1. Basics

Active Elements → Supplies energy (current leaves +ve terminal)

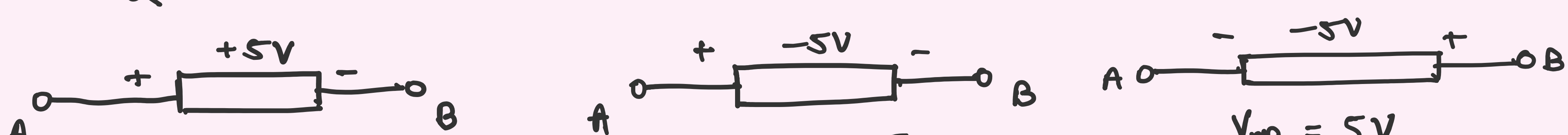
ex: Voltage/ current Sources

Passive Elements → Absorbs energy (current enters +ve terminal)

- $I = \frac{Q}{t}$ (or) $\frac{dq}{dt}$ unit : A (or) C/s

  $\frac{Q}{t}$ → D.C ; $\frac{dq}{dt}$ → AC

- $V = \frac{W}{Q}$ unit : V (or) J/C



$V_{AB} = 5V$; $V_{AB} = -5V$; $V_{AB} = 5V$

- $P = VI$ unit : W (or) VA

- $V = IR$ (Ohm's Law) ; $G = \frac{1}{R}$ → Unit : S (or) Siemens

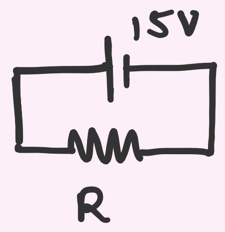
  V → Unit : V

  R → $R = \frac{\rho l}{A}$ → Unit : $\Omega = \frac{1}{S}$

2. Active Elements and Kirchoff Laws

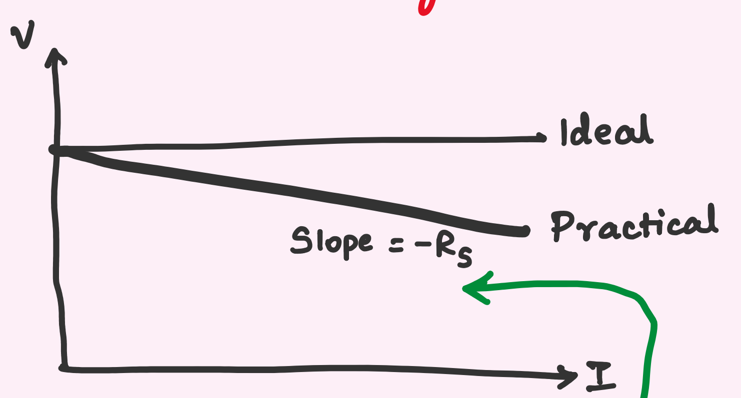
Ideal Voltage Source

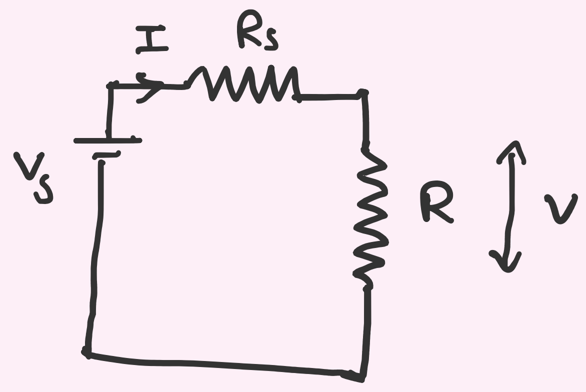
→ Independant of current flowing through it
→ Current depends on circuit



$R = 10\,\Omega \Rightarrow I = 1.5A$
$R = 1\,\Omega \Rightarrow I = 15A$

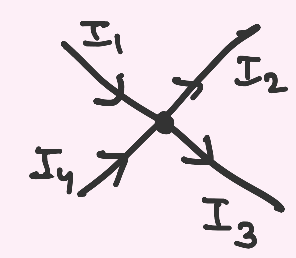
Practical Voltage Source





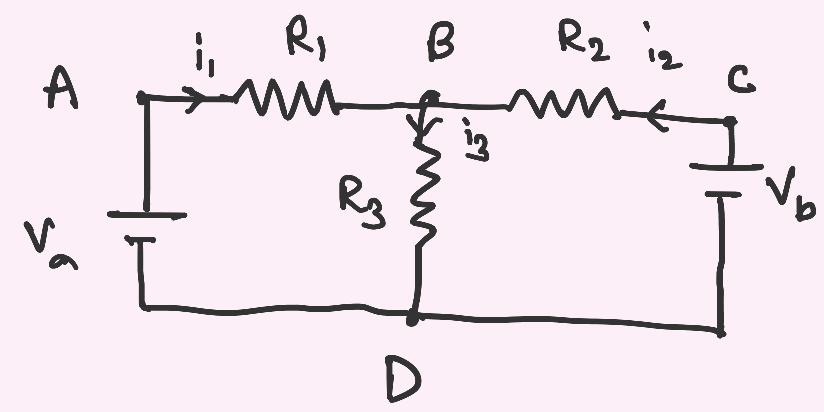
$V_s = V - IR_s$
$y = c + x\,m$

KCL



By KCL,
$I_1 + I_4 = I_2 + I_3$

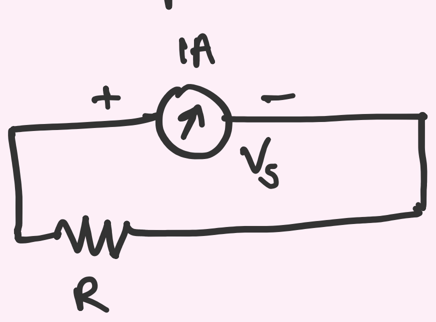
KVL



Loop ABDA , $V_a - i_1R_1 - i_3R_3 = 0$
Loop ACDA , $V_a - i_1R_1 + i_2R_2 - V_b = 0$
Loop BCDB , $V_b - i_2R_2 - i_3R_3 = 0$

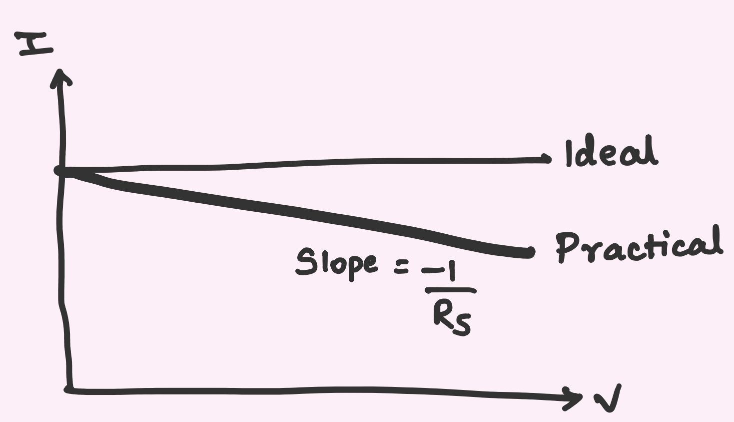
Ideal Current Source

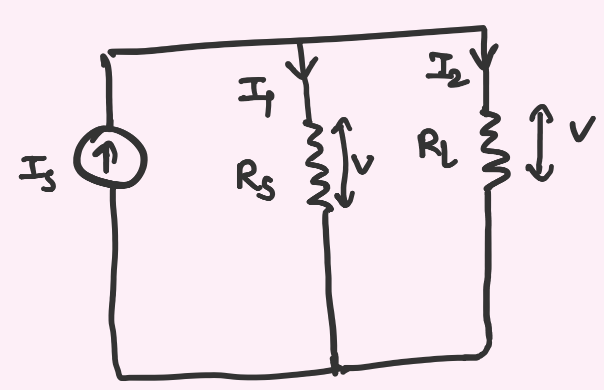
→ Independant of Voltage across it



$R = 10\,\Omega \Rightarrow V_s = 10V$
$R = 1\,\Omega \Rightarrow V_s = 1V$

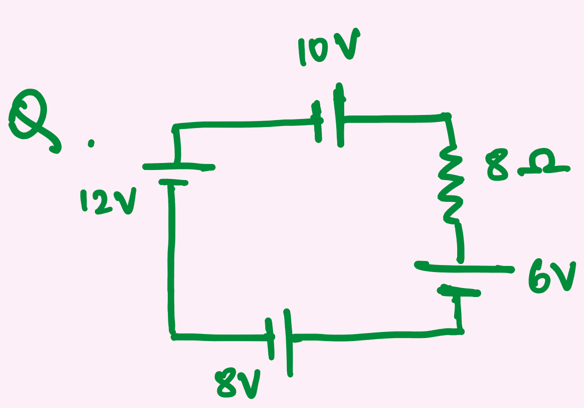
Practical current Source





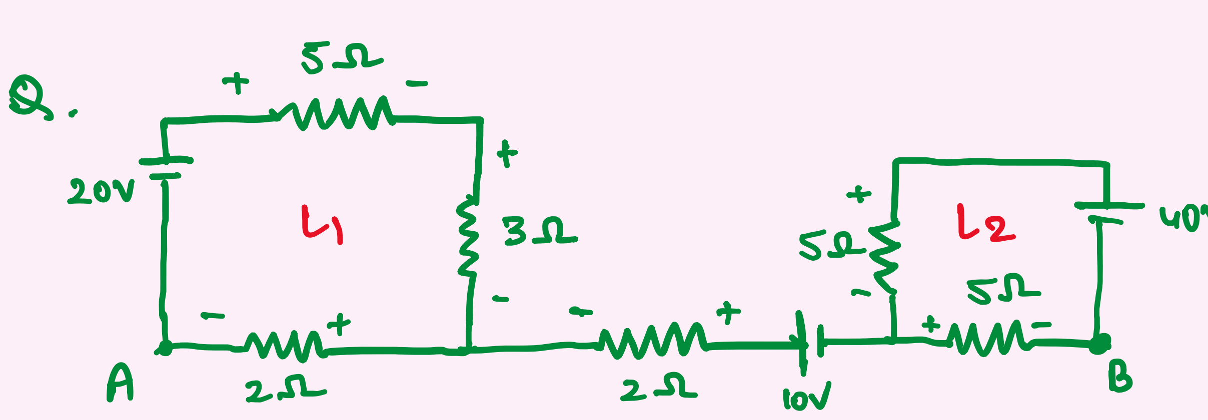
$I_s = I_1 + I_2$
$I_2 = I_s - I_1$
$I_2 = I_s - \frac{V}{R_s}$
$y = c - mx$

Q.



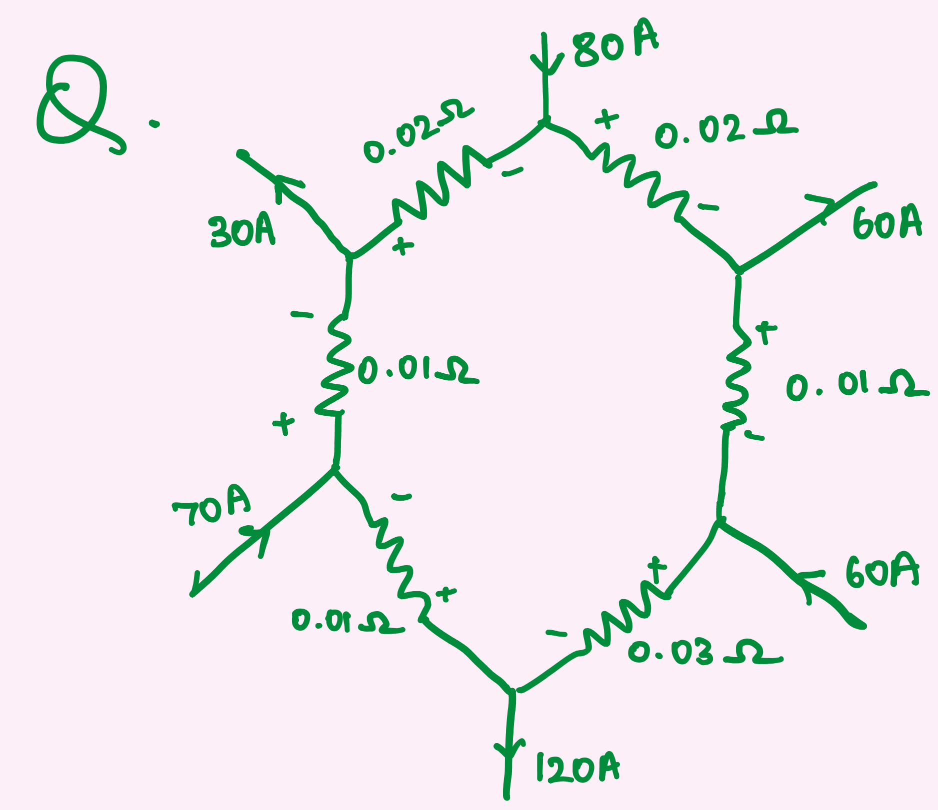
A. $12 + 10 - 8i - 6 - 8 = 0$
$i = 1A$

Q.

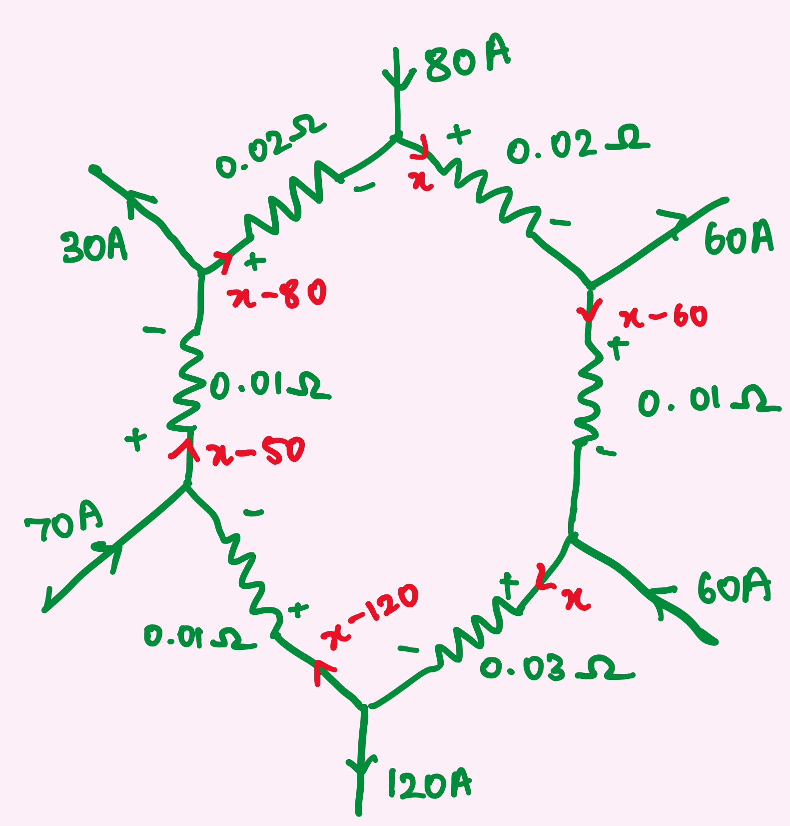


A. $L_1 \Rightarrow 20 - 5i_1 - 3i_1 - 2i_1 = 0 \Rightarrow i_1 = 2A$
$L_2 \Rightarrow 40 - 5i_2 - 5i_2 = 0 \Rightarrow i_2 = 4A$
$i_3 = 0$
$V_{AB} + 2i_1 + 2i_3 - 10 - 5i_2 = 0$
$V_{AB} + 4 + 0 - 10 - 20 = 0$
$V_{AB} = 26V$

Q.



