بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

বিস্‌মিল্লাহির রাহ্‌মানির রাহীম

উদ্ভাস

একাডেমিক এন্ড এডমিশন কেয়ার

Class 12: Physics 2nd Paper (Chapter-3)

Current electricity

Lecture : P-09

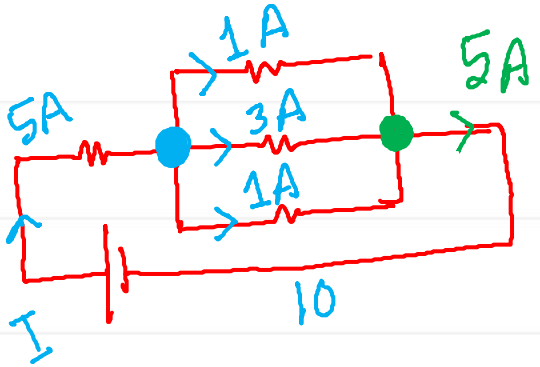
Today's Topics:

- Kirchhoff's Law
- Application of Kirchhoff's law
- Potential Divider
- Shunt and it's application in galvanometer
- Few symbols of components used in circuit
- Mathematical Problems

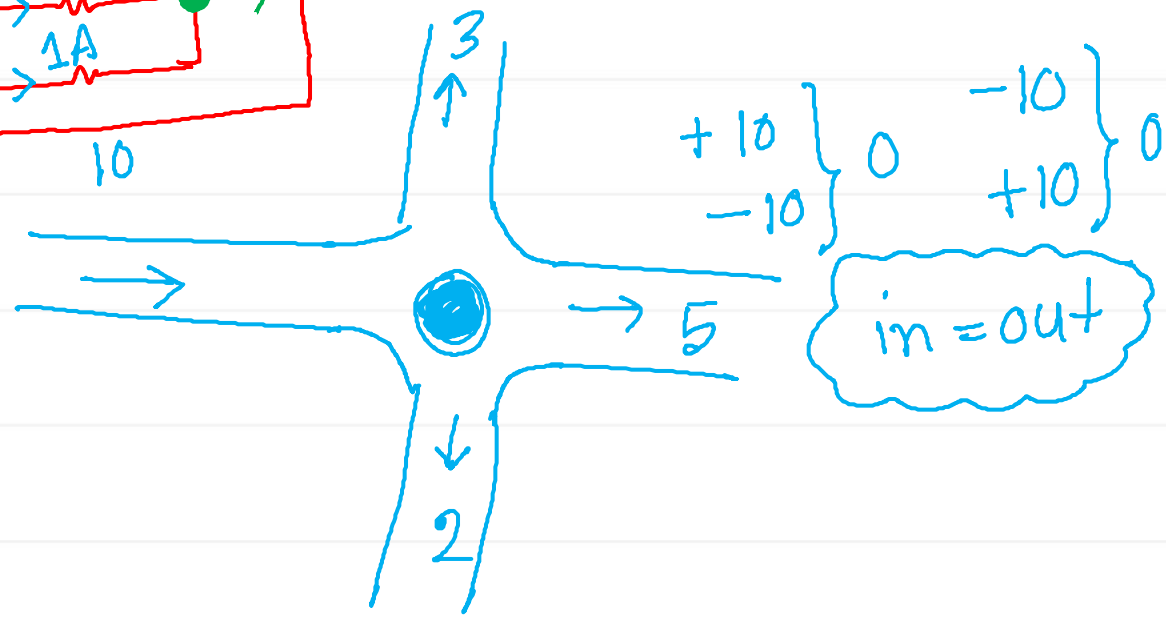
Kirchhoff's 1st law

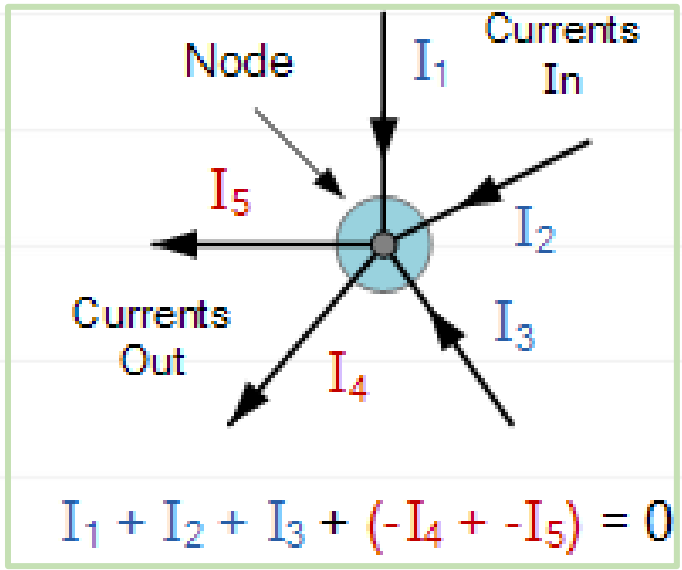
To solve critical circuits Kirchhoff's laws are us rather then ohm's law.

1st law: The algebraic sum of currents in a network of conductors meeting at a point is zero.



$$\Sigma i = 0$$





Poll Question 01

Which one is Kirchhoff's 1st law?

(a) $\Sigma\, i_1 + i_2 + i_3 + i_4 + \ldots\ldots = 0$

(b) $\Sigma\, i_1 + i_2 - i_3 + i_4 + \ldots\ldots = 0$

(c) $\Sigma\, i_1 + i_2 + i_3 - i_4 + \ldots\ldots = 0$

(d) $\Sigma\, i_1 - i_2 + i_3 + i_4 - \ldots\ldots = 0$

$$\sum_{n=0}^{n=n} n$$

per day

income → 5/-

expense → 5/-

+5 - 5

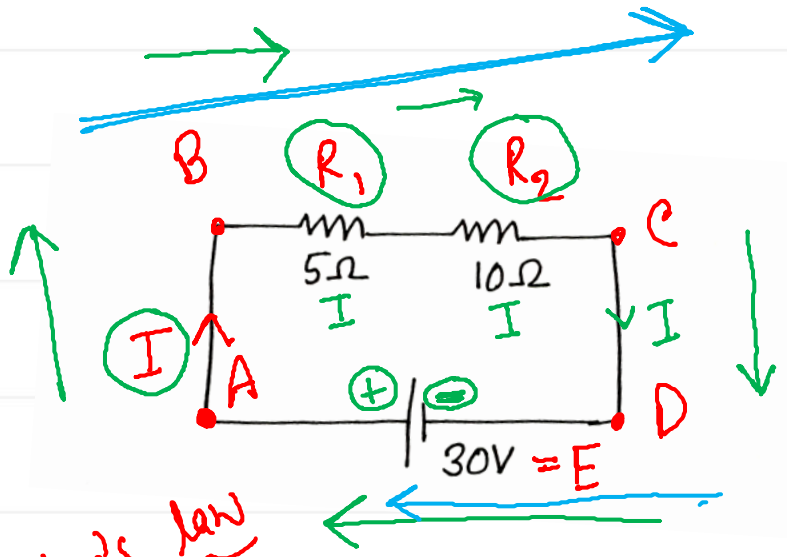
saving = 0

(+5) + (-5)

= 0

Kirchhoff's 2nd law

2nd law: The directed sum of the potential differences (voltages) around any closed loop is zero.



Ohm's law

$$I = \frac{E}{R_1 + R_2} = \frac{30}{15}$$

$I = 2\,amp$

$$\Sigma E = \Sigma iR$$

$$\Sigma E - \Sigma iR = 0$$

↻ or ↺

ABCDA loop

AB → X

BC → IR_1 ; IR_2

CD → X

DA → −30

↻ ABCDA

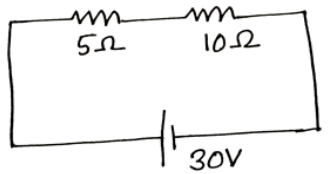
$+5I + 10I - 30 = 0$

$15I = 30$

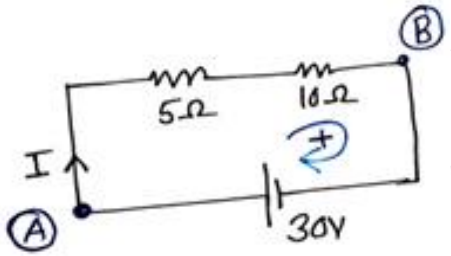
$I = 2\,amp$

Mathematical Example 01 on Kirchhoff's 2nd law

Loop-1, Voltage Source-1

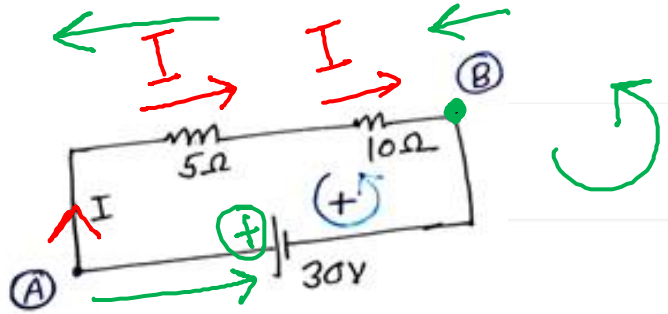


Step-1:



Step-1: ↻ or ↺

Step-2: Kirchhoff's 2nd law



$5I + 10I - 30 = 0 \Rightarrow 15I = 30$

$\therefore I = 2amp$

A বিন্দু থেকে clockwise ঘুরে A বিন্দুতে থাম।

$-10I - 5I + 30 = 0 \Rightarrow -15I + 30 = 30$

$\therefore I = 2amp$

A বিন্দু থেকে clockwise ঘুরে A বিন্দুতে থাম।

যদি B থেকে ঘুরতাম-

$-30V + 5I + 10I = 0 \Rightarrow I = 2amp$

যদি A থেকে ঘুরতাম-

$+30 - 10I - 5I = 0 \Rightarrow I = 2amp$

Poll Question 02

How much current will enter or out from the 6th branch?

