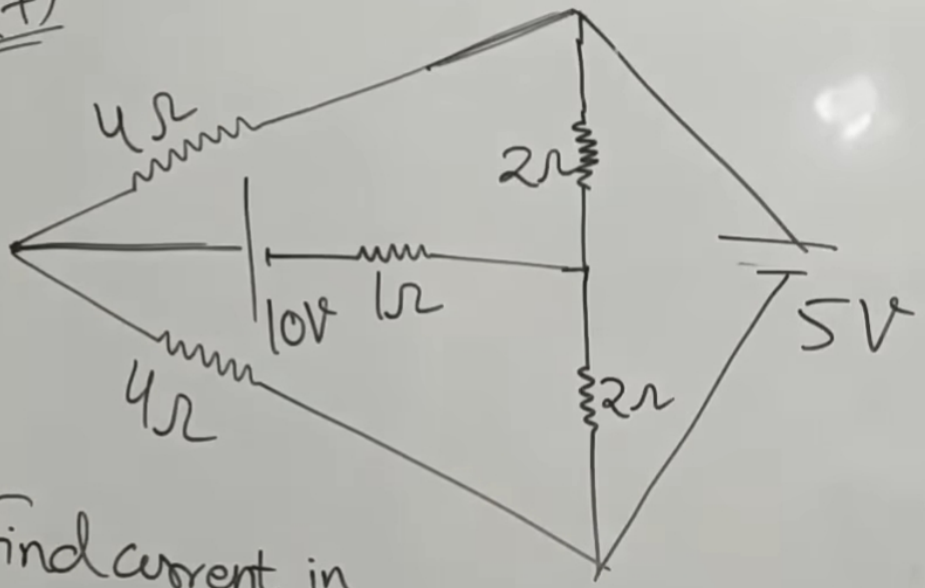
$\boxed{i_3=i_1=0}$

Loop III

$+2V+i_1-2V+i=0$

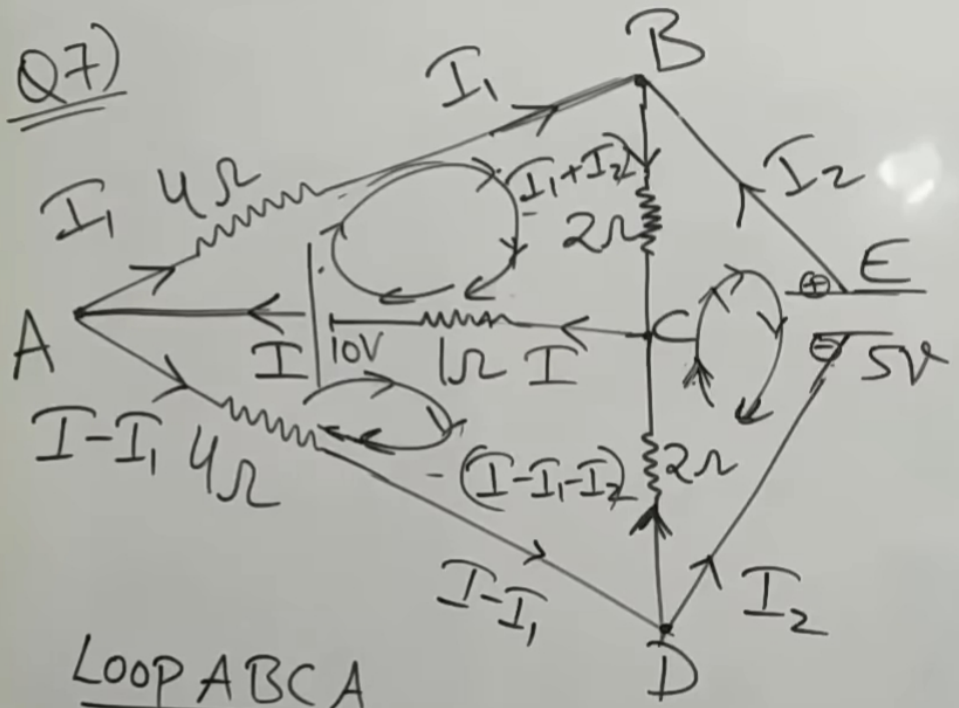
$i=-i_1=0$

Q7)



Find current in each resistor.