A

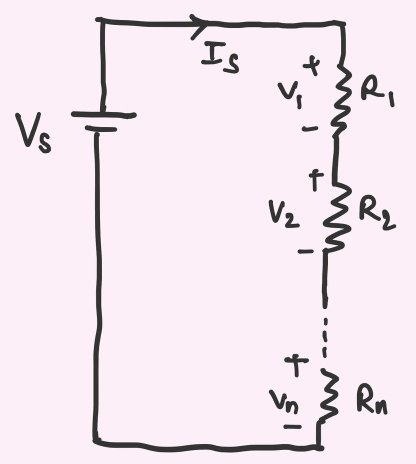


$-0.02(x) - 0.01(x-60) - 0.03(x) - 0.01(x-120)$
$-0.01(x-50) - 0.02(x-80) = 0$

$0.1x = 0.6 + 1.2 + 0.5 + 1.6$
$0.1x = 3.9$
$x = 39A$

3. Voltage, Current Division Rule and Open & Closed Circuit

Voltage Division Rule



$$V_1 = \frac{V_s R_1}{R_1+R_2+\dots+R_n}$$

$$V_2 = \frac{V_s R_2}{R_1+R_2+\dots+R_n}$$

$$V_n = \frac{V_s R_n}{R_1+R_2+\dots+R_n}$$

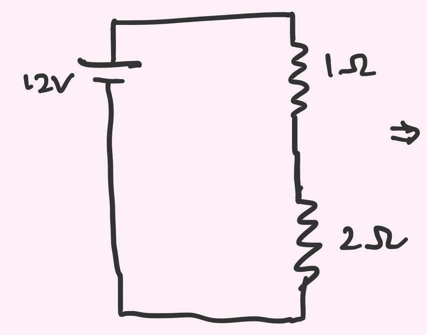
$$I_s = \frac{V_s}{R_1+R_2+\dots+R_n} = \frac{V_s}{R_{eq}}$$

Open Circuit

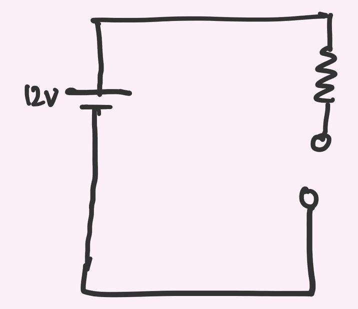
V = Finite
$I = 0$
$R = \infty$

Closed Circuit

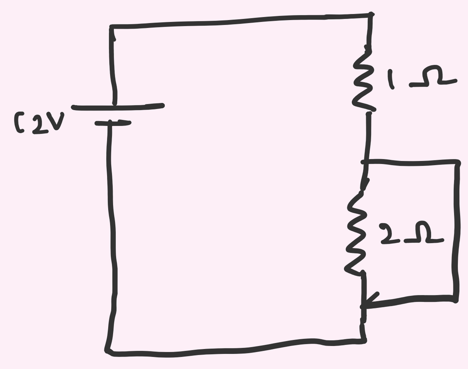
$V = 0$
$I = \infty$ → Dead Short Circuit
I = Finite → Short Circuit
$R = 0$



$\Rightarrow I_s = 4A$

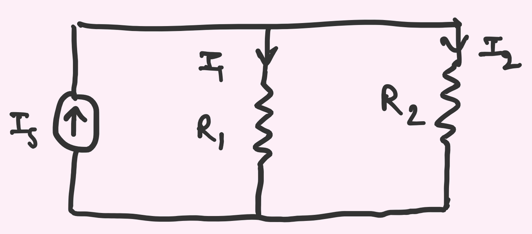


$\Rightarrow I_s = 0$

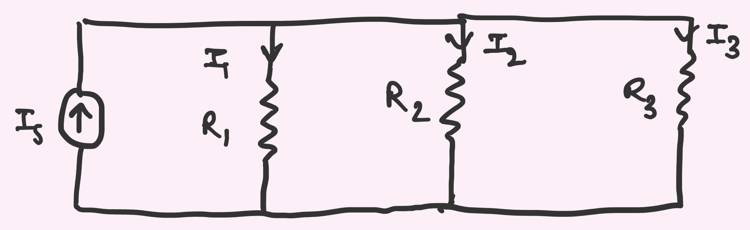


$\Rightarrow I_s = 12A$

Current Division Rule

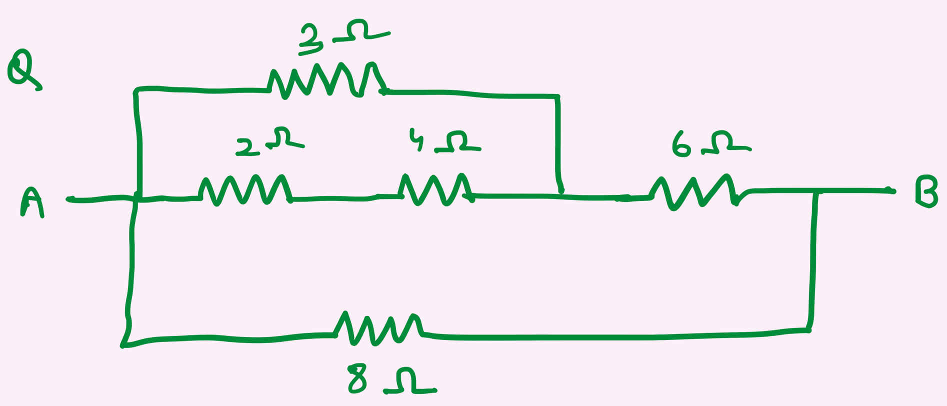


$$I_1 = \frac{I_s R_2}{R_1+R_2} \qquad I_2 = \frac{I_s R_1}{R_1+R_2}$$



$$I_1 = \frac{I_s\left(\frac{1}{R_2}+\frac{1}{R_3}\right)^{-1}}{R_1+\left(\frac{1}{R_2}+\frac{1}{R_3}\right)^{-1}} \qquad I_2 = \frac{I_s\left(\frac{1}{R_1}+\frac{1}{R_3}\right)^{-1}}{R_2+\left(\frac{1}{R_1}+\frac{1}{R_3}\right)^{-1}}$$

Q



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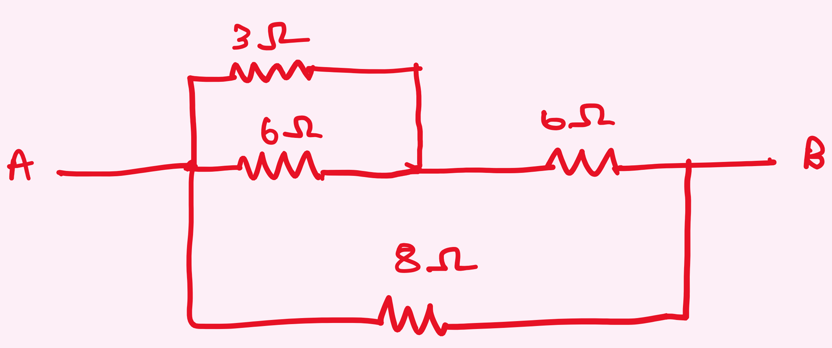

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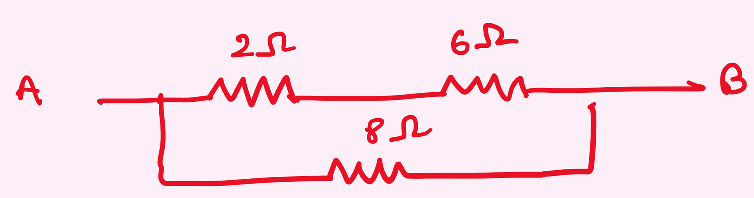

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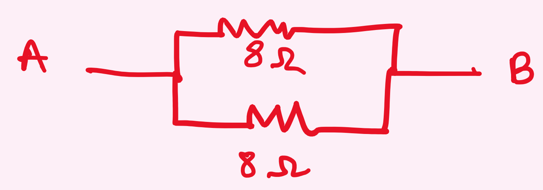
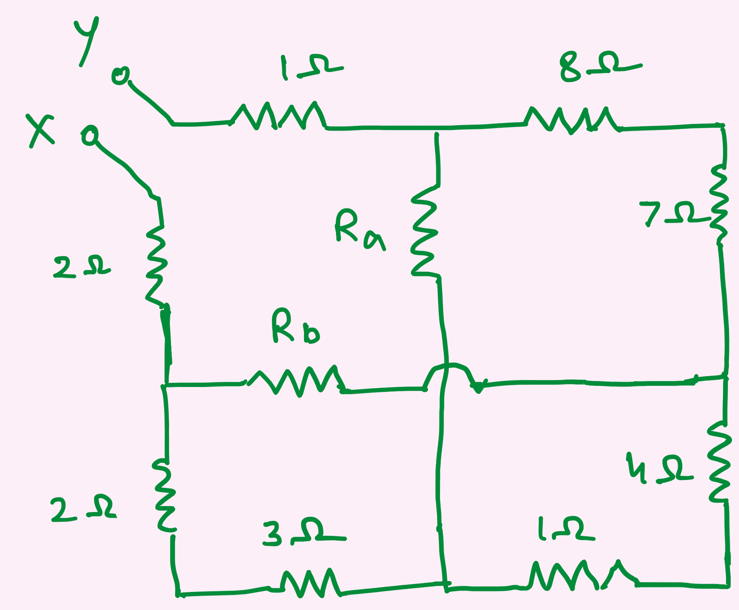


= A 4Ω B

Q. i) $R_a = \infty$ & $R_b = \infty$
ii) $R_a = 0$ & $R_b = \infty$
iii) $R_a = \infty$ & $R_b = 0$
iv) $R_a = 0$ & $R_b = 0$

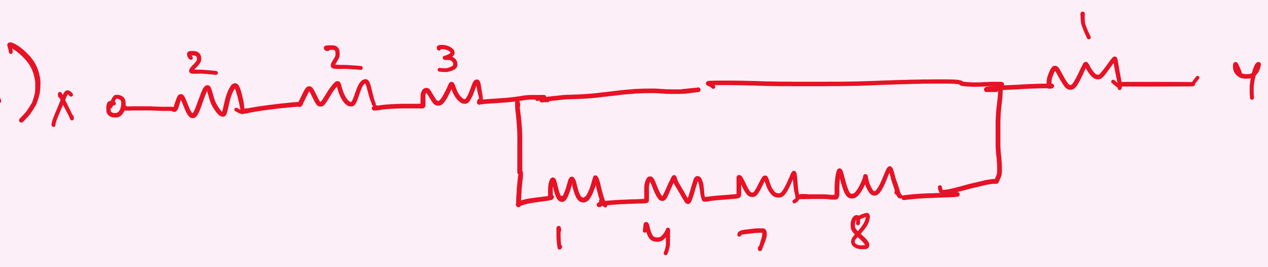
Find R_{eq} b/w X & Y



A. i)

$= 28\,\Omega$

ii)

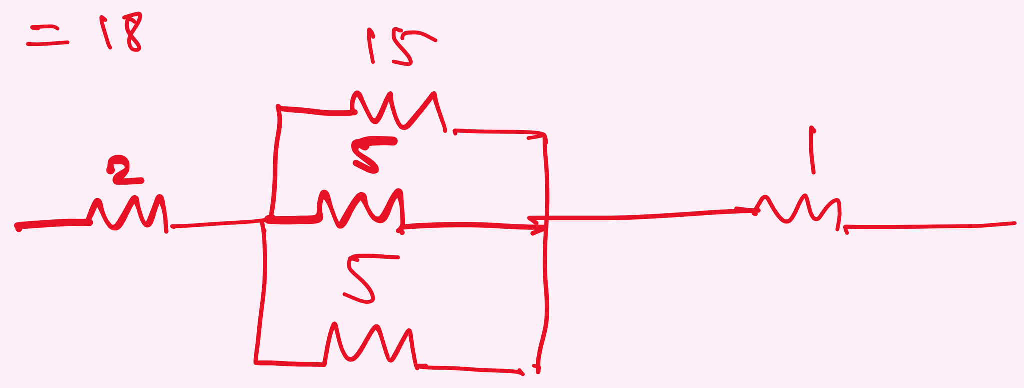


$= 8\,\Omega$

iii)

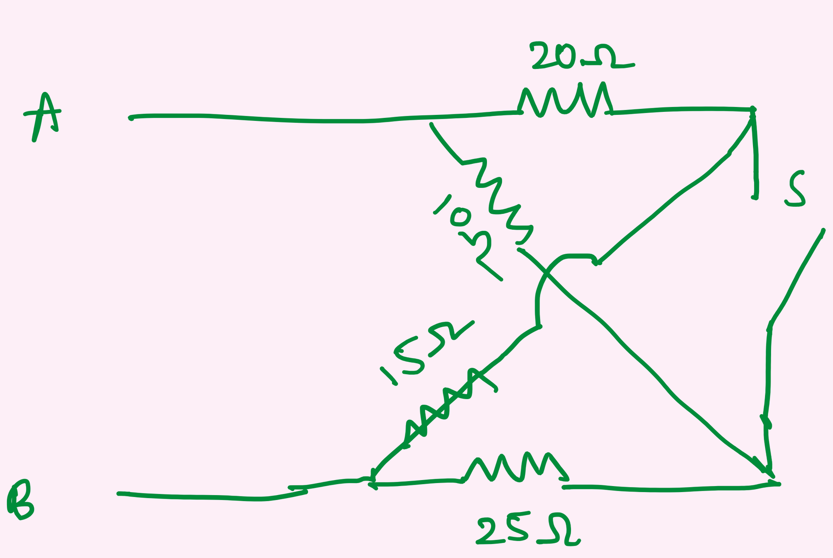
$= 18$

iv)

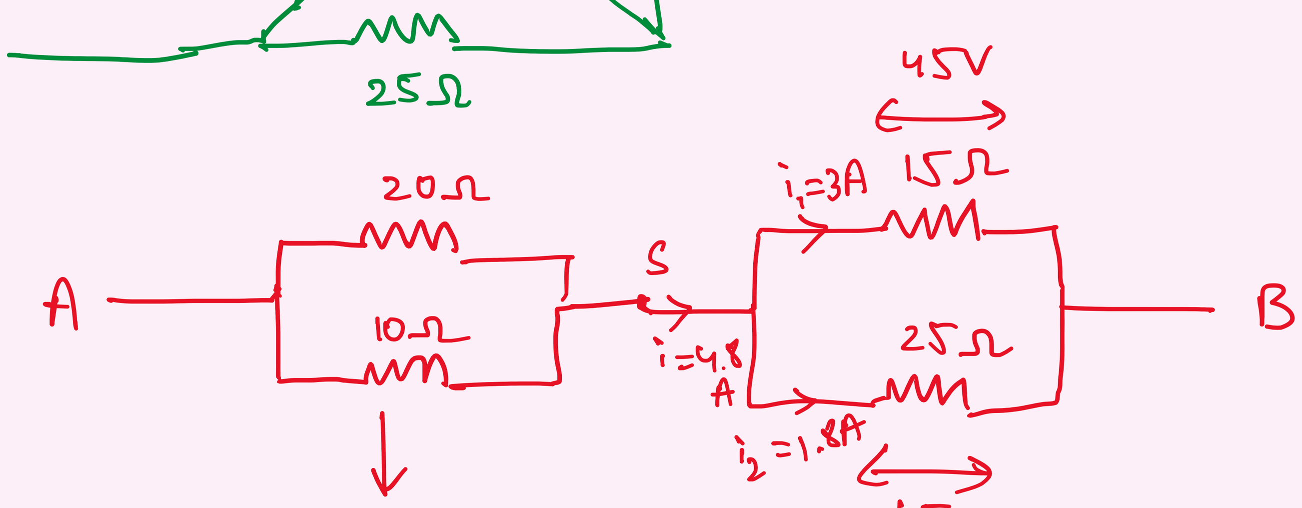


$= 5.14\,\Omega$

Q. Find V_{AB}, If current thru 15Ω resistor is 3A when switch is i) closed ii) open



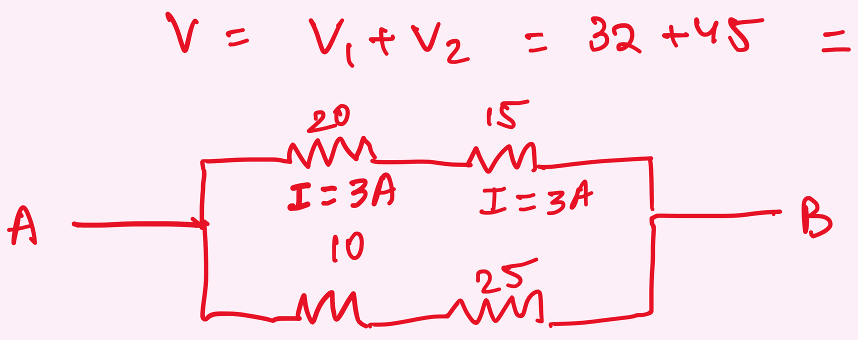
i)



$R_{eq} = 6.67$
$V_1 = 6.67 \times 4.8$
$= 32V$

$V = V_1 + V_2 = 32 + 45 = 77V$

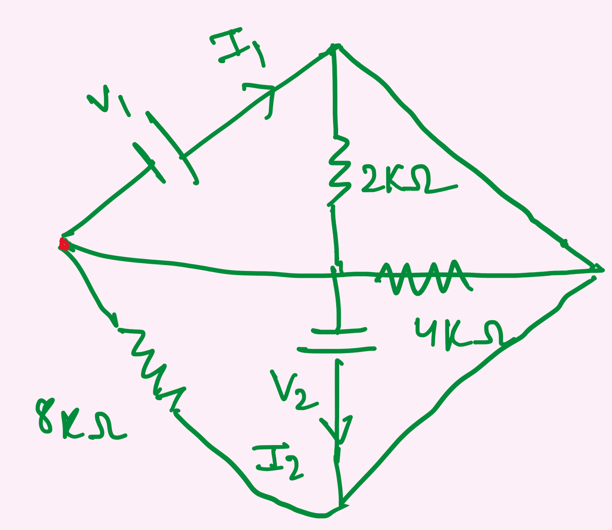
ii)