(a) 3 in

(b) 3 out

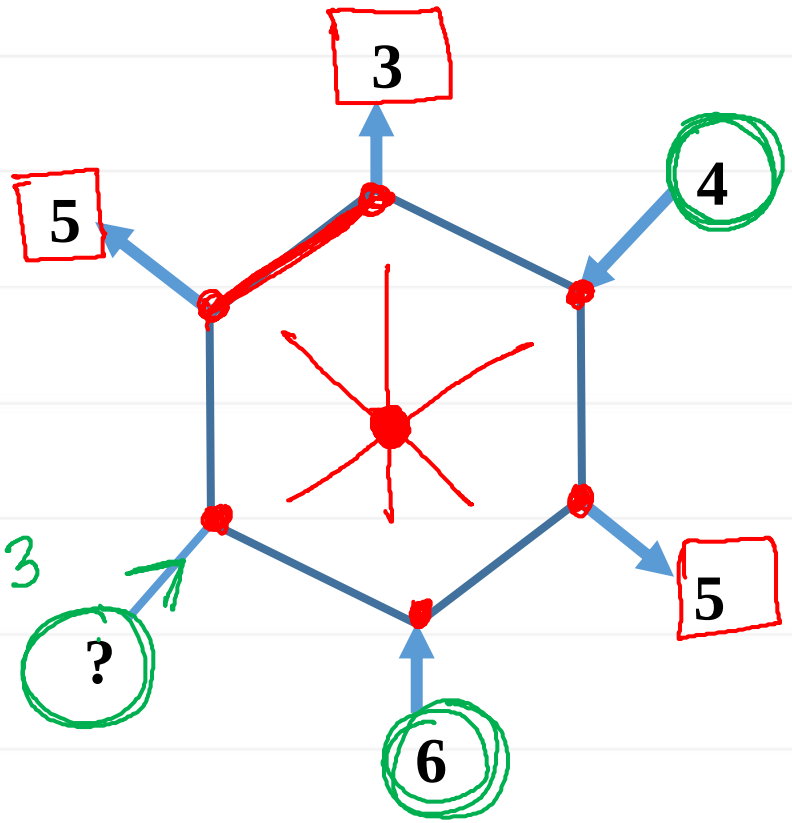
(c) 7 in

(d) 7 out

input = output

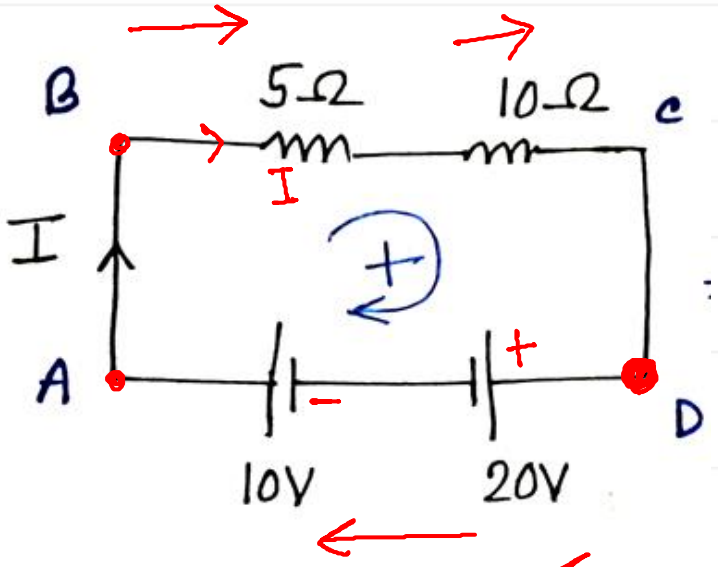
out = 5 + 3 + 5 = 13

in = 4 + 6 = 10 + 3



Math 01

How Much current is passing through each cell?



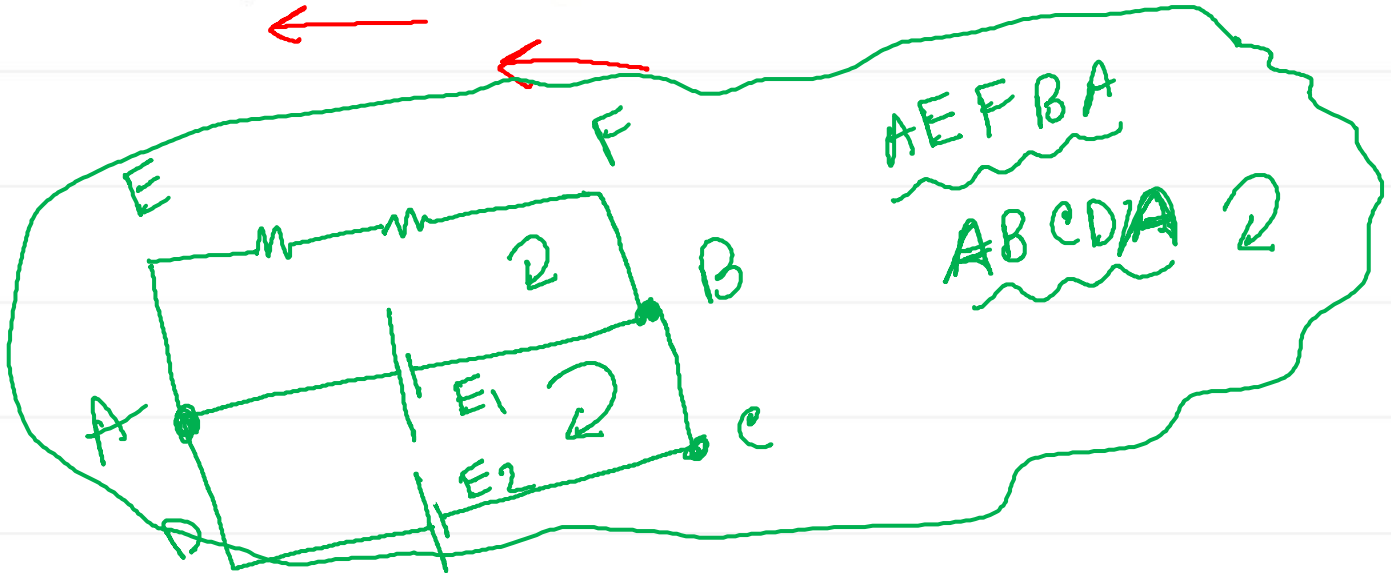
DABCD(2)

$+20 - 10 + 5I + 10I = 0$

$\Rightarrow 15I = -10$

$\therefore I = -10/15 = -2/3 = -0.67$ amp

-ve ?

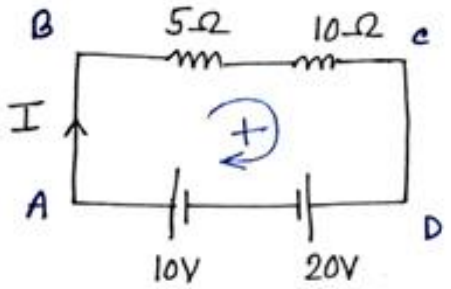


AEFBA

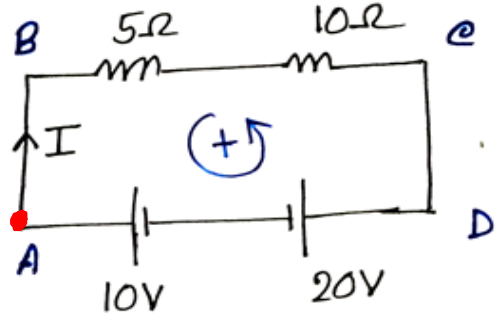
ABCDA 2

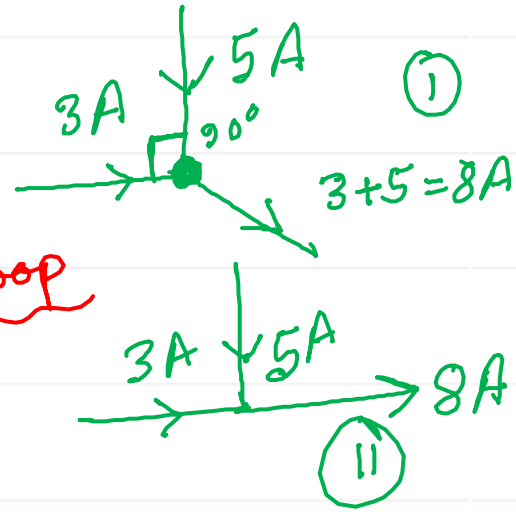
Mathematical Example 02 on Kirchhoff's 2nd law