Q7)



Loop ABCA

$+10-4I_1-2(I_1+I_2)-I=0$

$I+6I_1+2I_2=10$ -(i)

Loop ACDA

$-10+I+2(I-I_1-I_2)+4(I-I_1)=0$

$7I-6I_1-2I_2=10$ -(ii)

Loop III BEDB

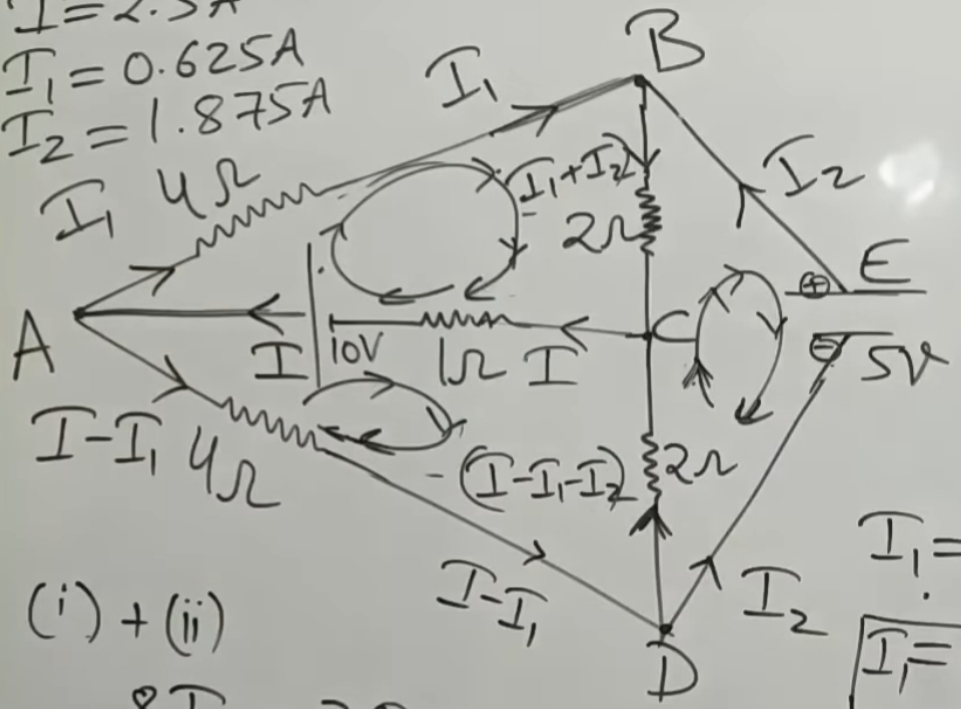
$-5-2(I-I_1-I_2)+2(I_1+I_2)=0$

$4I_1+4I_2-2I=5$ -(iii)

$I = 2.5A$

$I_1 = 0.625A$

$I_2 = 1.875A$



$6I_1 + 2I_2 = 7.5 \times 2$

$4I_1 + 4I_2 = 10$

$8I_1 + 0 = 5$

$I_1 = \frac{5}{8}$

$I_1 = 0.625A$

$7I - 6I_1 - 2I_2 = 10$ (ii)

(i) + (ii)

$8I = 20$

$I = \frac{20}{8} = \frac{5}{2} = 2.5A$

$I + 6I_1 + 2I_2 = 10$ (i)

$4I_1 + 4I_2 - 2I = 5$ (iii)

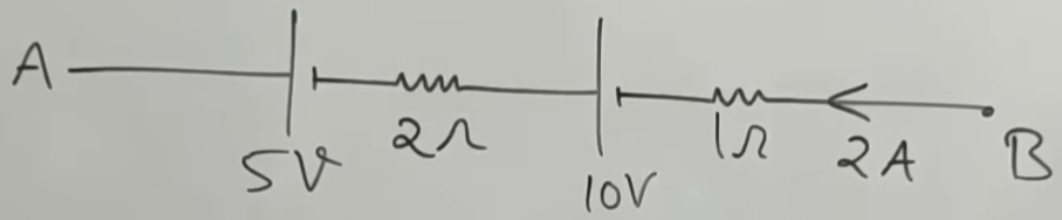
$36 \times \frac{5}{48} + 2I_2 = \frac{15}{2}$

$2I_2 = \frac{15}{2} - \frac{15}{4}$

$I_2 = \frac{15}{8}$

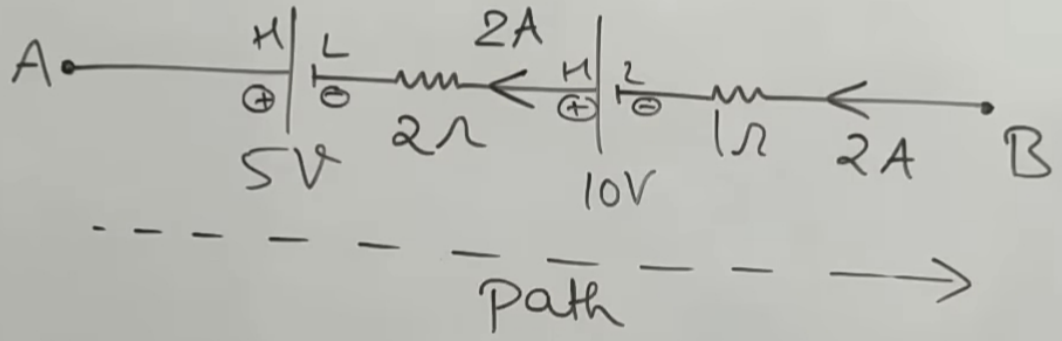
Potential difference between 2 points.

$V_A - V_B = ?$



Potential difference between 2 points.