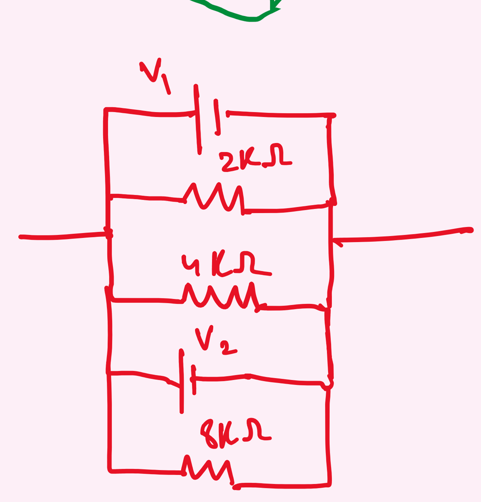
$V_1 = 20 \times 3 = 60V$
$V_2 = 15 \times 3 = 45V$
$V_1 + V_2 = 105V \Rightarrow$ First $\parallel^{el}$ wire $= 105V$
Since they are parallel, both will be 105V

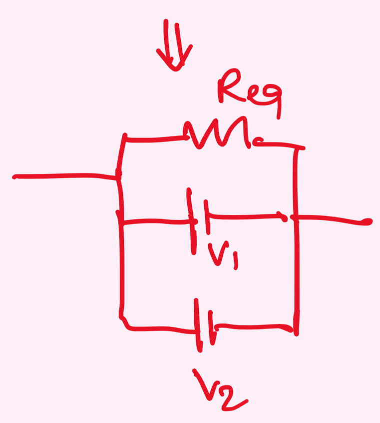
Q. Find V_1, V_2, P

Given $I_1 = 5mA$ $I_2 = 3mA$



A.





$$R_{eq} = \left(\frac{1}{2}+\frac{1}{4}+\frac{1}{8}\right)^{-1}$$
$= 1.142\,K\Omega$
$V = 8 \times 1.142 = 9.142V$

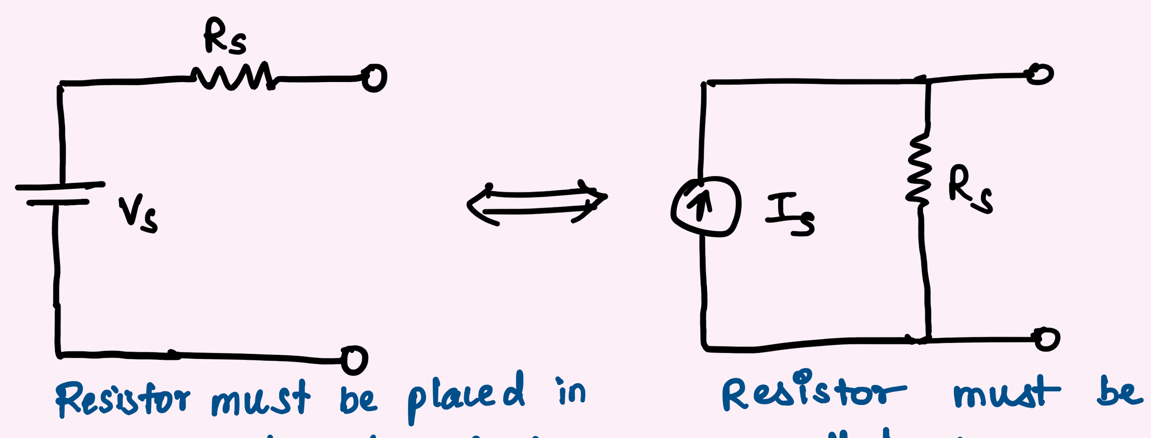
$$P_{(2)} = \frac{V^2}{R_1} = \frac{(9.142)^2}{2\times10^3} = 0.041W$$

$$P_{(4)} = \frac{V^2}{R_2} = \frac{(9.142)^2}{4\times10^3} = 0.020W$$

$$P_{(8)} = \frac{V^2}{R_3} = \frac{(9.142)^2}{8\times10^3} = 0.01W$$

4. Source transformation

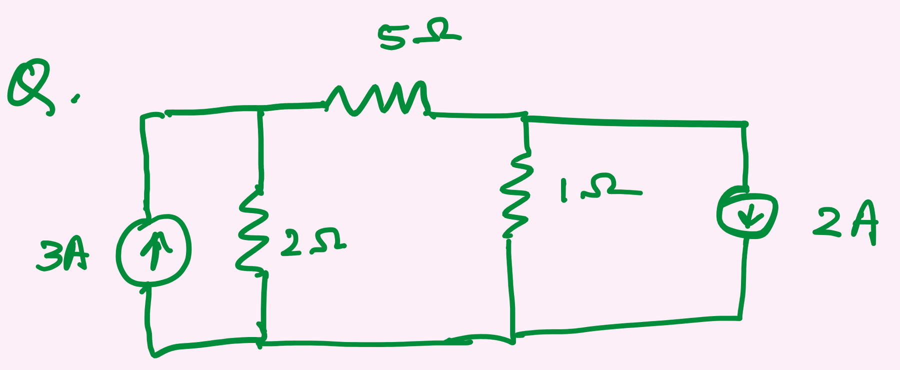
- Practical voltage source can be transformed to Practical current source & vice versa

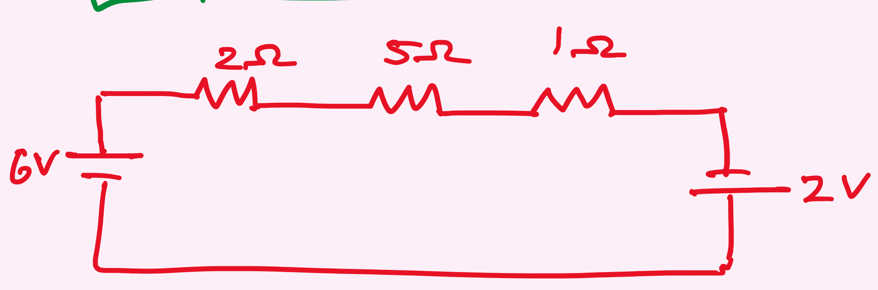


Resistor must be placed in series with voltage source

Resistor must be placed parallel to current source

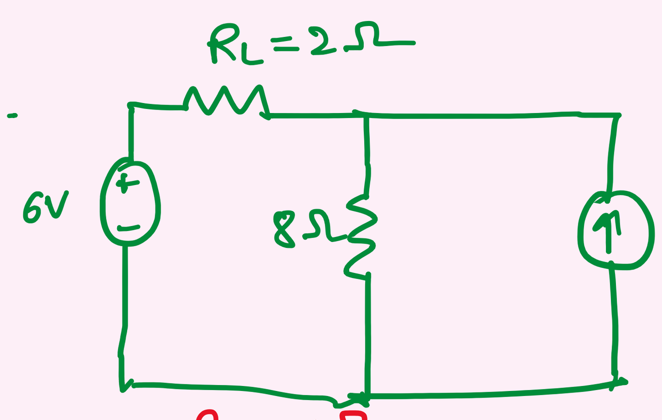
Q.

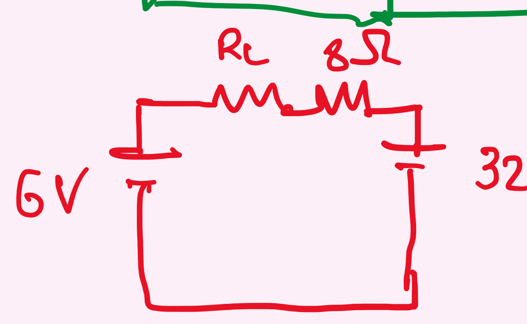




$8V = 8I \Rightarrow I = 1A$

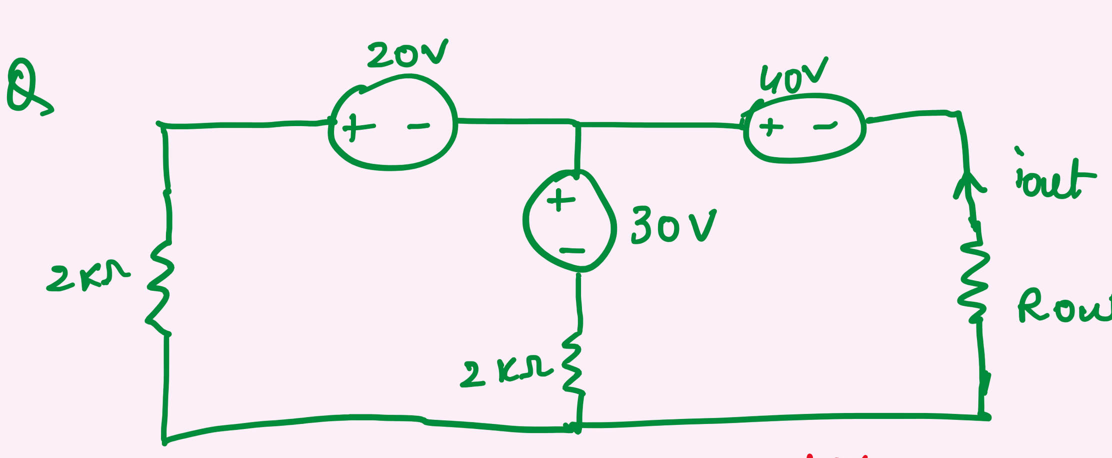
Q.



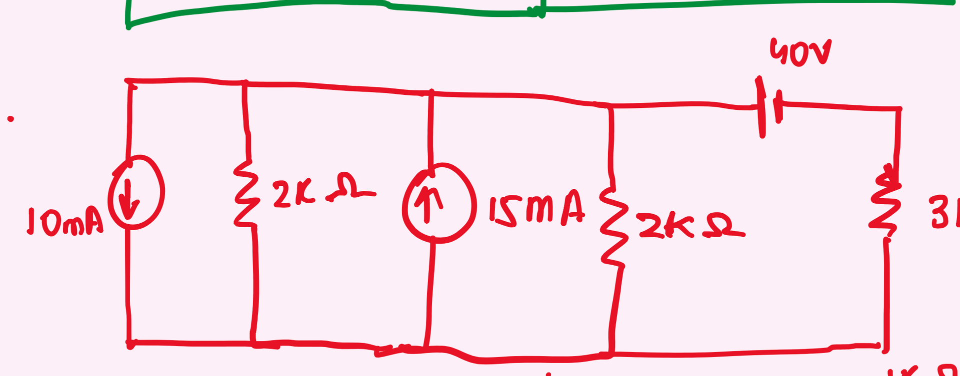


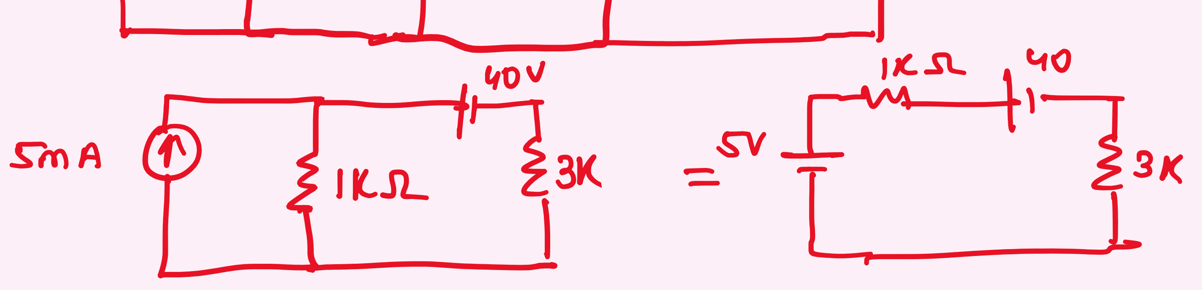
$$32 - 6 - iR_L - 8i = 0$$
$$26 = 10i$$
$$2.6A = i$$

Q



A.

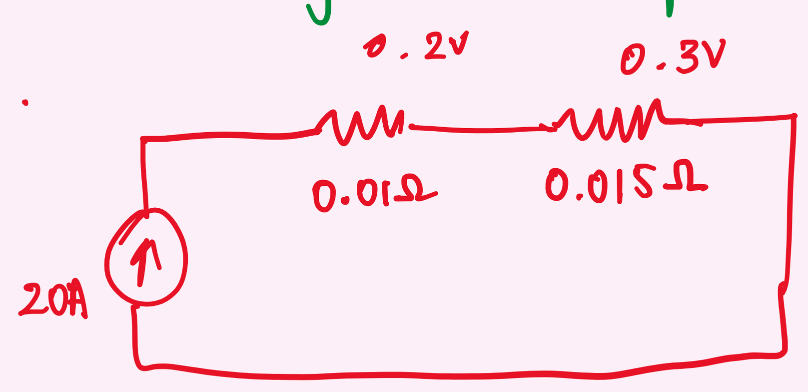


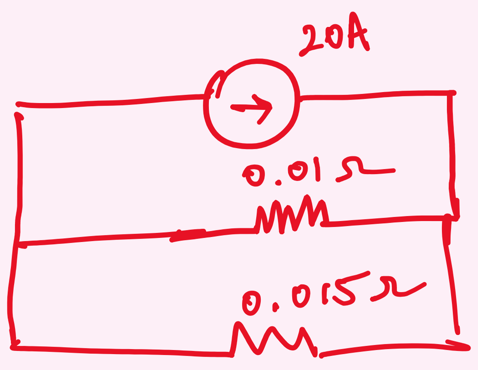


$$40 - 5 - 4Ki = 0$$
$$\frac{35}{4000} = i$$
$$i = 8.75mA$$

Q. A current of 20A flows through 2 ammeters A & B joined in series. Across A, the potential diff is 0.2V & across B it is 0.3V. Find how same current divides b/w A & B when joined in parallel

A.



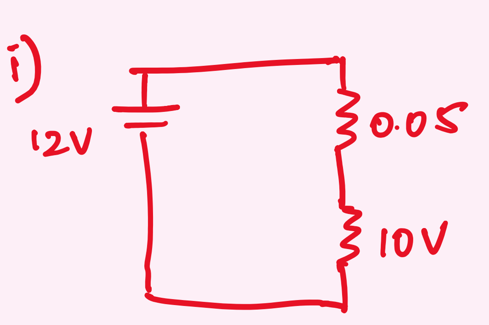


$$i_1 = \frac{\cancel{20 \times 0.015}}{\cancel{0.025}} = 12A$$

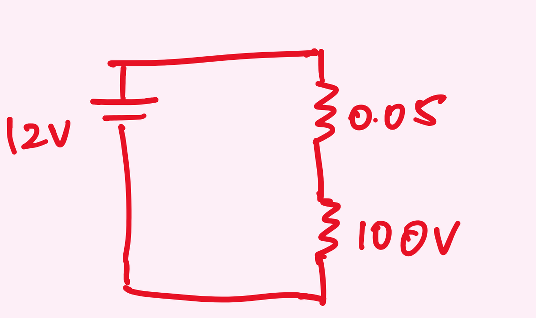
$$i_2 = \frac{\cancel{20} \times \cancel{0.01}}{\cancel{0.025}} = 8A$$

Q. Battery of EMF 12V & Internal resistance = 0.05Ω supplies power to load resistance R_L. Determine % Change in voltage as load resistance varies from 10Ω to 100Ω

A. i)



ii)



$$V_{(10)} = \frac{12 \times 10}{10 + 0.05} = 11.94$$

$$V_{(100)} = \frac{12 \times 100}{100 + 0.05} = 11.99$$

$$\%\ change = \frac{11.99 - 11.94}{11.94} \times 100 = 0.42\%$$

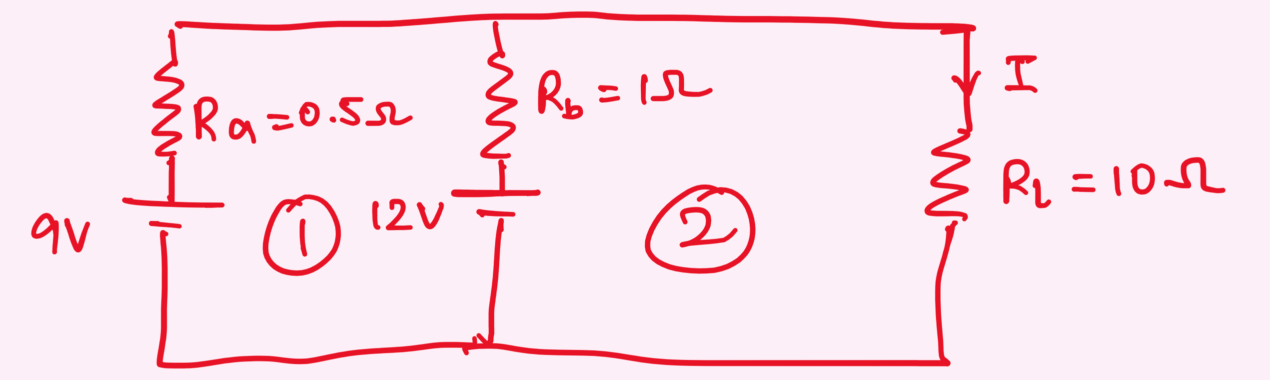
Q. 2 batteries connected in $\|^{el}$ & load of 10Ω connected across them. Battery A = 9V & Internal resistance = 0.5Ω. Battery B = 12V & internal resistance = 1Ω.

i) Find R_L magnitude & direction

ii) Find current supplied by both batteries

iii) Potential diff across R_L

A.



$$① \Rightarrow 9V - 0.5i_1 + i_2 - 12V = 0$$
$$3 = i_2 - \frac{i_1}{2}$$

$$② \Rightarrow 12 - i_2 - 10(i_1 + i_2) = 0$$
$$12 = 10i_1 + 11i_2$$

$$i_1 = \frac{-42}{31}, \quad i_2 = \frac{72}{31}$$

$$i = i_1 + i_2 = 0.97A$$

$$V_L = iR_L = 0.97 \times 10 = 9.7V$$

i) $R_L = 10\Omega$ Clockwise

ii) $i_A = -1.35A$ $\quad i_B = 2.32A$

iii) $V_L = 9.7V$

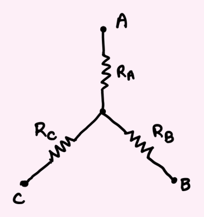
5. Star Delta Transformations

Sunday, 11 February 2024 7:40 AM

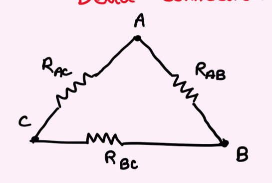
5. Star Delta Transform...