Loop-1, Voltage Source-1++



Or,





ABCDA লুপ-

$+5I + 10I + 20 - 10 = 0$

$\Rightarrow 15I + 10 = 0$

$\Rightarrow I = -\frac{10}{15} = -\frac{2}{3}A$

$\therefore I = -0.67A$

$-ve$ মানে direction যা ধরা হয়েছে, current এর flow উল্টাবাবে হবে।

~~ABCDA~~ লুপ- ADCBA loop

$+10 - 20 - 10I - 5I = 0$

$\Rightarrow -10 - 15I = 0$

$\Rightarrow I = -\frac{10}{15}$

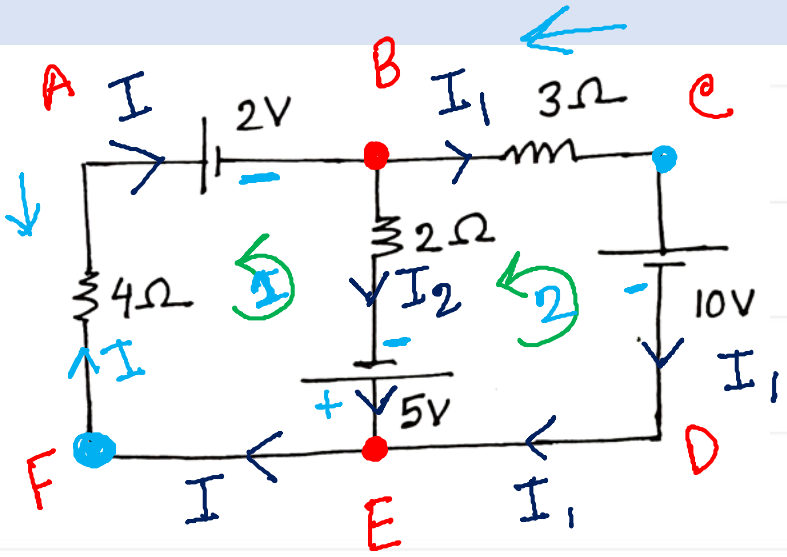
$\therefore I = -0.67A$

$-ve\ velue$ এর meaning direction opposite.

N.B.: Current এর direction both case এ same ধরে নেয়া। Loop যেভাবেই ঘুরুক answer same ই আসবে।

Math 02

Taking anti clockwise direction find out how much current is passing through each cell?



FEBAF

$+5 - 2I_2 - 2 - 4I = 0$

$\Rightarrow 3 - 2I_2 - 4(I_1 + I_2) = 0$

$\Rightarrow 3 - 6I_2 - 4I_1 = 0$

$\Rightarrow 4I_1 + 6I_2 = 3 \quad \cdots (I)$

CBEDC

$-3I_1 + 2I_2 - 5 - 10 = 0$

$\Rightarrow 3I_1 - 2I_2 = -15 \quad \cdots (II)$

B node

$I = I_1 + I_2 \cdots 1^{st}$ ✓

or

E node

$I_2 + I_1 = I \cdots 1^{st}$ ✓

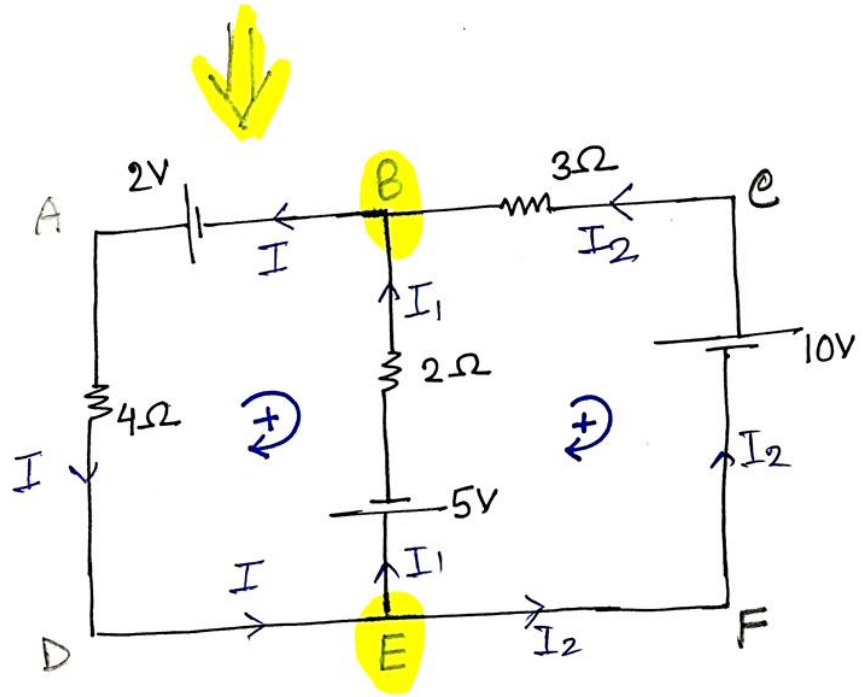
(I), (II)

$I_1 = -\frac{42}{13} = -3.231\ A$

$I_2 = \frac{69}{26} = 2.654\ A$

$I = I_1 + I_2 = -0.578\ A$

Mathematical Example 03 on Kirchhoff's 2nd law



B এবং E node এ-

$I = I_1 + I_2$ ... ... (i) [কার্শফের 1st law]

ছবিতে মোট ৩টি Loop আছে। আমরা আপাতা ২টি নিব।

ABEDA Loop,

$+2 - 2I_1 - 5 - 4I = 0$

$\Rightarrow -3 - 2I_1 - 4I_1 - 4I_2 = 0$ ... ... (i)

$\Rightarrow 6I_1 + 4I_2 = -3$ ... ... (ii)

BCFEB Loop,

$-3I_2 + 10 + 5 + 2I_1 = 0$

$\Rightarrow 15 + 2I_1 - 3I_2$

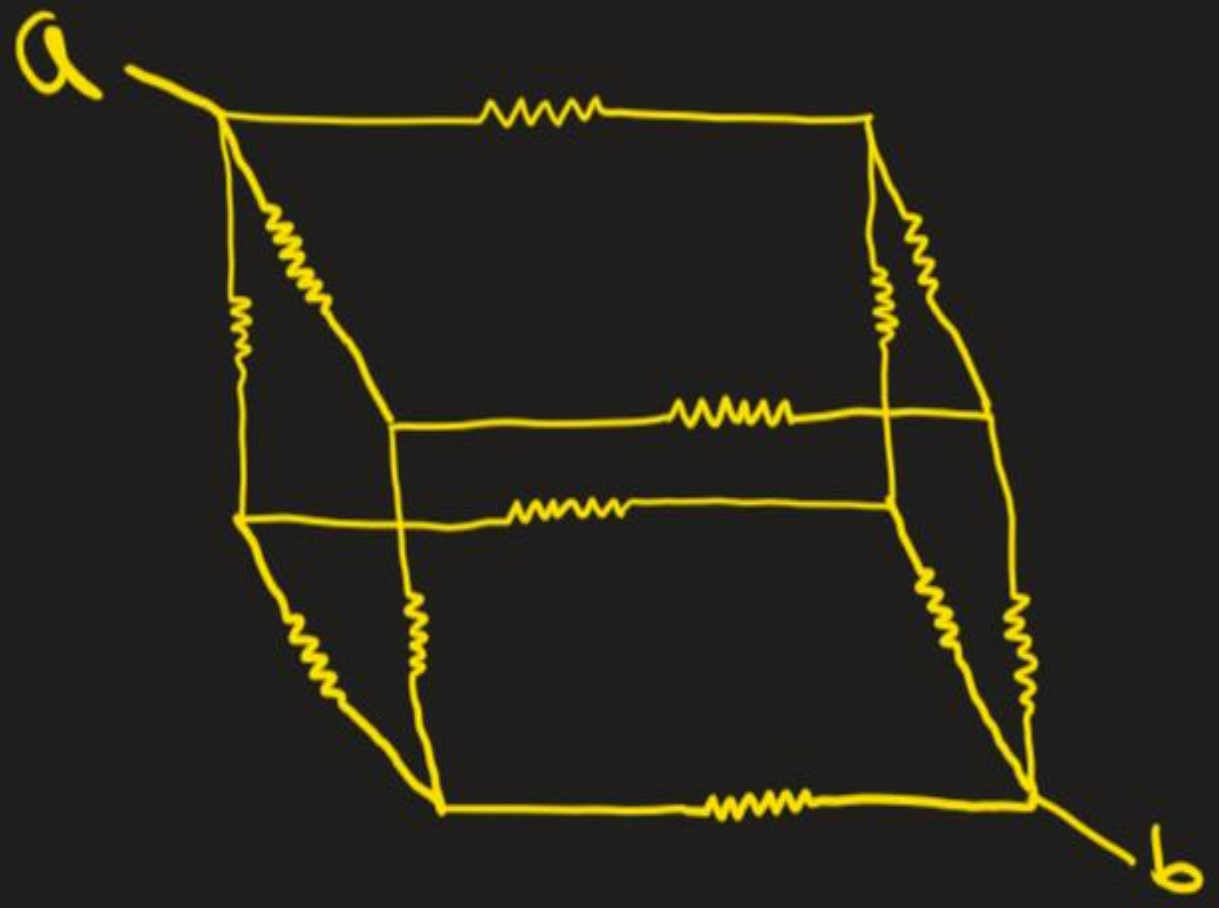
$\Rightarrow 2I_1 - 3I_2 = -15$ ... ... (iii)