$V_A - V_B = 8V$.



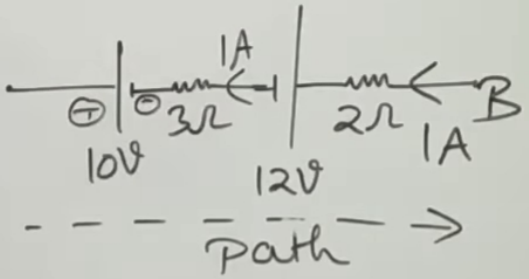
$V_A - 5 + 2\times2 - 10 + 1\times2 = V_B$

$V_A - 8 = V_B$

$V_A - V_B = 8V$

Potential difference between 2 points.

$V_A - V_B = 8V$.

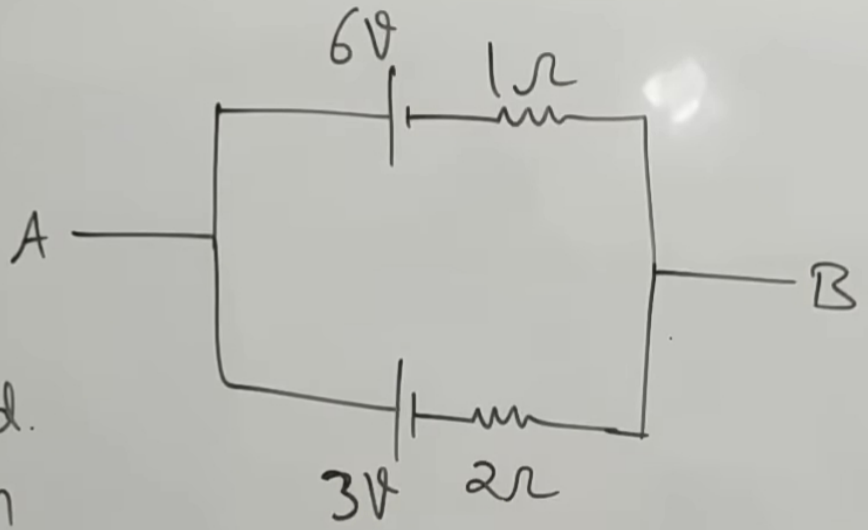


$$V_A - 10 + 3\times1 + 12 + 2\times1 = V_B$$

$$V_A + 7 = V_B$$

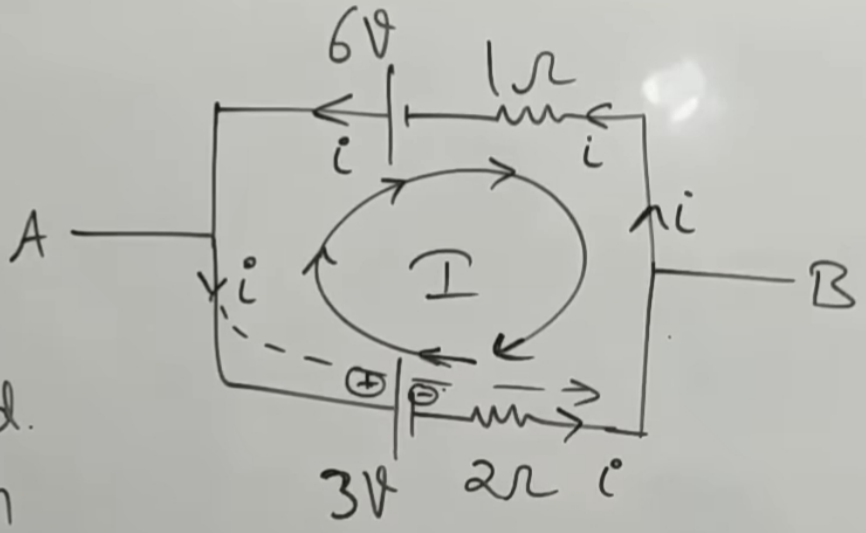
$$\boxed{V_A - V_B = -7V}$$

IIT
2011



Find p.d. between A & B.

IIT
2011



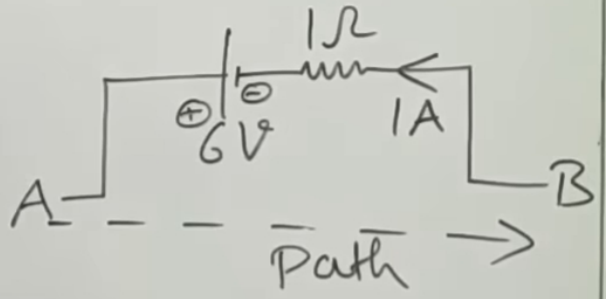
Find p.d. between A & B.

$V_A - 3 - 2\times1 = V_B$

$3V - 6V + i\times1 + 2\times i = 0$

$-3 = -3i$

$i = 1A$



$V_A - 6 + 1\times1 = V_B$

$V_A - 5 = V_B$

$V_A - V_B = 5V$