5. Star Delta Transformations

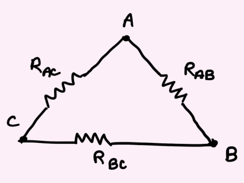
Star Connection



Delta Connection



Delta to Star Conversion



A to B ⇒ 2 paths

$$R_A + R_B = \frac{R_{AB} * (R_{BC} + R_{AC})}{R_{AB} + (R_{BC} + R_{AC})} \longrightarrow 1$$

$$\boxed{R_{eq} = \frac{R_a * R_b}{R_a + R_b}}$$

Similarly,
B to C,

$$R_B + R_C = \frac{R_{BC} * (R_{AB} + R_{AC})}{R_{BC} + (R_{AB} + R_{AC})} \longrightarrow 2$$

And,
A to C,

$$R_A + R_C = \frac{R_{AC} * (R_{AB} + R_{BC})}{R_{AC} + R_{AB} + R_{BC}} \longrightarrow 3$$

Now, 1 − 2 + 3

$$2R_A = \frac{\cancel{R_{AB}R_{BC}} + R_{AB}R_{CA} - \cancel{R_{BC}R_{AB}} - \cancel{R_{BC}R_{CA}} + \cancel{R_{AC}R_{BC}} + R_{AC}R_{AB}}{R_{AB} + R_{BC} + R_{AC}}$$

$$R_A = \frac{R_{AB} \cdot R_{AC}}{R_{AB} + R_{BC} + R_{AC}} \longrightarrow 4$$

Similarly, $R_B = \frac{R_{AB} \cdot R_{BC}}{R_{AB} + R_{BC} + R_{AC}} \longrightarrow 5$, $R_C = \frac{R_{AC} \cdot R_{BC}}{R_{AB} + R_{BC} + R_{AC}} \longrightarrow 6$

Star to Delta Conversion

4 * 5 + 5 * 6 + 6 * 4

$$\frac{R_{ab}^2 R_{ac} R_{bc} + R_{ab} R_{ac} R_{bc}^2 + R_{ab} R_{ac}^2 R_{bc}}{(R_{ab} + R_{bc} + R_{ca})^2}$$

$$R_A R_B + R_B R_C + R_C R_A = \frac{R_{ab} * R_{bc} * R_{ca}}{R_{ab} + R_{bc} + R_{ca}}$$

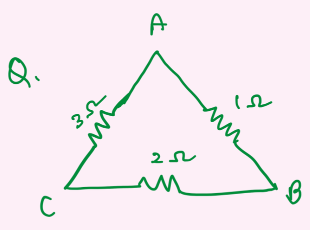
$$R_A R_B + R_B R_C + R_C R_A = R_A * R_{bc}$$

$$R_{bc} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A} \longrightarrow 7$$

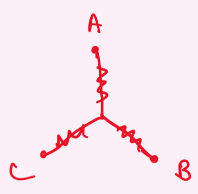
Similarly, $R_{ab} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C} \longrightarrow 8$

$$R_{ca} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B} \longrightarrow 9$$

Q.



A. $R_{AC} = 3\Omega$ $R_{AB} = 1\Omega$ $R_{BC} = 2\Omega$

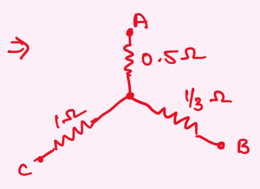


$$R_A = \frac{R_{BA} \cdot R_{AC}}{R_{AB} + R_{BC} + R_{CA}} = \frac{1 \times 3}{6} = \frac{1}{2}\Omega$$

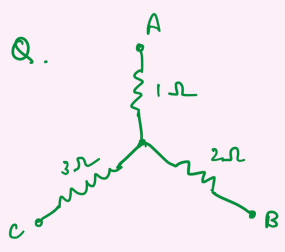
$$R_B = \frac{R_{AB} \cdot R_{BC}}{6} = \frac{1 \times 2}{6} = \frac{1}{3}\Omega$$

$$R_C = \frac{R_{AC} \cdot R_{BC}}{6} = \frac{3 \times 2}{6} = 1\Omega$$

⇒



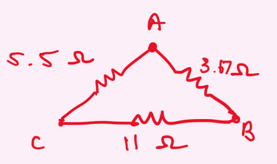
Q.



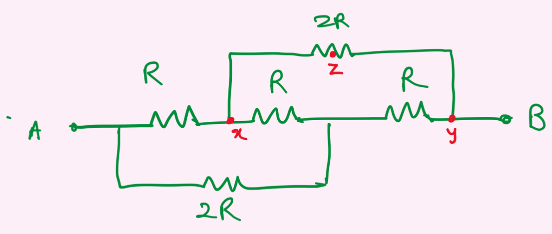
A. $R_{AB} = \frac{1 \times 2 + 2 \times 3 + 1 \times 3}{3} = \frac{2+6+3}{3} = \frac{11}{3}$

$$R_{BC} = \frac{11}{1} = 11\Omega$$

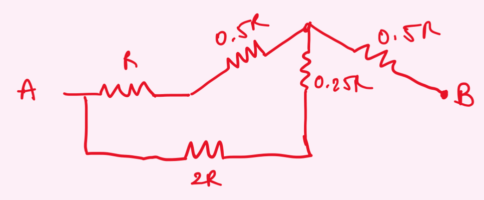
$$R_{CA} = \frac{11}{2} = 5.5\Omega$$



Q.



A.

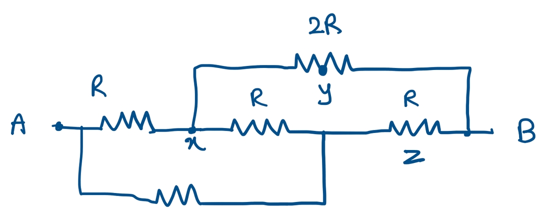


$$R_x = \frac{R_{xy} \cdot R_{xz}}{R_{xy} + R_{xz} + R_{yz}} = \frac{\cancel{2}R^{\cancel{2}}}{2\cancel{4}\cancel{R}} = \frac{R}{2}$$

$$R_y = \frac{R_{xy} \cdot R_{yz}}{4R} = \frac{\cancel{2}R \times \cancel{R}}{2\cancel{4}\cancel{R}} = \frac{R}{2}$$

$$R_z = \frac{R_{xz} \cdot R_{yz}}{4R} = \frac{R^2}{4R} = \frac{R}{4}$$

$$R_{eq} = 1.4R$$



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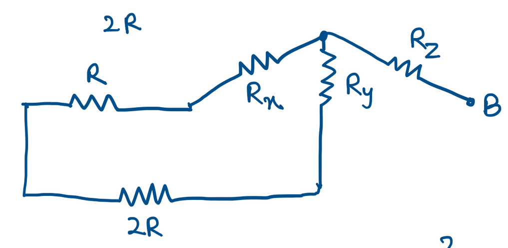
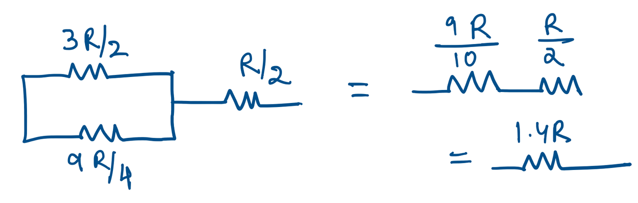


$$R_x = \frac{R_{xy} \cdot R_{xz}}{R_{xy} + R_{xz} + R_{yz}} = \frac{2R^2}{4R} = \frac{R}{2}$$

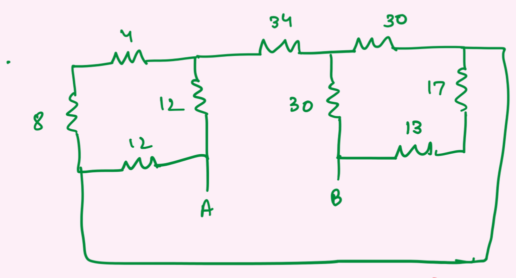
$$R_y = \frac{R_{xy} \cdot R_{yz}}{4R} = \frac{R}{4}$$

$$R_z = \frac{R_{xz} \cdot R_{yz}}{4R} = \frac{R}{2}$$

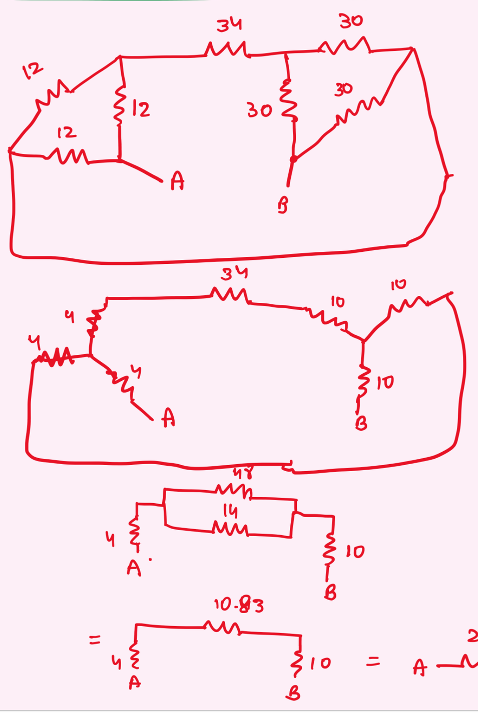
=



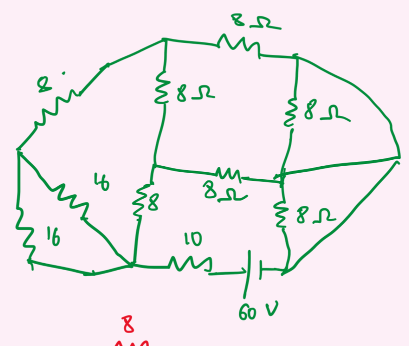
Q.

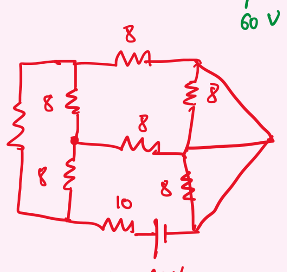


A.

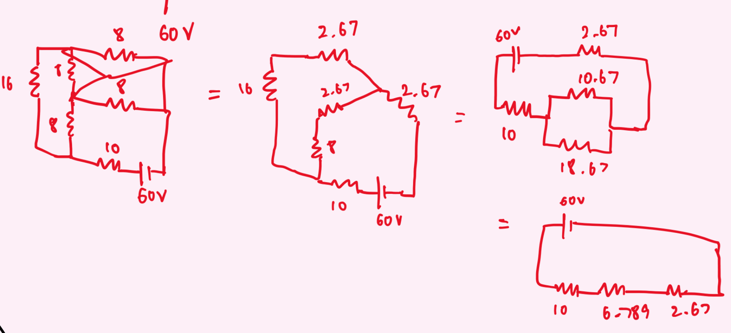


Q.





$\frac{\cancel{64}}{\cancel{24}}$ $\frac{8}{3}$

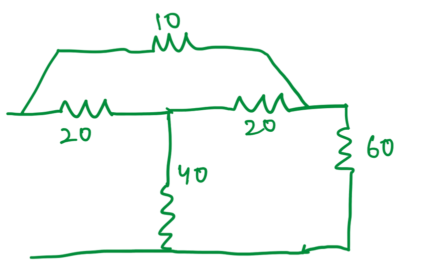


⇒ 19.46 Ω

I = 3.083A

V(10Ω) = 3.083 × 10 = 30.83 V

Q.



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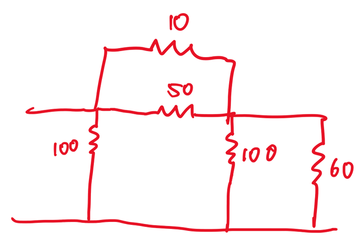

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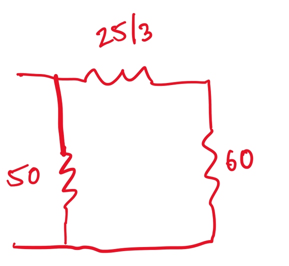
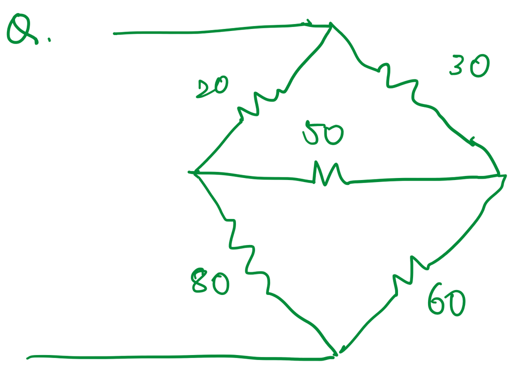


$$\frac{800+800+400}{40} = 50$$

$$\frac{2000}{20} = 100$$

$$\left(\frac{205}{3}\right)^{-1} + 50^{-1}$$

Q.



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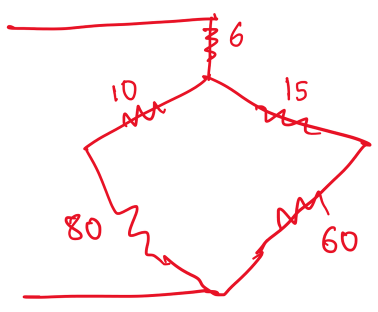
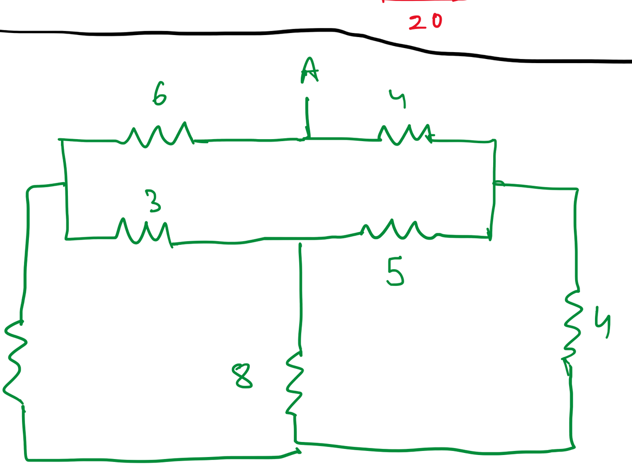


= 6 40.9

= 46.9

Q.