Solving equation (ii) & (iii),

$I_1 = -\frac{69}{26} = -2.654$ amp

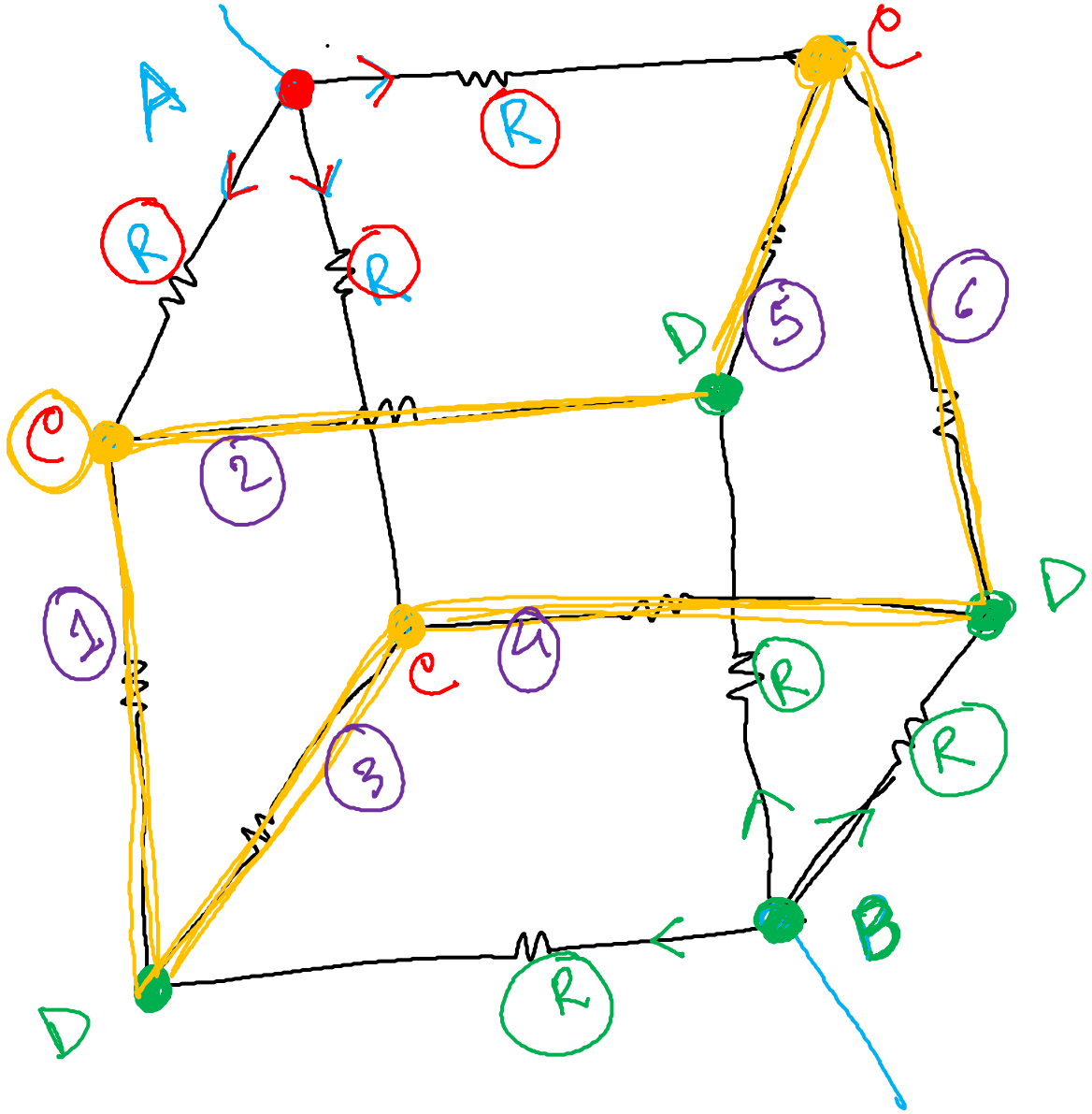
$I_2 = \frac{42}{13} = 3.231$ amp

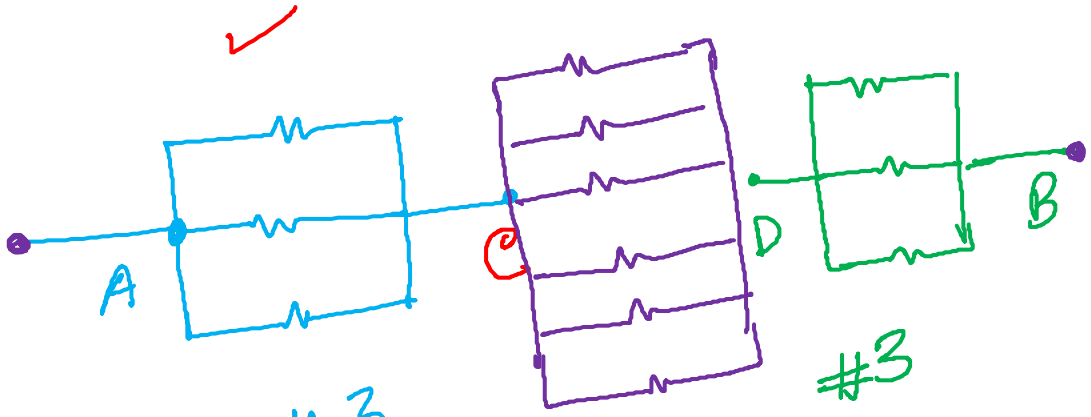
$\therefore I = \frac{15}{26} = 0.577$ amp



Ques: if all the resistors are of equal value (R).

Then, $R_{ab} = ?$



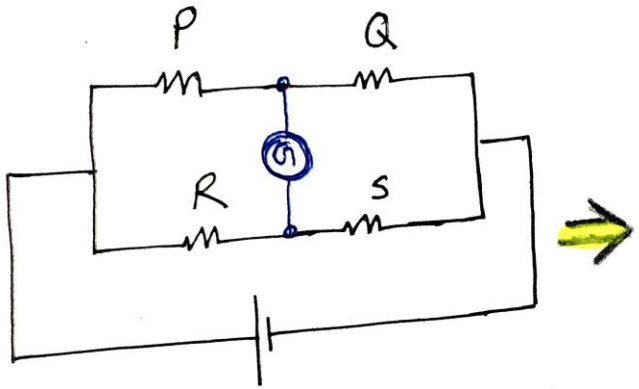


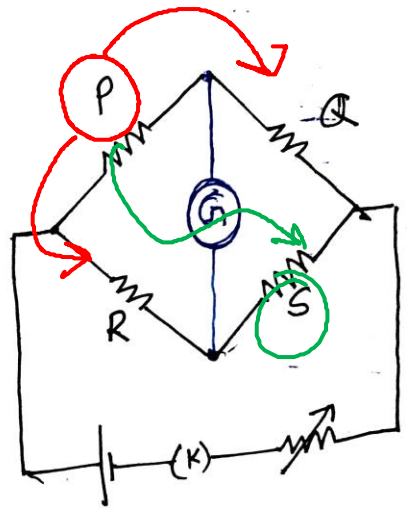
#3 #6 #3

$$R_{AB} = \frac{R}{3} + \frac{R}{6} + \frac{R}{3}$$

$$= \frac{5R}{6}$$

Use of Kirchhoff's law in Wheatstone bridge





$I_g = 0$ [cond.]