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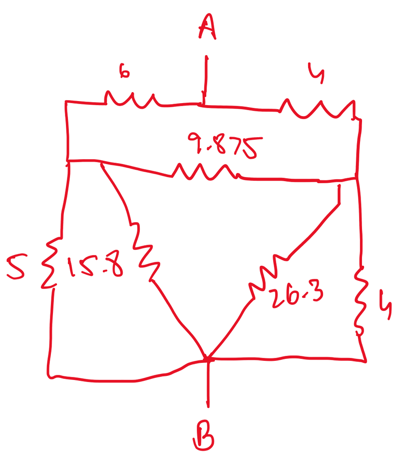
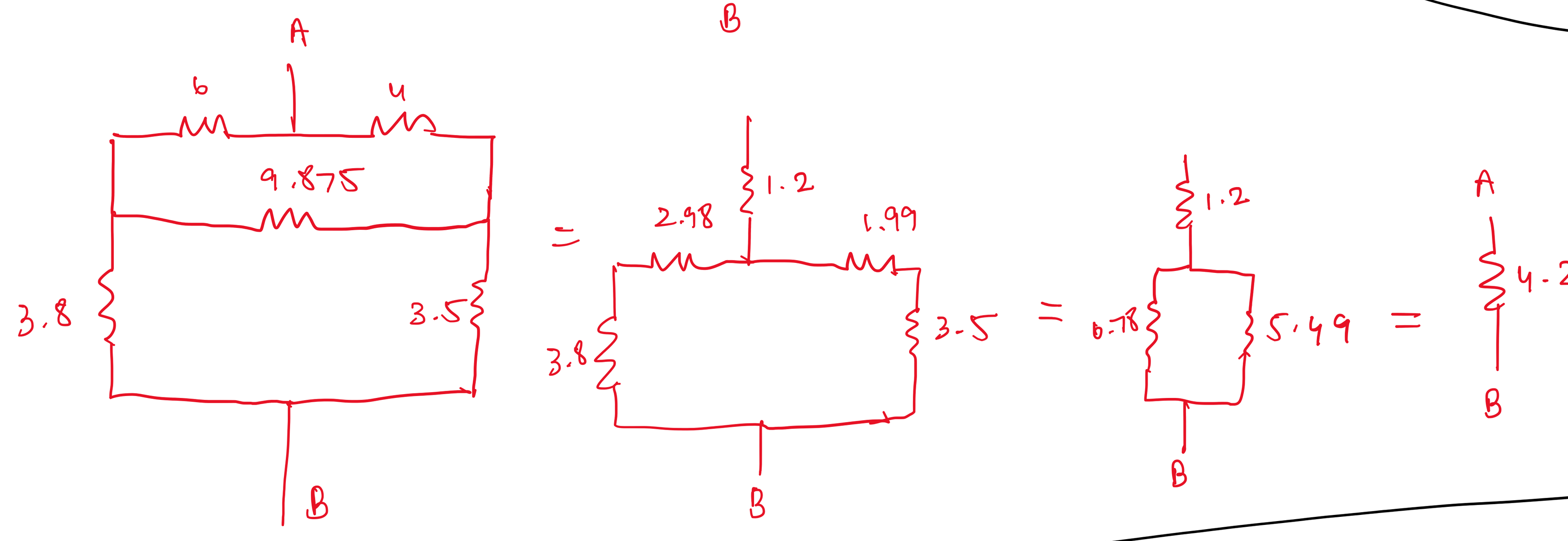


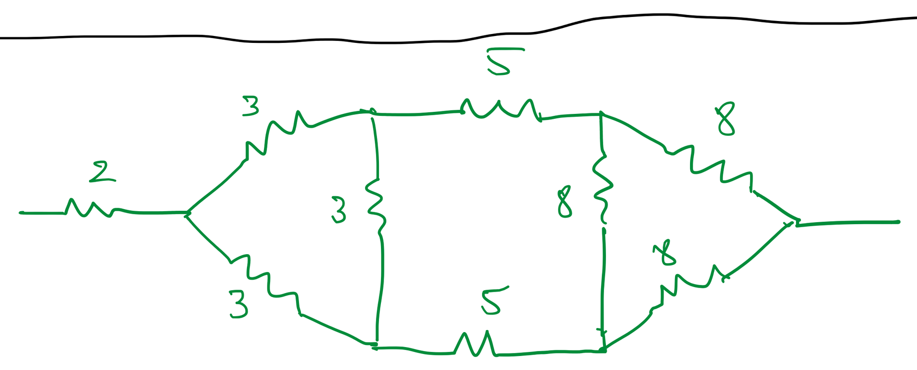
$$\frac{15+40+24}{8}$$

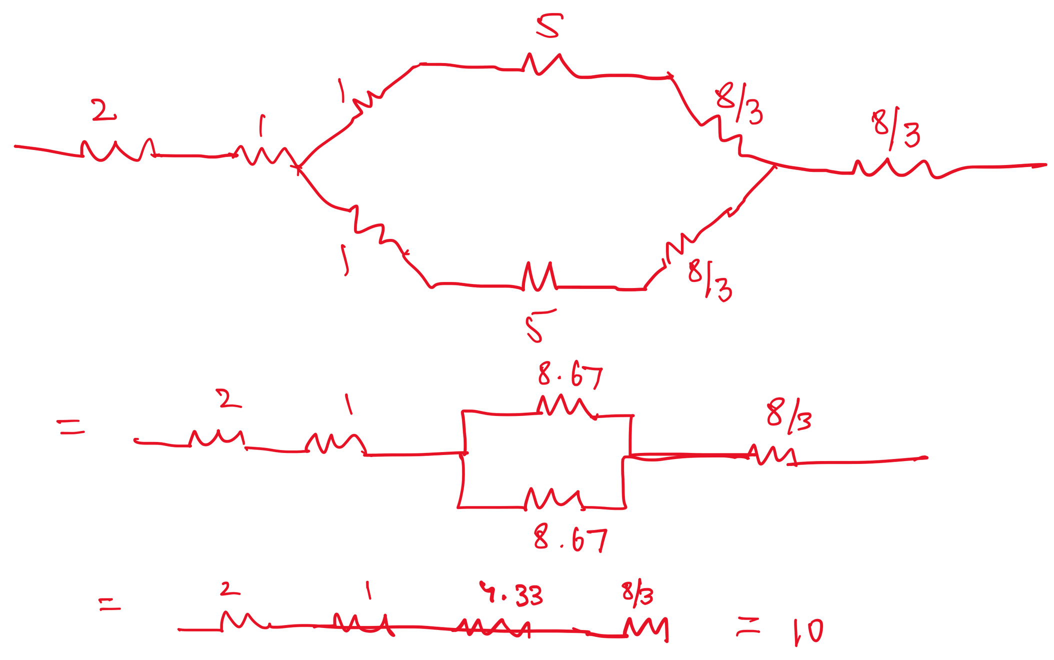
$$\frac{79}{5}$$

=



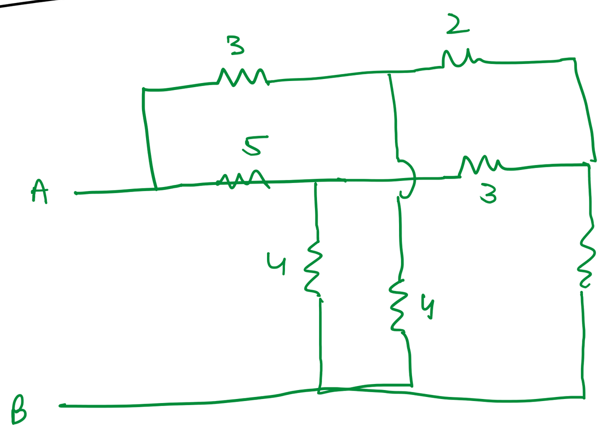
Q.





= 10

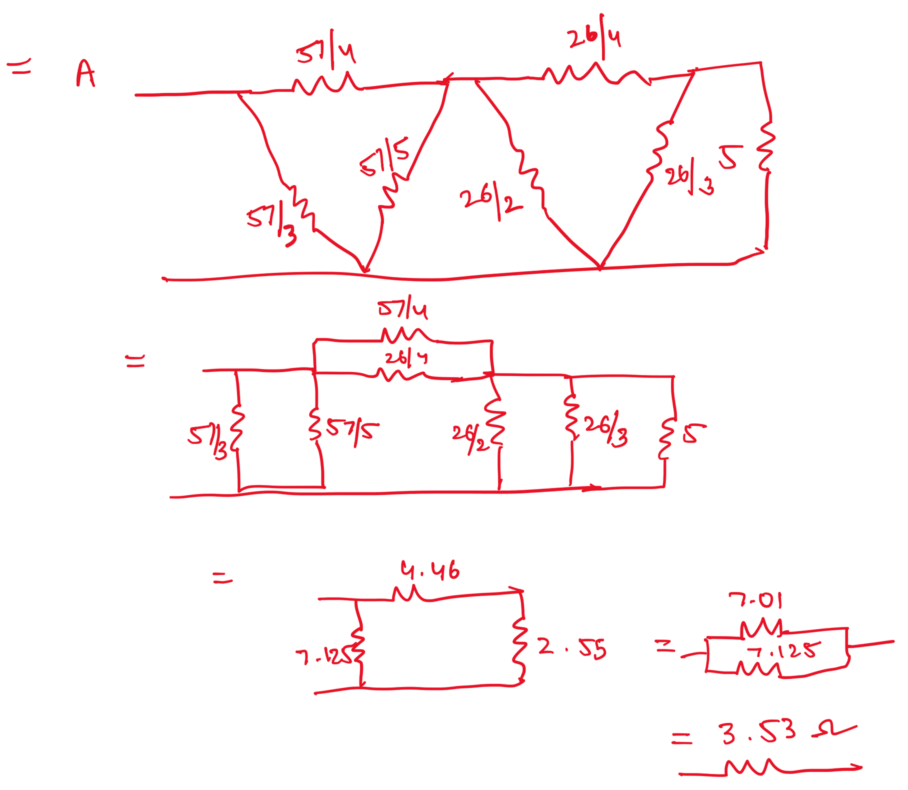
Q.



~~15 + 12 + 20~~ 57

6 + 8 + 12

= A



= 3.53 Ω

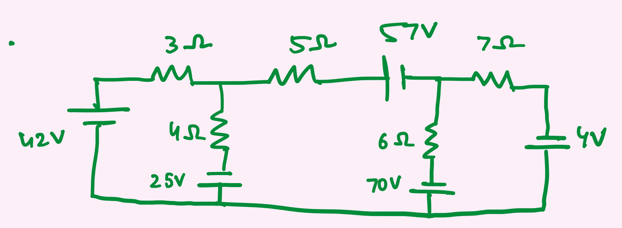
6. Mesh Analysis

→ Most Fundamental loop in a circuit

Steps:

1) Find all mesh
2) Apply KVL in clockwise & give a current to each mesh
3) Solve simultaneous equations

Q.



A.

$7I_1 - 4I_2 - 0I_3 = 25 + 42$

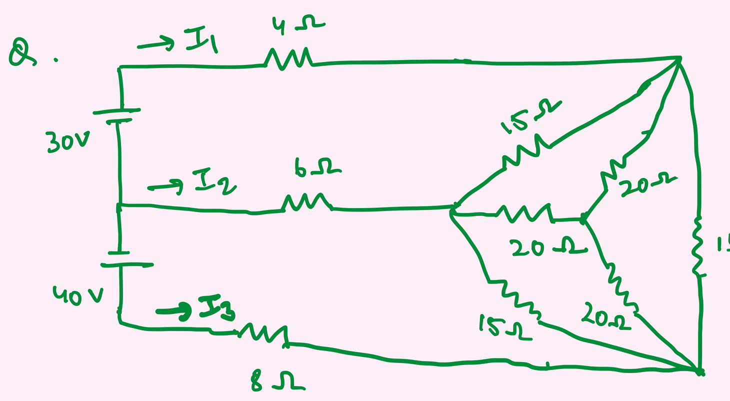
$-4I_1 + 15I_2 - 6I_3 = -70 - 25 - 57$

$-0I_1 - 6I_2 + 13I_3 = 4 + 70$

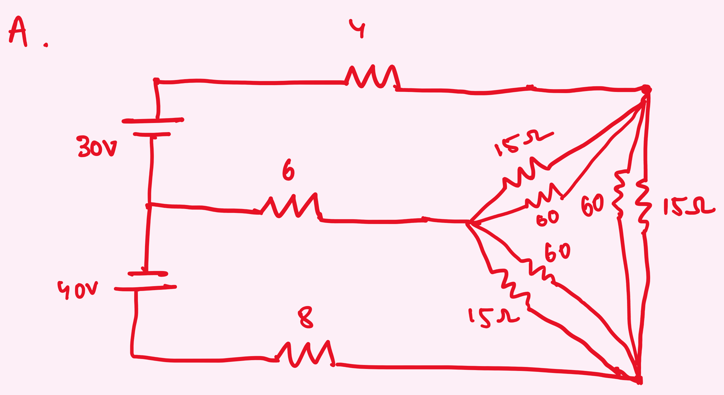
$I_1 = 5, \; I_2 = -8, \; I_3 = 2$

I thru $6\Omega = I_3 - I_2 = 2 - (-8) = 10\,A$

Q.



A.



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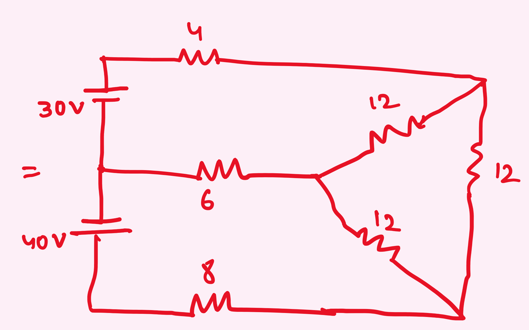

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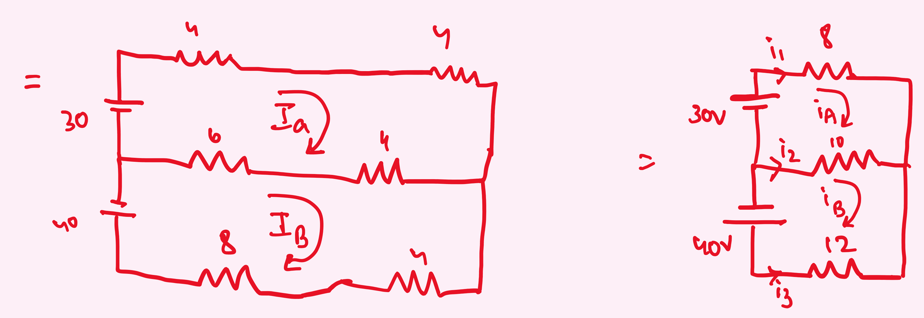


$(8+10)i_A - 10i_B = 30$

$-10i_A + 22i_B = -40$

$i_A = 0.88A$

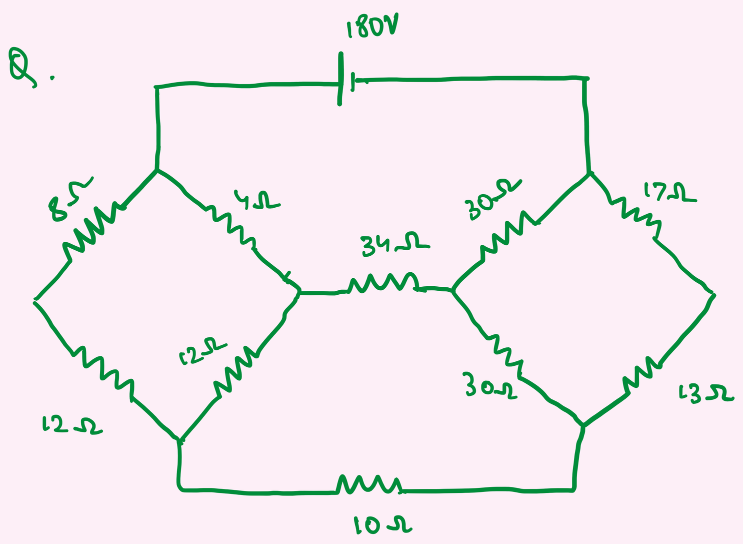
$i_B = -1.42A$

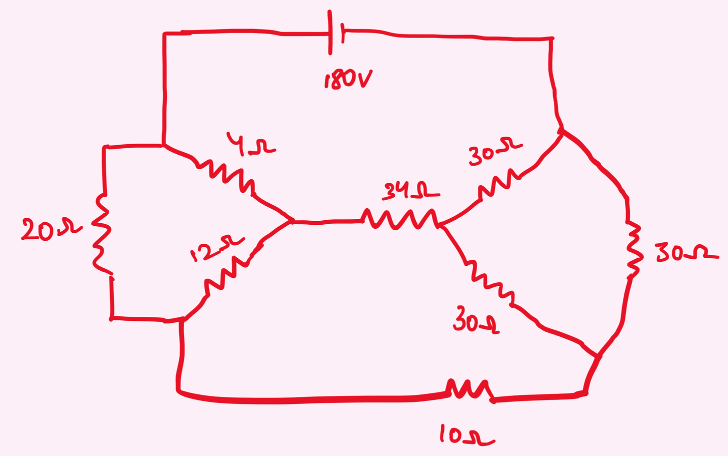
$i_1 = i_A = 0.88A$

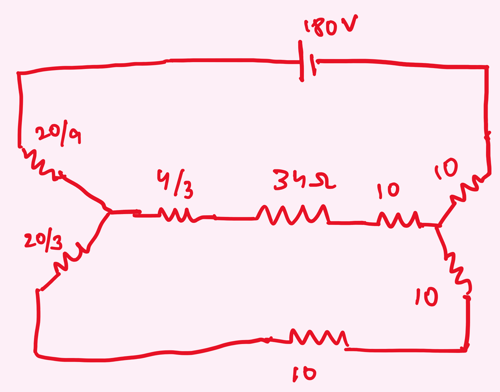
$i_3 = i_B = -1.41A$

$i_2 = -i_1 - i_3 = 1.41 - 0.88 = 0.532$

Q.







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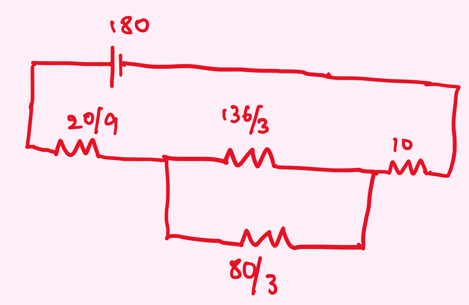

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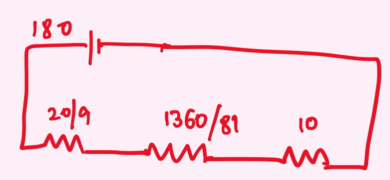

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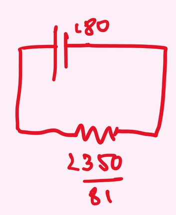


$I = \frac{180}{\frac{2350}{81}} = 6.2A$

$I_{(10\Omega)} = 6.2 \times \frac{1540/81}{2350/81} = 4A$

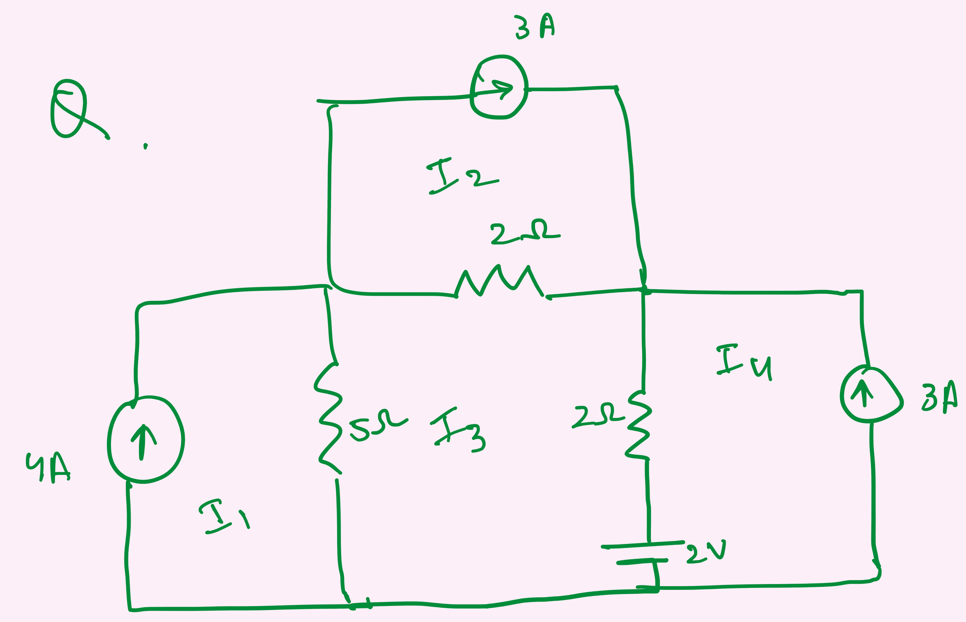
⇒ $57.5I_1 - 45.3I_2 = 180$

$-45.3I_1 + 71.3I_2 = 0$

$I_1 = -6.26A$

$I_2 = -3.98A$ ⟹ Current thru 10Ω resistor

Q.



$I_1 = 4A$

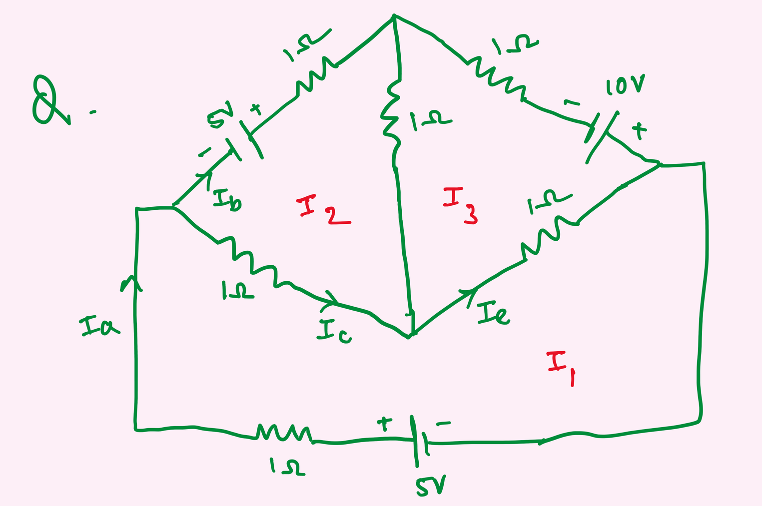
$I_2 = 3A$

$5I_1 - 2I_2 + 9I_3 - 2I_4 = -2$ ⇒ $-20 - 6 + 9I_3 + 6 = -2$

$I_4 = 3A$ $\qquad I_3 = 2A$

$I_{(5\Omega)} = I_1 - I_3 = 2A$

Q.



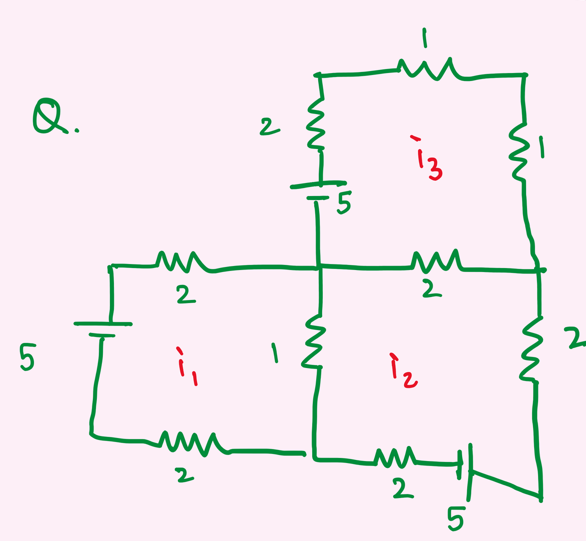
$3I_1 - I_2 - I_3 = 5$

$-I_1 + 3I_2 - I_3 = 5$

$-I_1 - I_2 + 3I_3 = 10$

$I_1 = 6.25 \quad I_2 = 6.25 \quad I_3 = 7.5$

Q.



$5i_1 - 1i_2 - 0i_3 = 5$

$-1i_1 + 7i_2 - 2i_3 = -5$

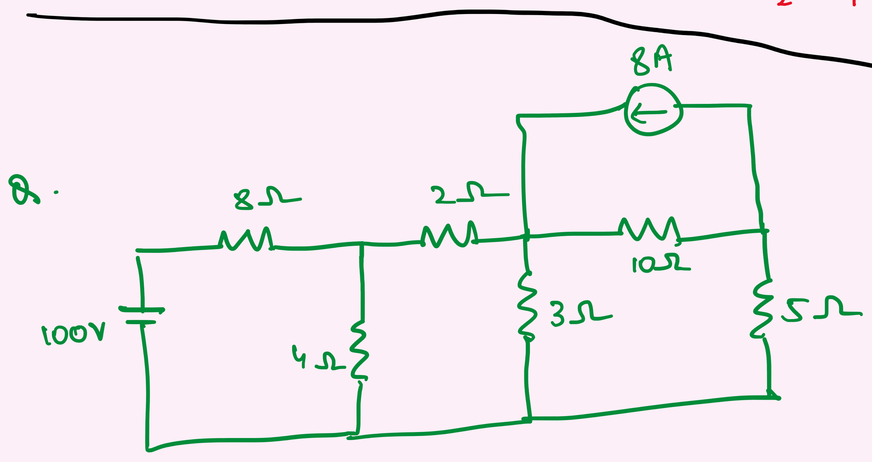
$0i_1 - 2i_2 + 6i_3 = +5$

$i_1 = 0.92$

$i_2 = -0.38$

$i_3 = 0.706$

Q.



Find $I_{(4\Omega)}$

$12I_1 - 4I_2 + 0I_3 + 0I_4 = 100$

$-4I_1 + 9I_2 - 3I_3 + 0I_4 = 0$

$0I_1 - 3I_2 + 18I_3 - 10I_4 = 0$

$I_4 = -8A$

$I_1 = 9.26$

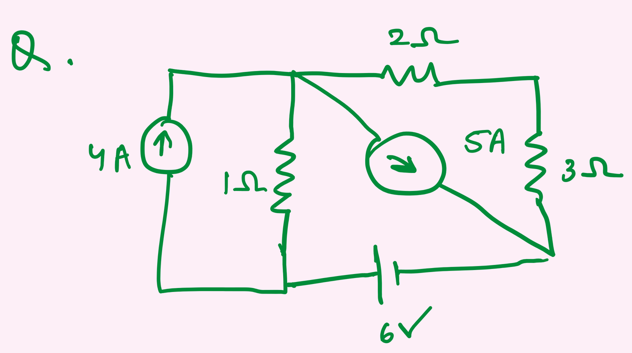
$I_2 = 2.79$

$I_3 = -3.98$

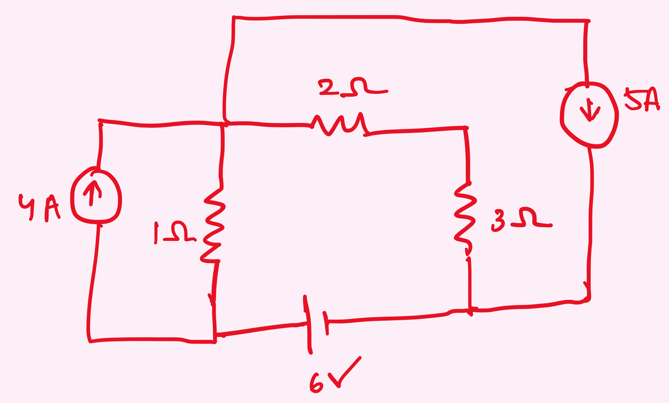
$I_4 = -8$

$I_{(4\Omega)} = 6.47$

Q.



A.



$I_1 = 4A$

$-1I_1 + 6I_2 - 5I_3 = 6$

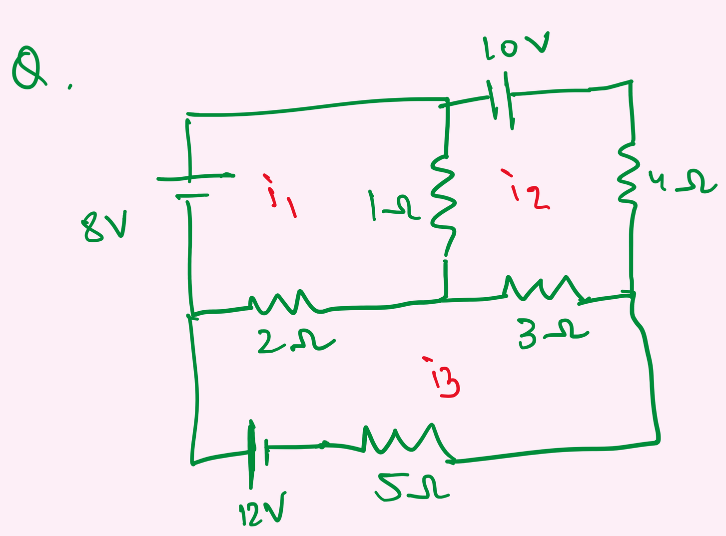
$I_3 = 5A$

$I_2 = 5.833A$

$I_{(3\Omega)} = I_2 - I_3 = 0.833A$

$V_{(3\Omega)} = 0.833 \times 3 = 2.5V$

Q.



$3i_1 - i_2 - 2i_3 = 8$

$-1i_1 + 8i_2 - 3i_3 = 10$

$-2i_1 - 3i_2 + 10i_3 = 12$

$i_1 = 6.01$

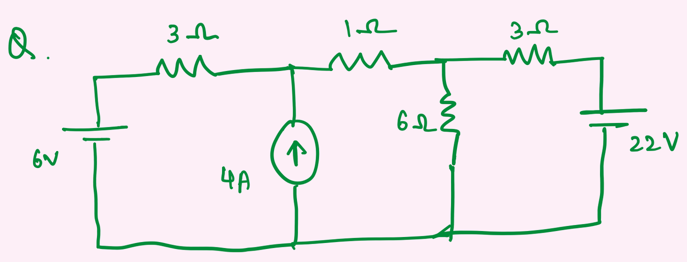
$i_2 = 3.27$

$i_3 = 3.38$

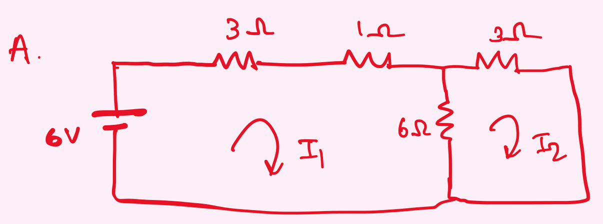
7. Superposition Theorem

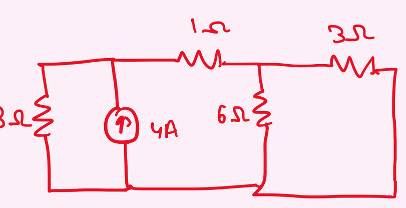
→ In a linear network with 1 or more than 1 independant source, the total response in any element is the algebraic sum of individual responses causes by each independant source acting alone, while all other independant sources are replaced by their internal resistances i.e, all other ideal voltage sources with short circuit & all other ideal current sources with open circuit

Q.



A.

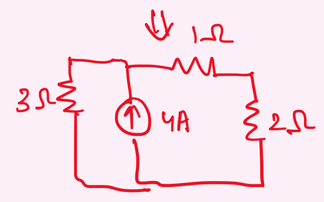




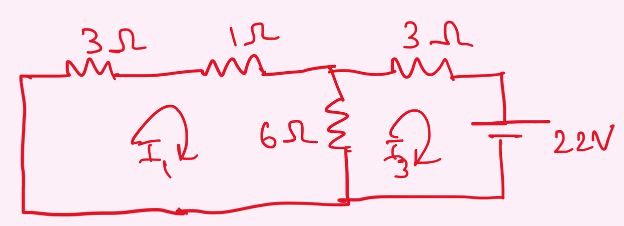
$10I_1 - 6I_2 = 6V$

$-6I_1 + 9I_2 = 0$

$I_1 = 1A \qquad I_2 = 0.67$



$I_{(1\Omega)} = \frac{4 \times 3}{3 + (1+2)} = 2A$



$10I_1 - 6I_3 = 0$

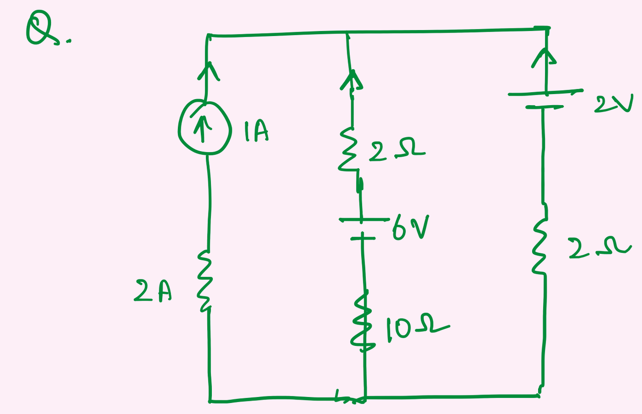
$-6I_1 + 9I_3 = -22$

$I_1 = -2.44$

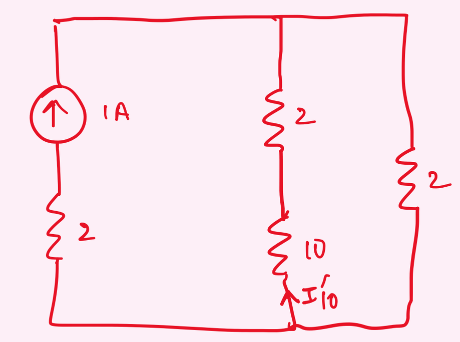
$I_2 = -4.074$

$I_{(1\Omega)} = 1 + 2 - 2.44$
$= 0.56$

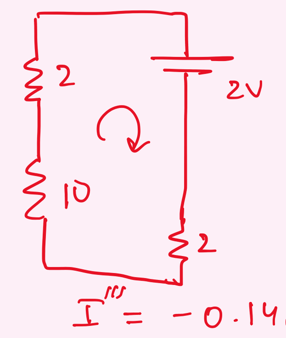
Q.