Equilibrium achieve

$\frac{P}{Q} = \frac{R}{S}$

or $\frac{P}{R} = \frac{Q}{S}$

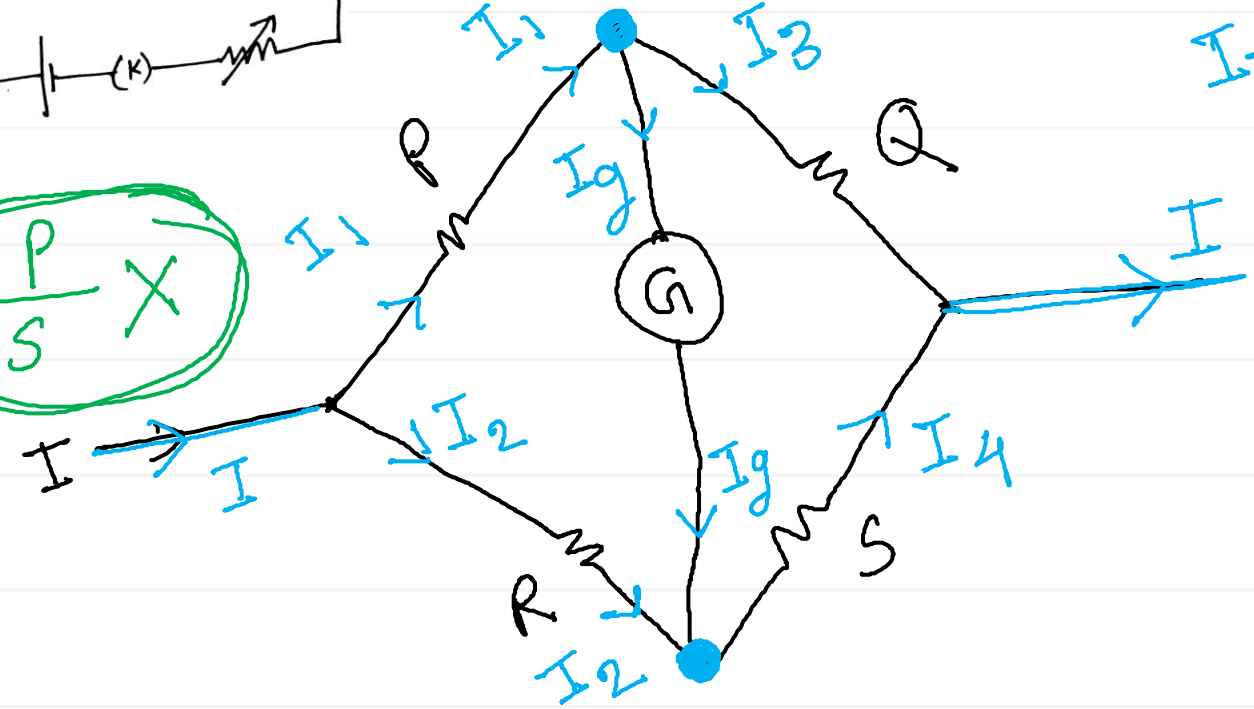
$I = I_1 + I_2$

$I_1 = I_g + I_3$

$I_2 + I_g = I_4$

$I_3 + I_4 = I$

$\frac{P}{S} \times$



Poll Question 03

If R1, R2, R3 are 5,2,15 ohms respectively,

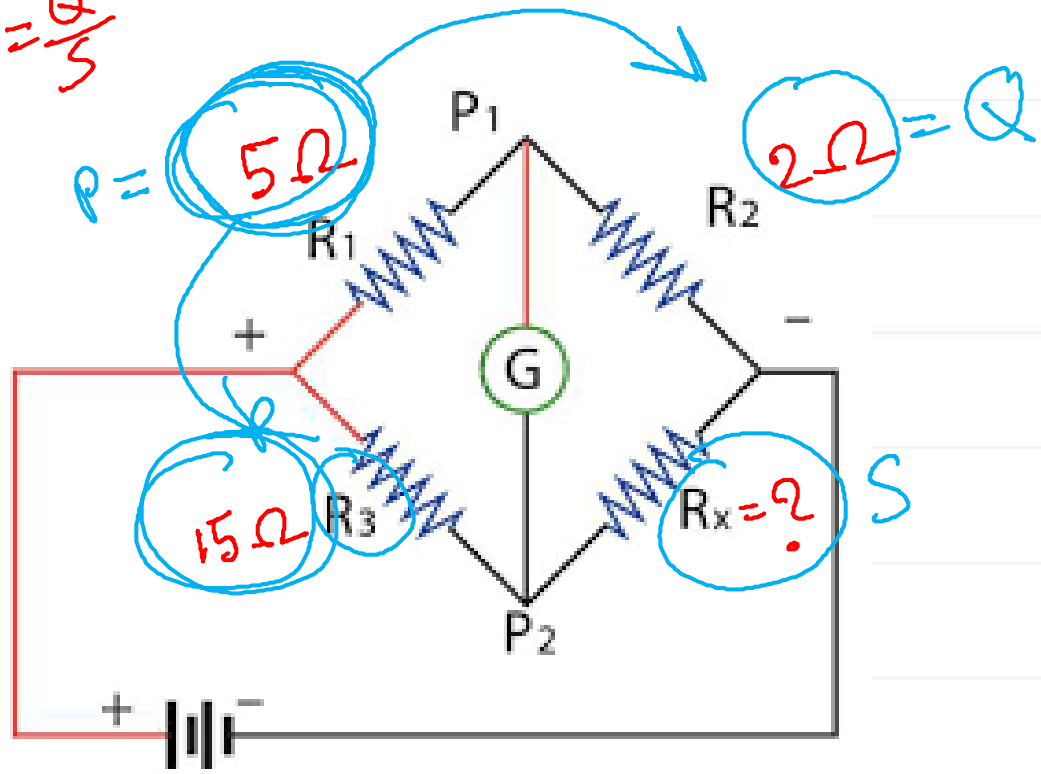
to attain equilibrium how much resistance is to be applied on the 4th arm?