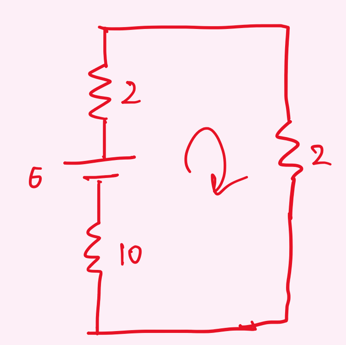
A.



$I'_{10} = \frac{-1 \times 2}{12 + 2} = \frac{-1}{7}A = -0.142A$



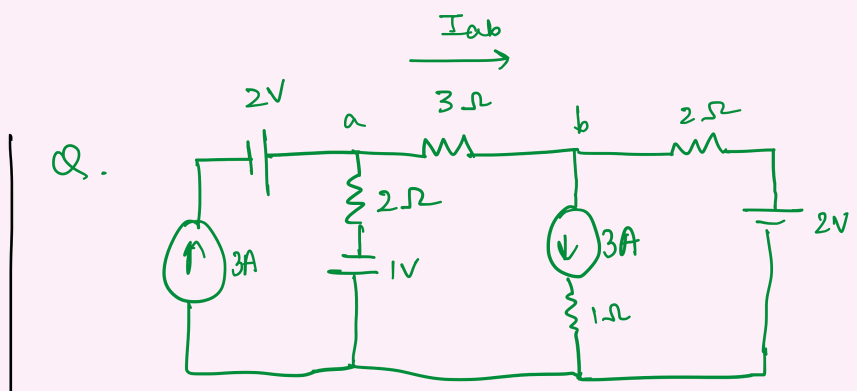
$I''' = -0.142A$



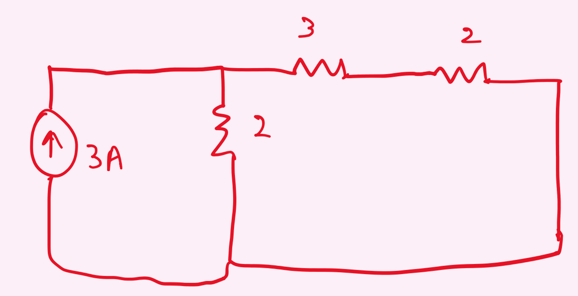
$I'' = 0.428A$

$I_{10} = 0.142$

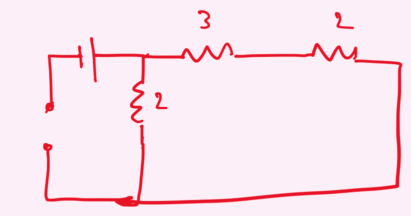
Q.



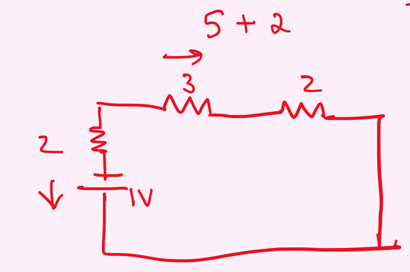
A.



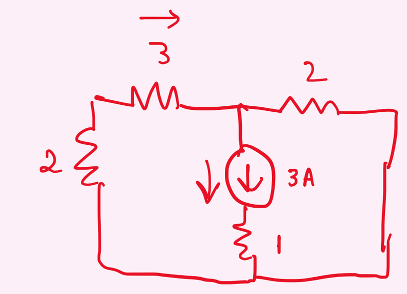
$I' = \frac{3 \times 2}{5+2} = \frac{6}{7}$



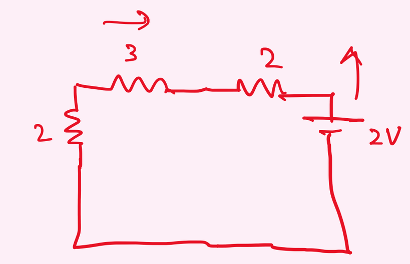
$I'' = 0$



$I''' = \frac{-1}{7}$



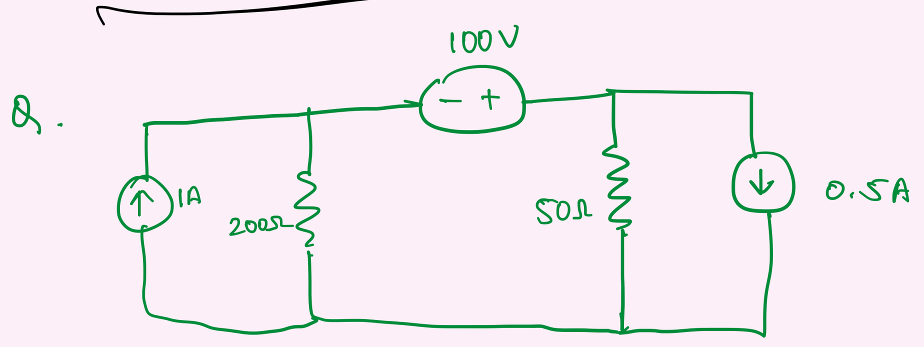
$I'''' = \frac{3 \times 2}{5+2} = \frac{6}{7}$



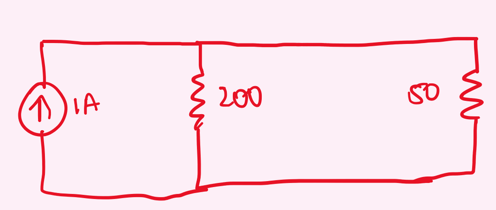
$I''''' = \frac{-2}{7}$

$I = I' + I'' + I''' + I'''' + I''''' = \frac{6 + 0 - 1 + 6 - 2}{7} = \frac{9}{7} = 1.285A$

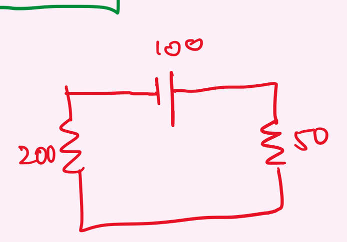
Q.



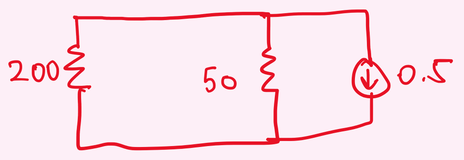
A.



$I'_{50} = \frac{1 \times 200}{250} = \frac{-4}{5}A$



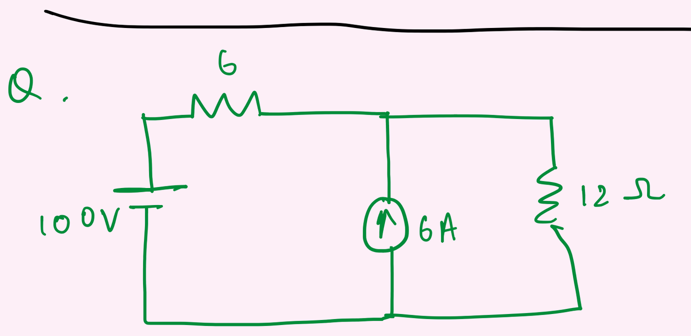
$I''_{50} = \frac{100}{250} = \frac{-2}{5}A$

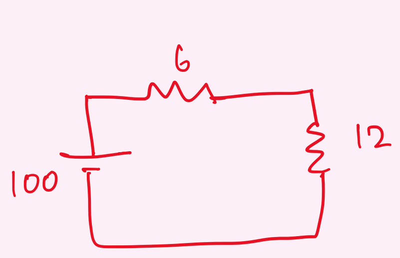


$I'''_{50} = +\frac{0.5 \times 200}{250} = \frac{+2}{5}$

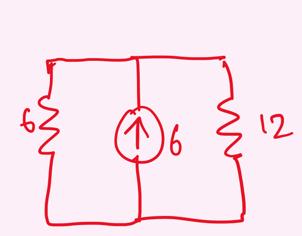
$I_{50} = I' + I'' + I'''$
$= -\frac{4}{5}A$
$= -800\,mA$

Q.





$I'_6 = \frac{100}{18}$
$= 5.55$

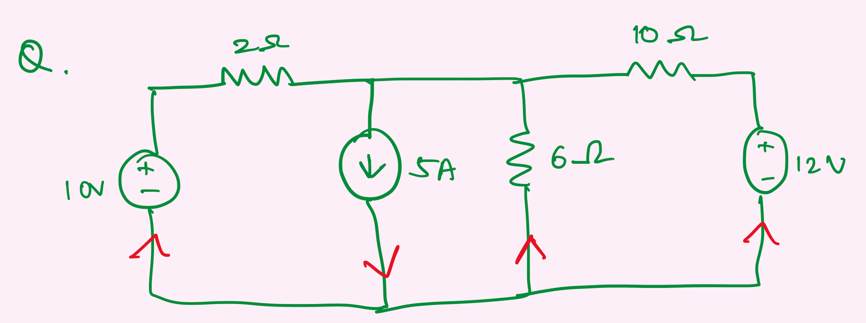


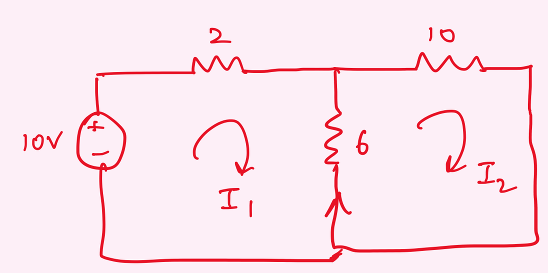
$I''_6 = \frac{\cancel{6} \times \cancel{6}}{\cancel{18}} = 2$

$I = I' + I'' = 7.55$

$P = I^2R = (7.55)^2 \times 12 = 684.03$

Q.





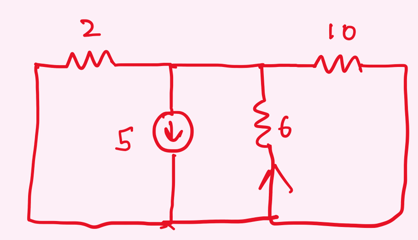
$8I_1 - 6I_2 = 10$

$-6I_1 + 16I_2 = 0$

$I_1 = 1.739\,A$

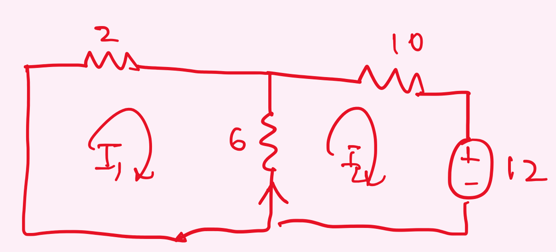
$I_2 = 0.65\,A$

$I'_6 = I_1 - I_2 = 1.08\,A$



$I''_6 = \frac{5 \times \left(\frac{1}{10} + \frac{1}{2}\right)^{-1}}{6 + \left(\frac{1}{10} + \frac{1}{2}\right)^{-1}}$

$= 1.08\,A$



$8I_1 - 6I_2 = 0$

$-6I_1 + 16I_2 = 12$

$I_1 = 0.78$

$I_2 = 1.04$

$I'''_6 = 0.26\,A$

Now,

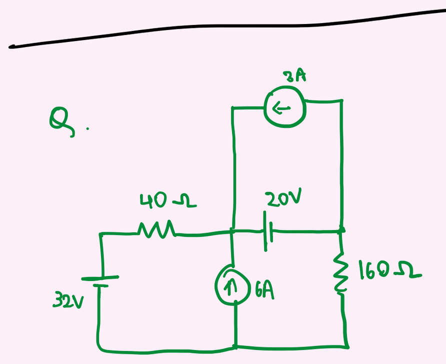
$-I' + I'' - I'''$

$= -0.26A$

⇓

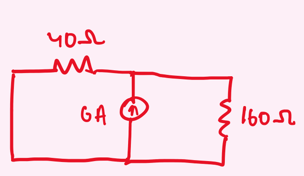
$0.26A$ Downward

Q.



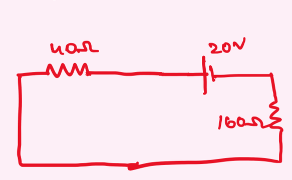
$\frac{32}{200} = 0.16A$

$0.16 \times 40 = 6.4V$

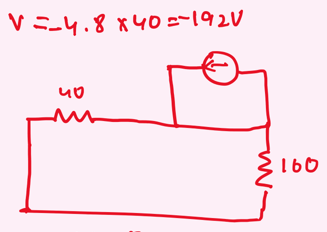


$I = \frac{160}{200} \times 6 = 4.8A$

$V = -4.8 \times 40 = -192V$



$\frac{40 \times 20}{200} = -4V$

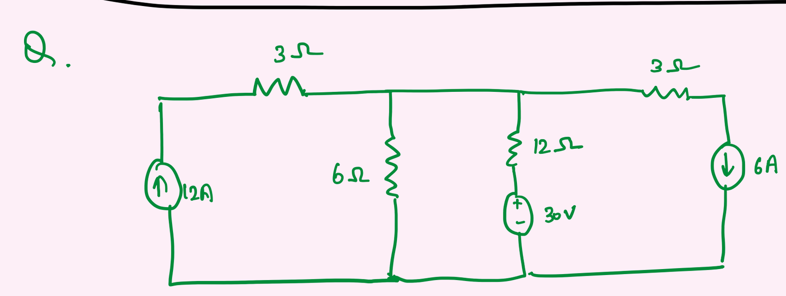


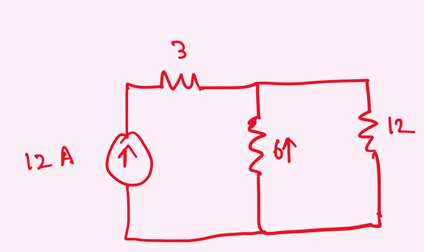
$V = 0$

$-192 - 4 + 6.4 = -189.6V$

189.6 V ACW

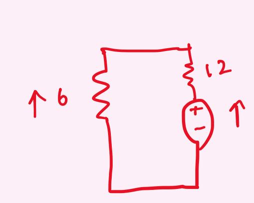
Q.





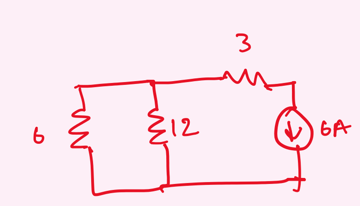
$I' = -\frac{12 \times 12}{6 + 12}$

$= -8$



$I'' = \frac{-30}{18}$

$= -1.67A$



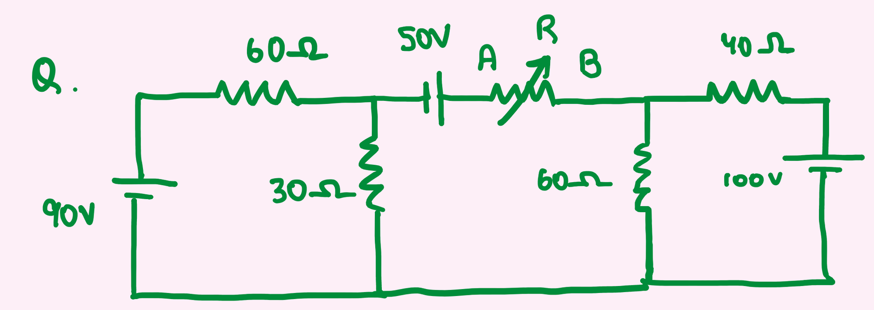
$I''' = \frac{6 \times \cancel{12}^{2}}{\cancel{18}_{3}} = 4A$

$I = I' + I'' + I''' = -5.67$

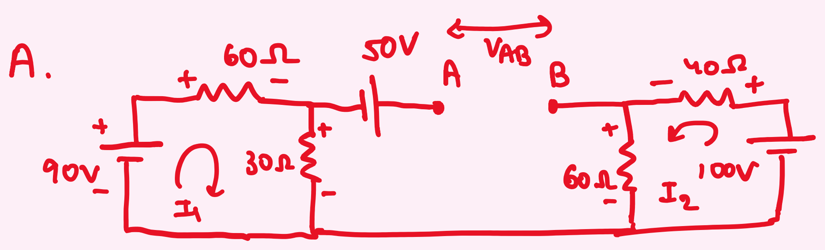
8. Thevenin's theorem

→ A linear network with a large number of independant and dependant sources and resistors b/w 2 terminals can be replaced with a simple 2 element series equivalent in which a voltage source called 'Thevenin's Equivalent Voltage' (V_{TH}) is in series with a resistance called 'Thevenin's Equivalent Resistance' (R_{TH}).

Q.

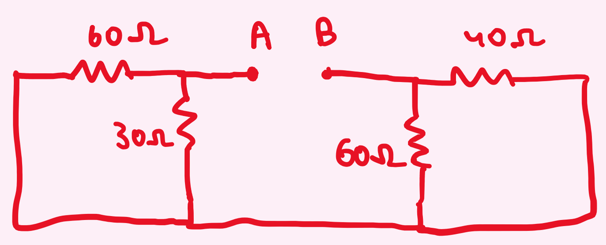


A.