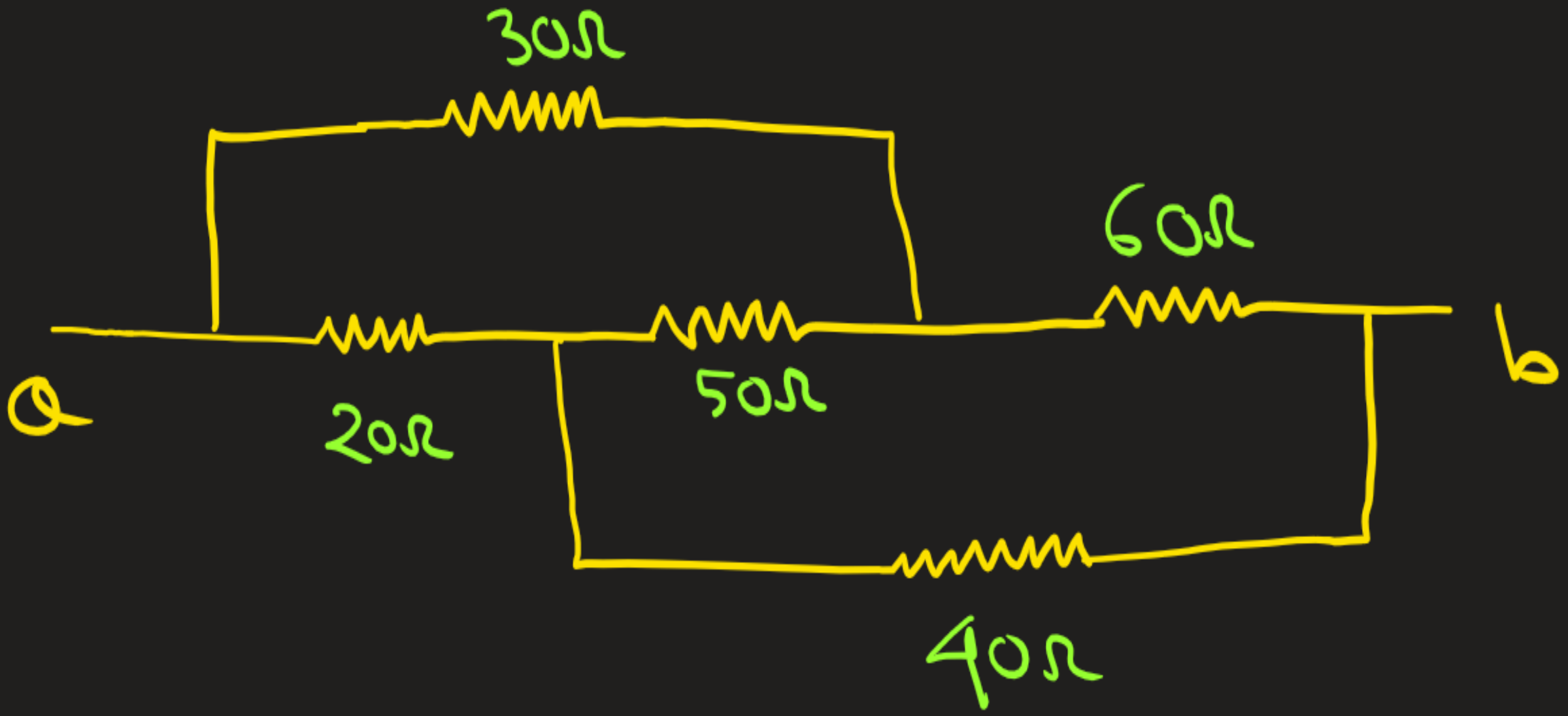
(a) 3 ohm

(b) 4 ohm

(c) 7.5 ohm

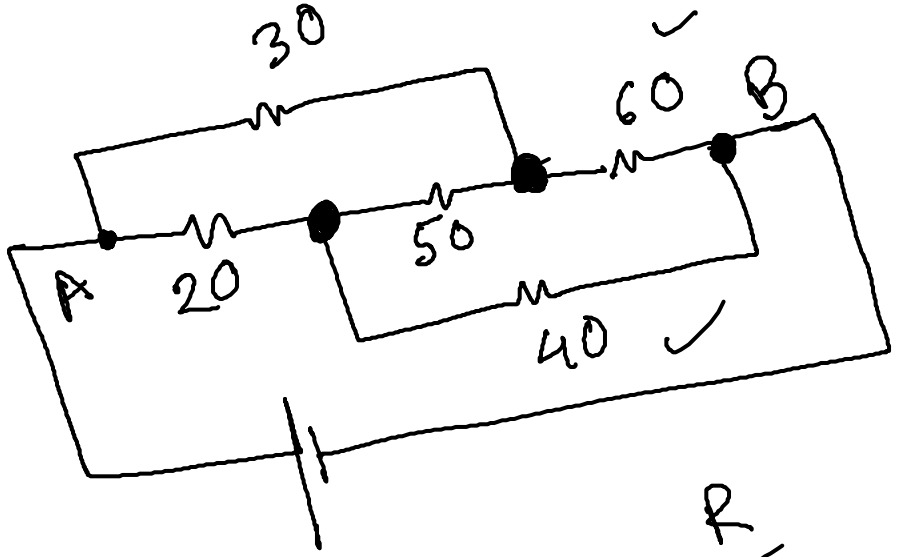
(d) 6 ohm





Quen.: $R_{ab} = ?$

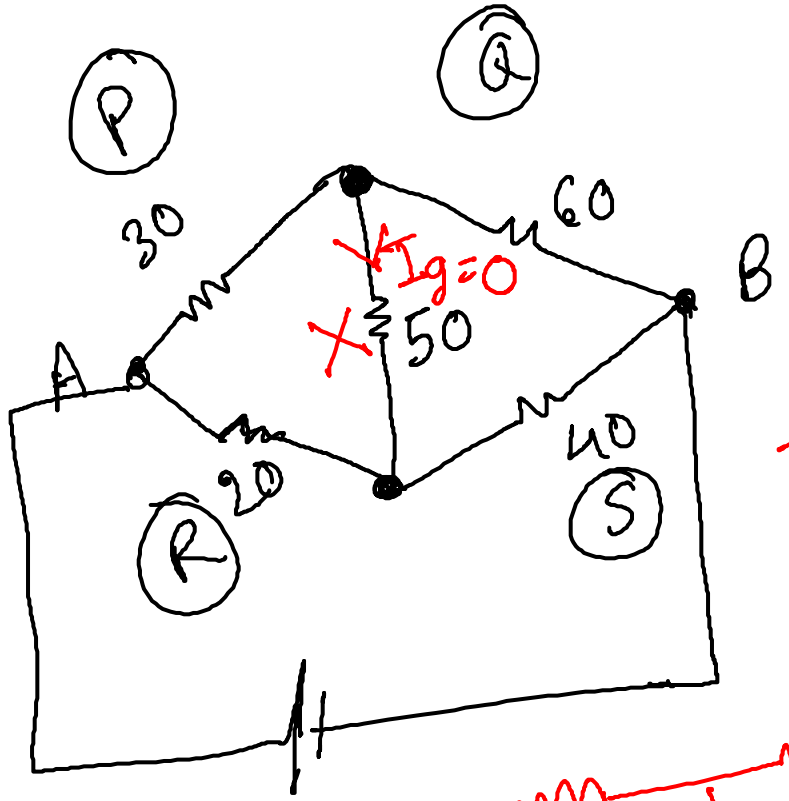
$R_{ab} = \left(\frac{1}{90} + \frac{1}{60}\right)^{-1}$

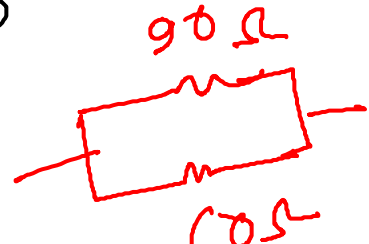


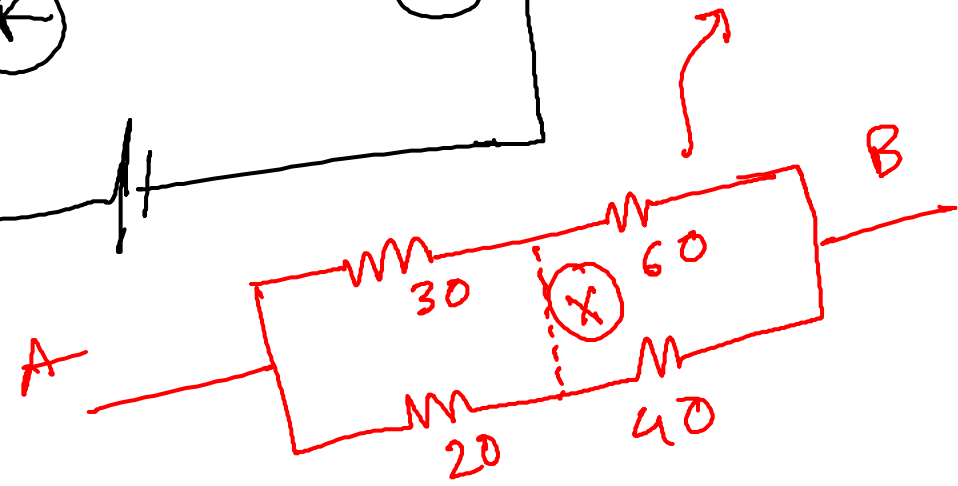
$\therefore \frac{P}{Q} = \frac{R}{S}$

Equilibrium

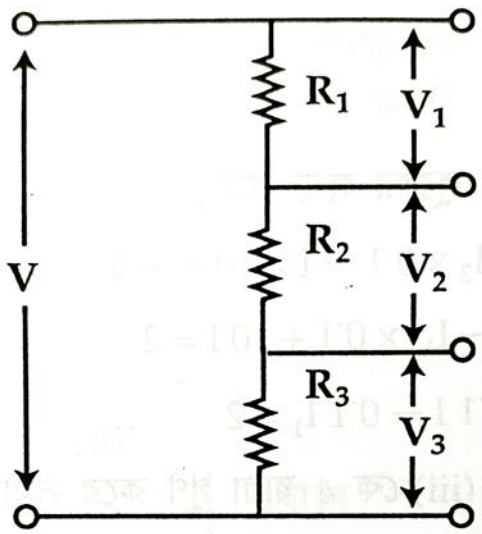
$I_g = 0$

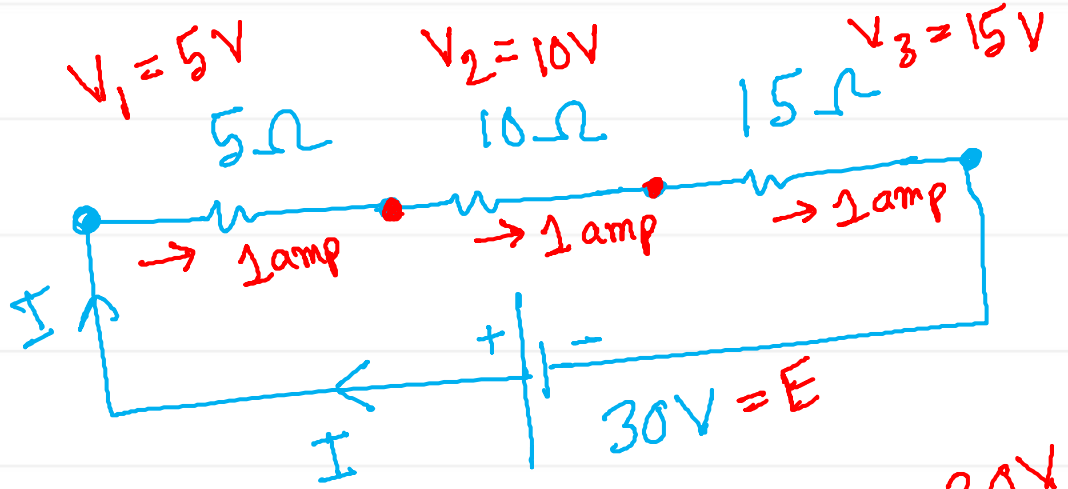






Potential Divider





$$I = \frac{30}{30}$$

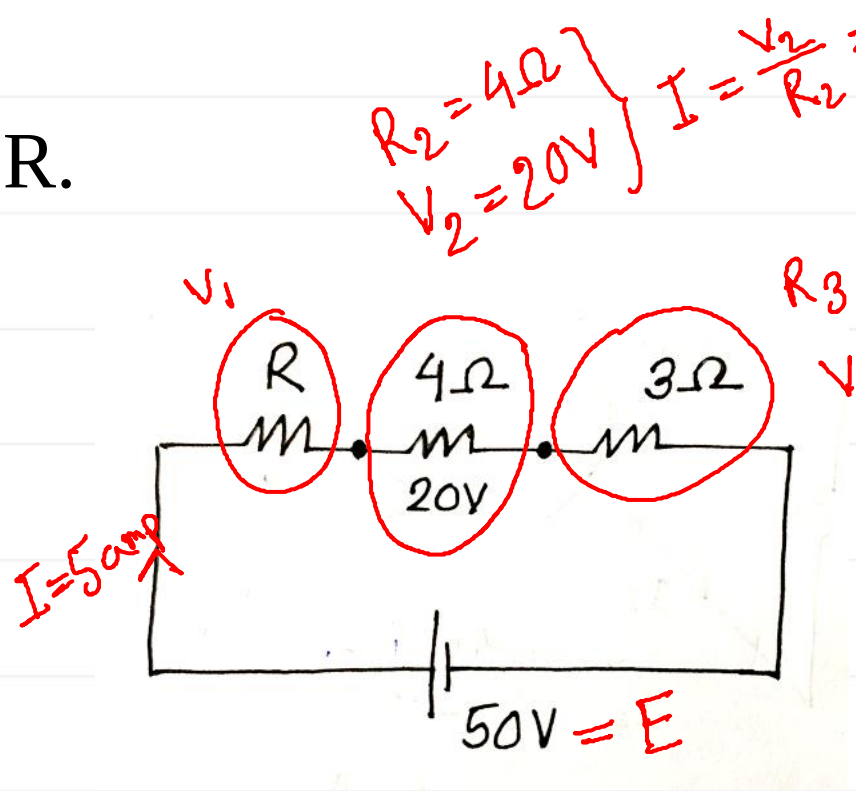
$$= 1\ \text{amp}$$

$$V_1 + V_2 + V_3 = 30V$$

$$E = 30V$$

Poll Question 04

Find out value of R.



(a) 3 ohm

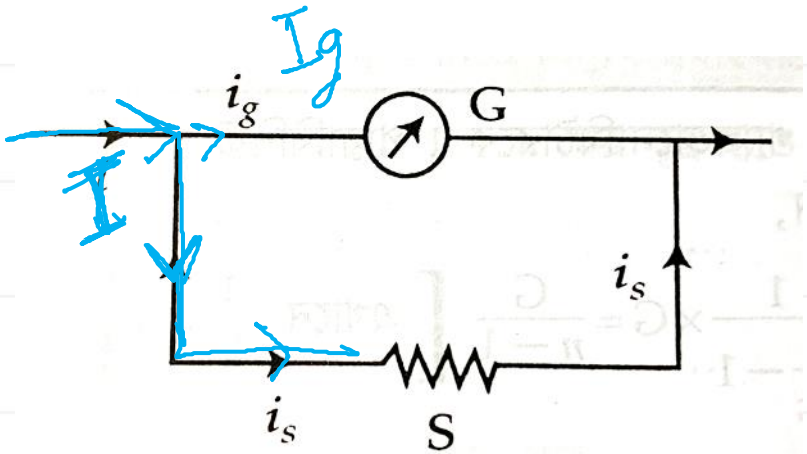
(b) 4 ohm

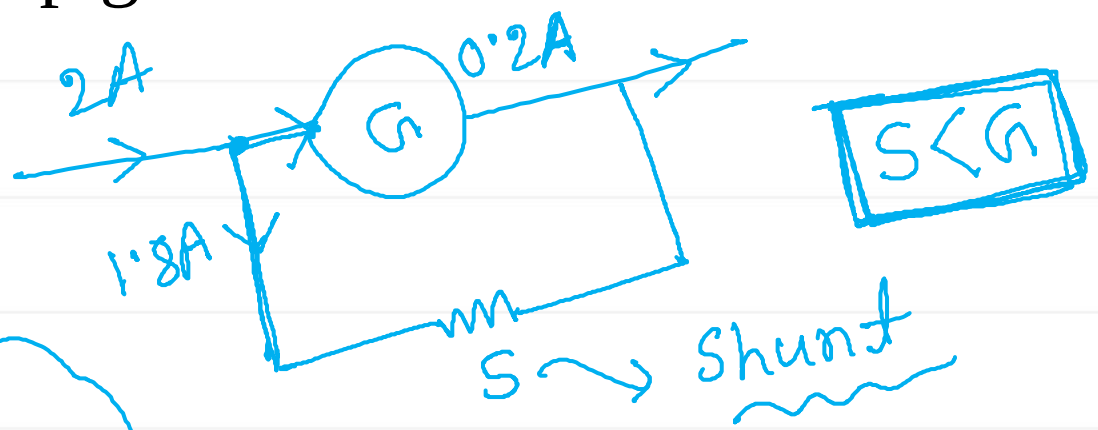
(c) 5 ohm

(d) 6 ohm

Shunt

In electronics, a shunt is a device that creates a low-resistance path for electric current, to allow it to pass around another point in the circuit. The resistor of very low but accurately known resistance, is placed in **parallel** with a galvanometer, so that virtually all of the current to be measured will flow through the resistor and keep galvanometer safe.





$$S = \frac{G}{n-1}$$

$$n = \frac{2}{0.2} = 10$$

Math 03

A galvanometer of 100 ohm resistance can safely measure 10mA current. How we can measure 10 A current with this galvanometer?

$G = 100\ \Omega$

$I = 10mA = 10 \times 10^{-3} A$

$I' = 10A$

$n = \frac{I'}{I} = \frac{10}{10 \times 10^{-3}} = 10^3$

$S = ?$

V same

$I_g < I_s$

$G > S$

$S = \frac{G}{n-1} = \Omega$

$V = IR$

$V = 10 = 1 \times 10$

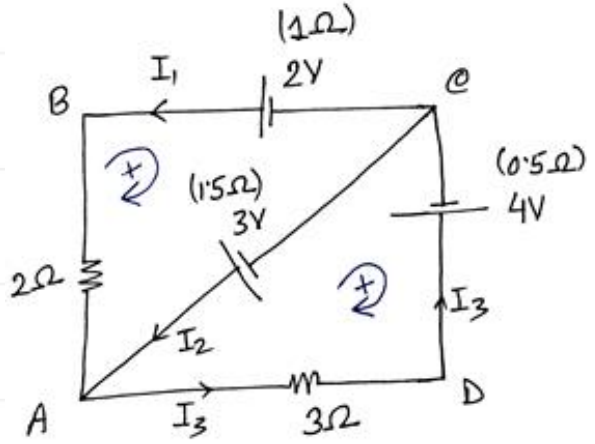
$10 = 2 \times 5$

parallelly S connect

MATH 04

Calculate current flow through each cell.

In figure, $E_1 = 2V, E_2 = 3V, E_3 = 4V, r_1 = 1\Omega, r_2 = 1.5\Omega, r_3 = 0.5\Omega, R_4 = 2\Omega$ ও $R_5 = 3\Omega$.



$ACBA$ লুপে কির্শফের দ্বিতীয় সূত্র প্রয়োগ করে পাই,

$$I_1 r_1 + I_1 R_4 - I_2 r_2 = E_1 - E_2$$

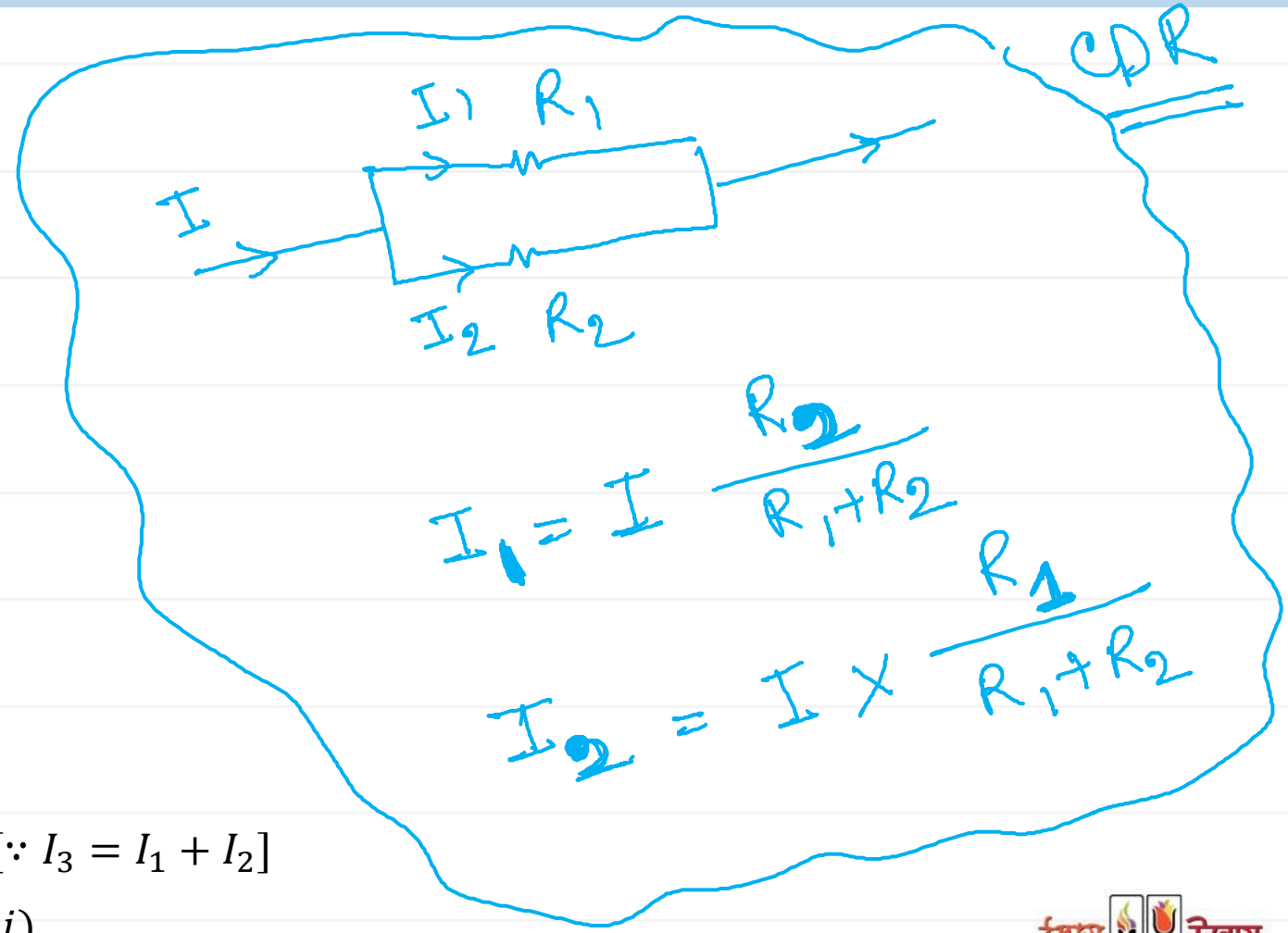
$$\therefore I_1(r_1 + R_4) - I_2 r_2 = E_1 - E_2 \ldots\ldots\ldots\ldots (i)$$

$ADCA$ লুপে কির্শফের দ্বিতীয় সূত্র প্রয়োগ করে পাই,

$$I_2 r_2 + I_3 R_5 + I_3 r_3 = E_2 - E_3$$

$$\therefore I_2 r_2 + (I_1 + I_2) R_5 + (I_1 + I_2) r_3 = E_2 - E_3 \qquad [\because I_3 = I_1 + I_2]$$

$$\therefore I_1(R_5 + r_3) + I_2(r_2 + R_5 + r_3) = E_2 - E_3 \ldots\ldots\ldots (ii)$$



MATH 04

সমীকরণ (i) ও (ii) এ মানগুলো বসিয়ে পাই,

$I_1(1+2) - I_2 \times 1.5 = 2 - 3$

বা, $3I_1 - 1.5I_2 = -1$

বা, $15.I_2 - 3I_1 = 1 \ldots\ldots\ldots\ldots (iii)$

এবং $I_1(3+0.5) + I_2(1.5+3+0.5) = 3 - 4$

বা, $3.5I_1 + 5I_2 = -1 \ldots\ldots\ldots\ldots (iv)$

By solving equation (iii) and (iv)

$\therefore I_1 = -\frac{26}{81} = -0.321A$

$\therefore I_2 = \frac{2}{81} = 0.025A$

$\therefore I_3 = I_1 + I_2 = -0.295A$

value madeh ✗

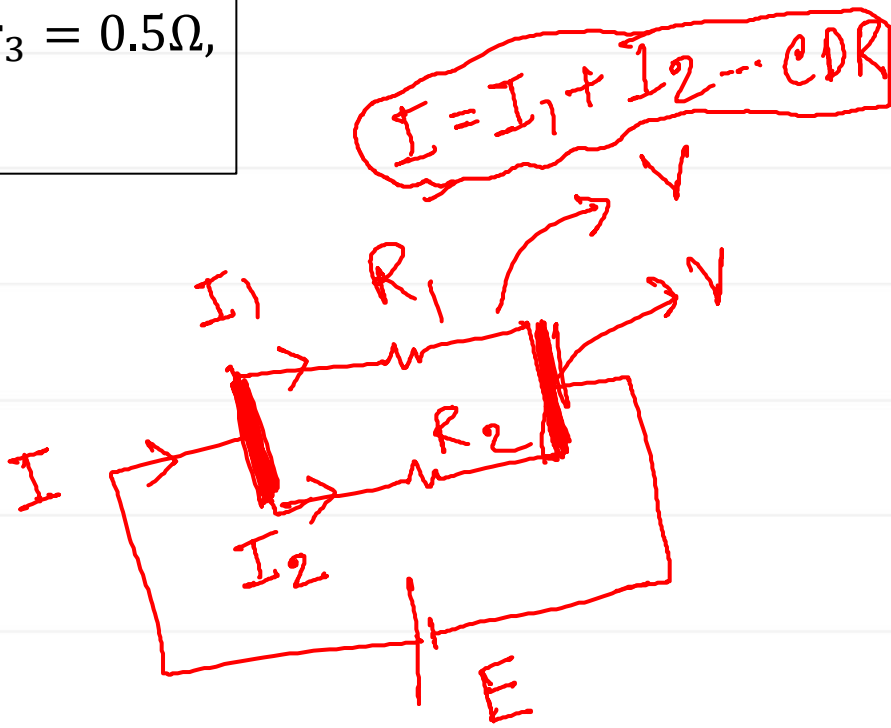
Ishaq, 169 page

Here,

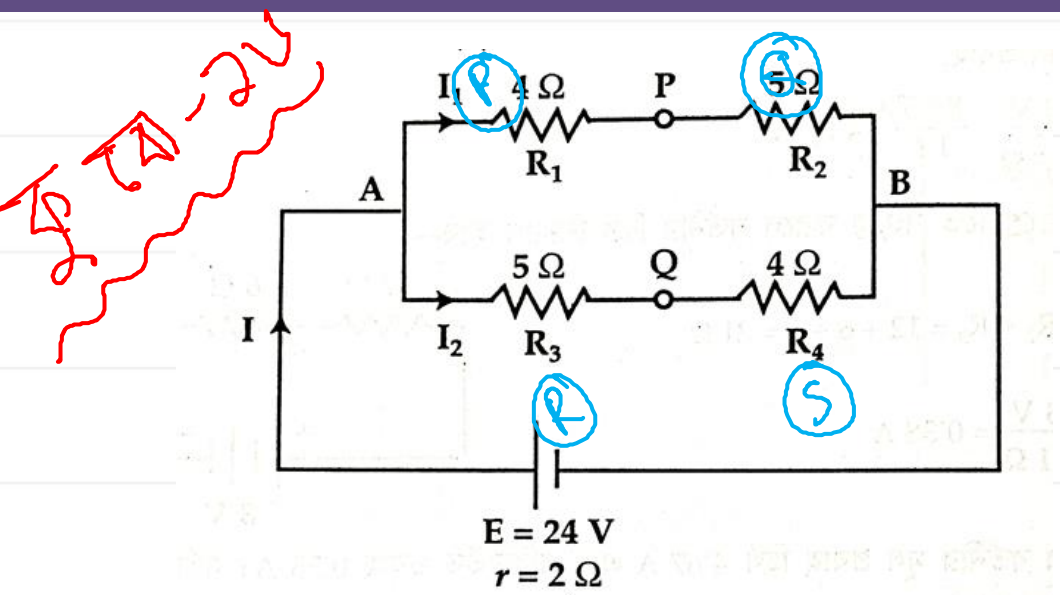
$E_1 = 2V,\ E_2 = 3V,\ E_3 = 4V,$

$r_1 = 1\Omega,\ r_2 = 1.5\Omega,\ r_3 = 0.5\Omega,$

$R_4 = 2\Omega, R_5 = 3\Omega.$



Math 05



(a) Calculate current flow in the circuit.

(b) If a galvanometer of low resistance is placed between P and Q point, In which direction current will flow?

a) $I = \dfrac{E}{R_{eq}} = 3.69$ amp

$R_1 + R_2 = 9$, $R_3 + R_4 = 9$ $\Rightarrow \dfrac{9}{2} = R_p = 4.5\ \Omega$

$r = 2\ \Omega$

$R_{eq} = r + R_p$

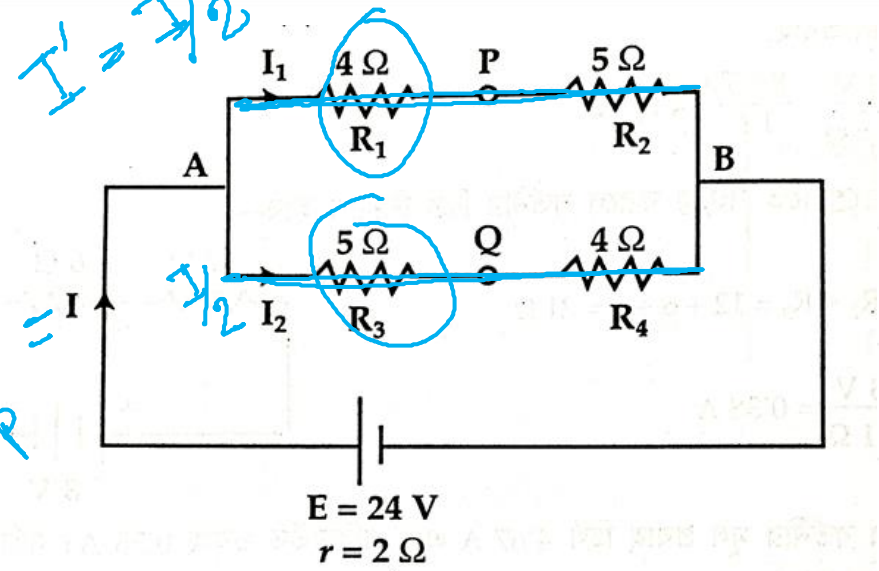
b)

$\dfrac{P}{Q} \neq \dfrac{R}{S}$ $\quad \dfrac{4}{5} \neq \dfrac{5}{4}$

$\dfrac{P}{R} \neq \dfrac{Q}{S}$

not in Equilibrium

Math 05 continued



(a) Calculate current flow in the circuit.

(b) If a galvanometer of low resistance is placed between P and Q point, In which direction current will flow?

$I' = I/2$

$V_{xy} = V_x - V_y$

$I = 3.69$ amp

$I' = \frac{I}{2} = 1.845$ amp

$\because$ not in equilibrium

$\therefore$ flow

$V_A > V_B$

$A \to B$

$V_{AP} = (1.845 \times 4) = 7.38\ V = V_A - V_P$

$V_{AQ} = (1.845 \times 5) = 9.225\ V = V_A - V_Q$

$V_{PQ} = V_{AQ} - V_{AP} = V_P - V_Q$

$V_{PQ} = 1.845\ V$

$V_P > V_Q$

$P \to Q$

Few symbols of components used in circuit

Cell

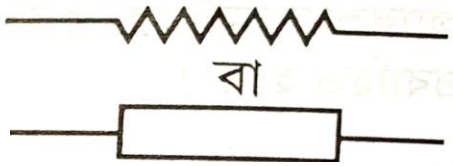
Battery

Capacitor

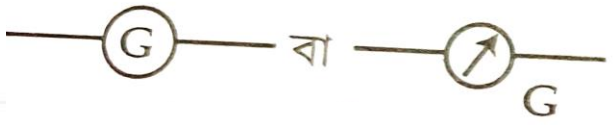
Switch

Inductor

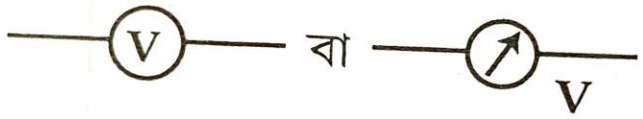
Rheostat or
variable resistance



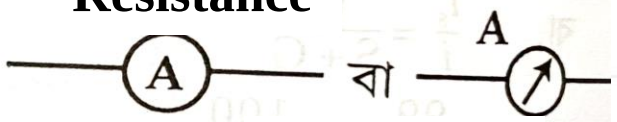
Fixed
Resistance



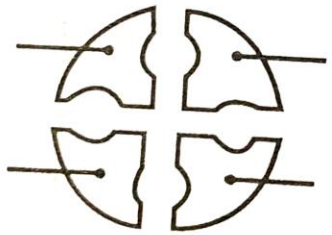
Galvanometer



Voltmeter



Ammeter



Commutator

লেগে থাকো সৎভাবে,
স্বপ্ন জয় তোমারই হবে

উদ্ভাস-উন্মেষ শিক্ষা পরিবার

Thank You