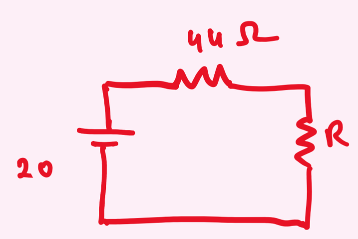
$I_1 = \frac{90V}{90\Omega} = 1A$ $I_2 = \frac{100V}{100\Omega} = 1A$

$50 - V_{TH} - 60I_1 + 30I_2 = 0 \Rightarrow V_{TH} = 20V$



$R_{TH} = \left(\frac{1}{60}+\frac{1}{30}\right)^{-1} + \left(\frac{1}{60}+\frac{1}{40}\right)^{-1}$

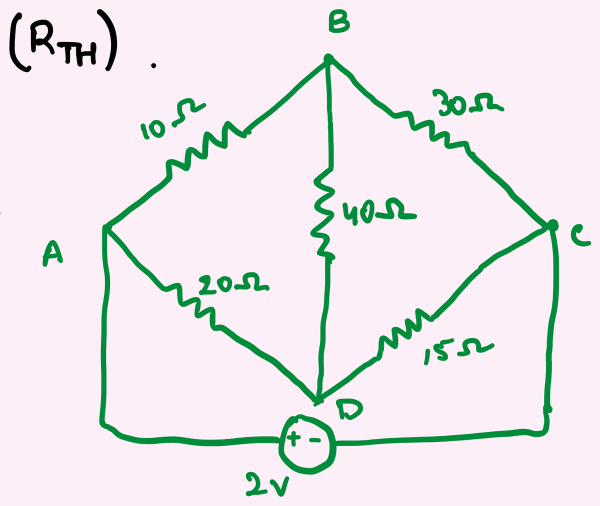
$20 + 24 = 44\Omega$



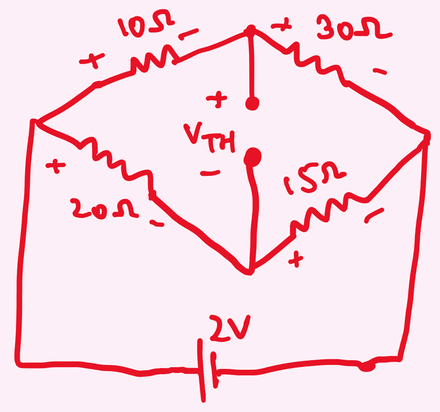
i) $I_L = \frac{20}{44+6} = 0.4A$

ii) $I_L = \frac{20}{44+36} = 0.25A$

Q.



A.



$I_1 = \frac{2}{10+30} = 0.05A$; $I_2 = \frac{2}{20+15} = 0.057$

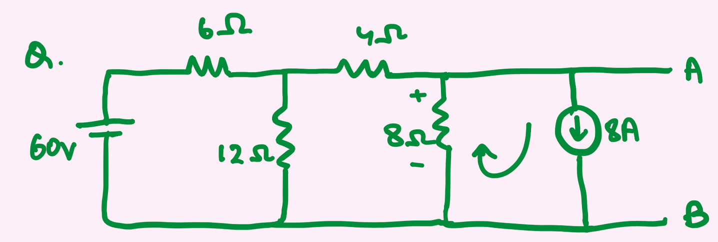
$-10I_1 - V_{TH} + 20I_2 = 0$

$V_{TH} = 1.14 - 0.5 = 0.64$

$R_{TH} = \left(\frac{1}{10}+\frac{1}{30}\right)^{-1} + \left(\frac{1}{20}+\frac{1}{15}\right)^{-1} = 16.07\Omega$

$I = \frac{V_{TH}}{R_{TH}+R} = \frac{0.64}{16.07+40} = 0.011A = 11.41mA$

Q.



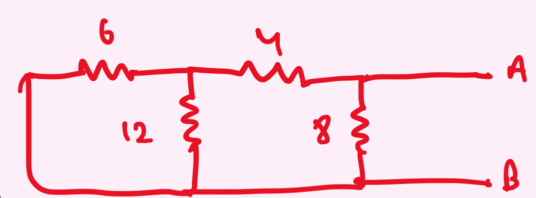
$18I_1 - 12I_2 - 0I_3 = 60$

$-12I_1 + 24I_2 - 8I_3 = 0$

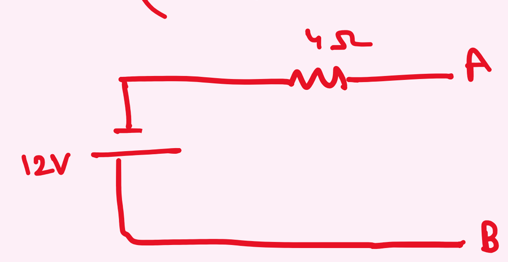
$0I_1 + 0I_2 + I_3 = 8$

$I_1 = 7.66A$ $I_2 = 6.5A$ $I_3 = 8A$

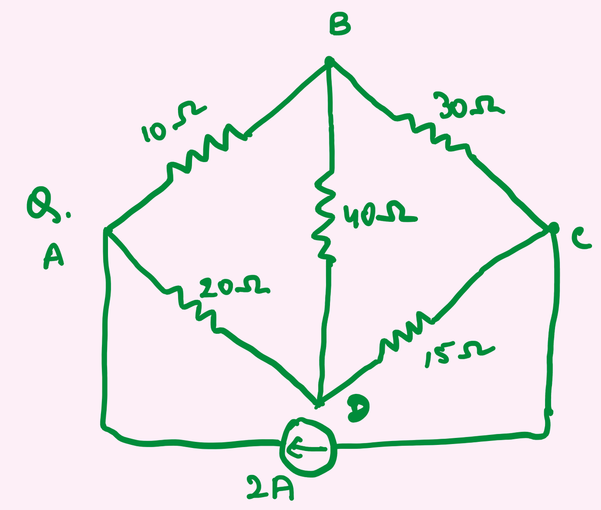
$V_{TH} = 8 \times (I_2 - I_3) = -12V$

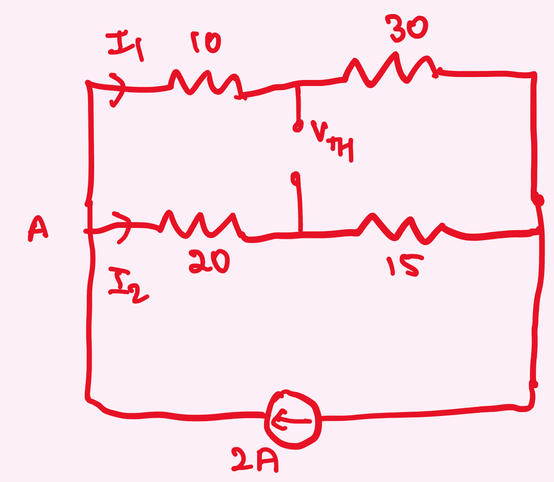


$R_{TH} = \left(\frac{1}{8} + \left(4 + \left(\frac{1}{6}+\frac{1}{12}\right)^{-1}\right)^{-1}\right)^{-1} = 4\Omega$



Q.





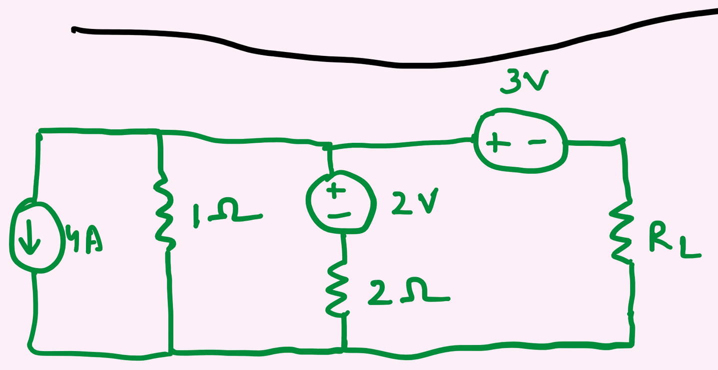
$I_1 = \frac{2 \times 35}{40+35} = 0.933A$

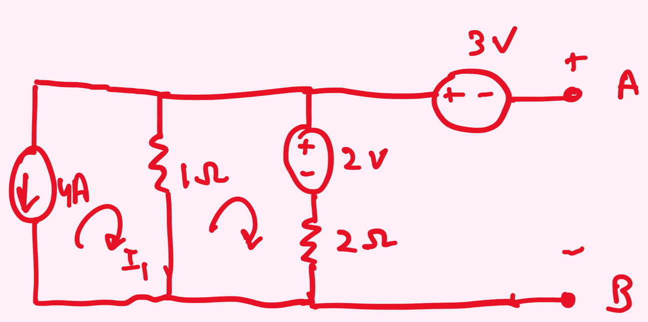
$I_2 = \frac{2 \times 40}{75} = 1.067A$

$V_{TH} + 10I_1 - 20I_2 = 0 \Rightarrow V_{TH} = 12.01$

$R_{TH} = \left(\frac{1}{30}+\frac{1}{45}\right)^{-1} = 18\Omega$

$I_L = \frac{12.01}{18+40} = 0.207A$





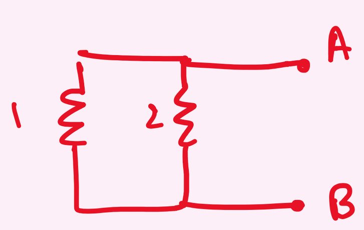
$I_1 = -4A$

$-I_1 + 3I_2 = -2$

$I_2 = -2A$

$V_{TH} + 3 - 2 - 2I_2 = 0$

$V_{TH} = -5V$

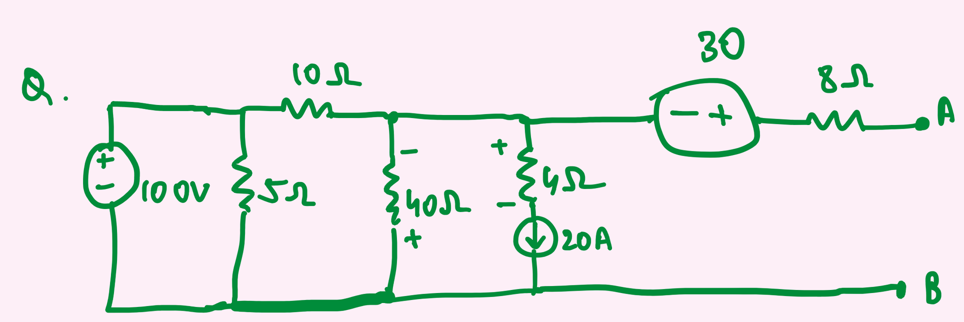


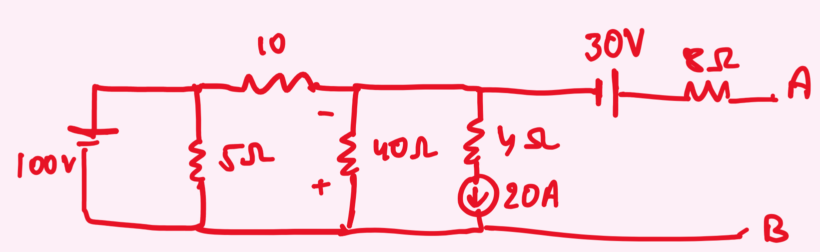
$\left(1+\frac{1}{2}\right)^{-1} = \frac{2}{3} = 0.67\Omega$

$R_L = 10\Omega \Rightarrow I_L = \frac{5}{10+0.67} = 0.468A$

$R_L = 100\Omega \Rightarrow I_L = \frac{5}{100+0.67} = 49.66mA$

Q.





$5I_1 - 5I_2 + 0I_3 = 100$

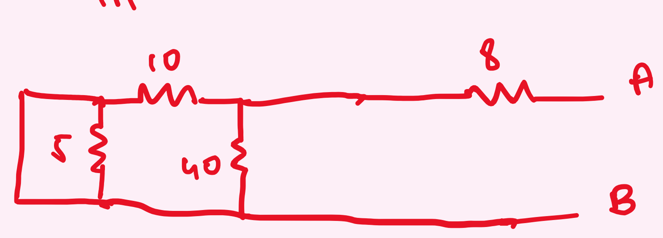
$-5I_1 + 55I_2 - 40I_3 = 0$

$I_3 = 20$

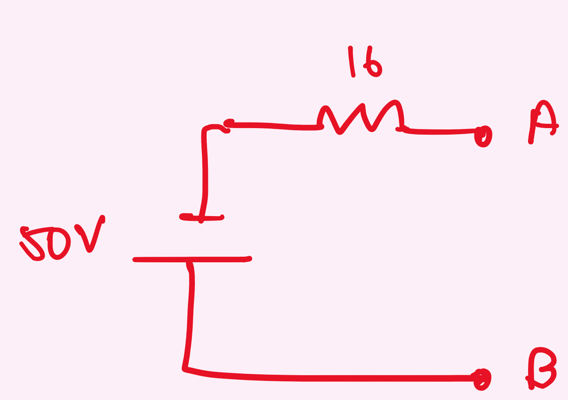
$I_1 = 38A$, $I_2 = 18A$, $I_3 = 20A$

$V_{TH} - 8(0) - 30 + 40(I_3 - I_2) = 0$

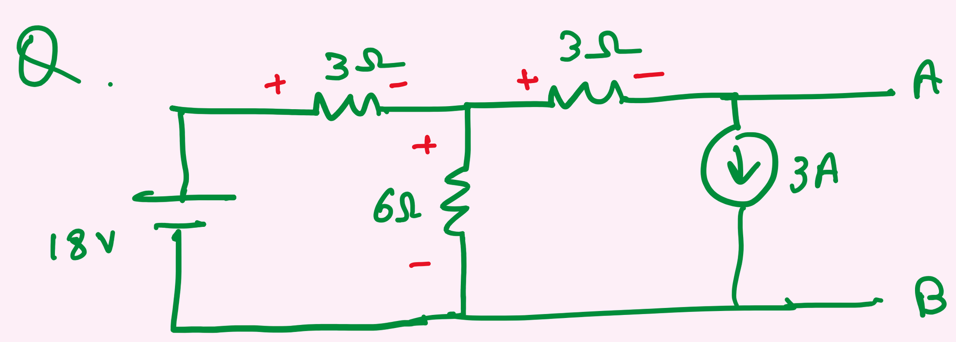
$V_{TH} = 30 - 80 = -50V$



$8 + \left(\frac{1}{10}+\frac{1}{40}\right)^{-1} = 16\Omega$



Q.



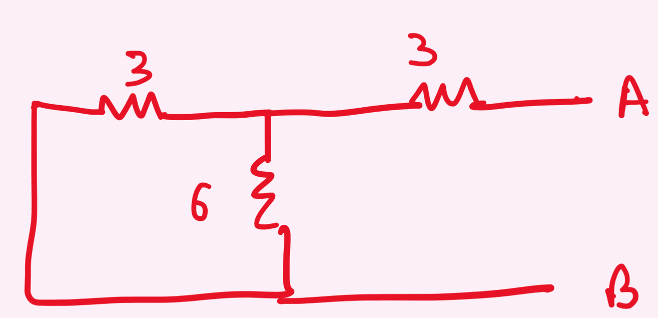
$9I_1 - 6I_2 = 18$

$I_2 = 3A$

$I_1 = 4A$

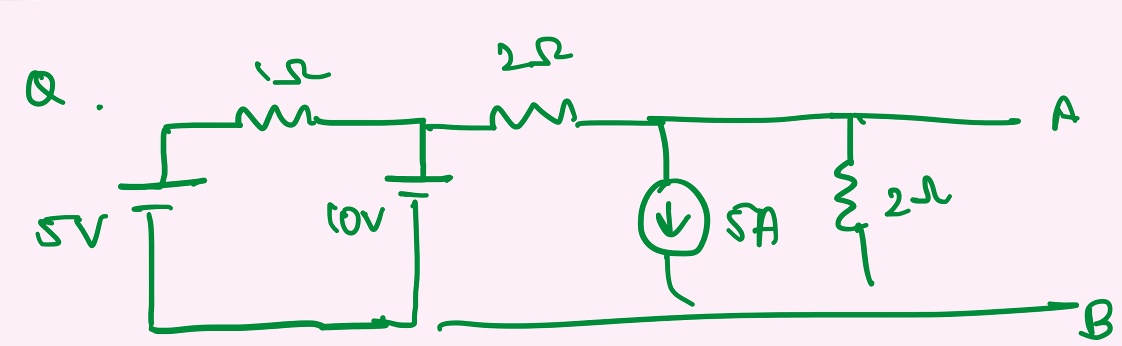
$V_{TH} + 9 - 6 = 0$

$V_{TH} = -3V$

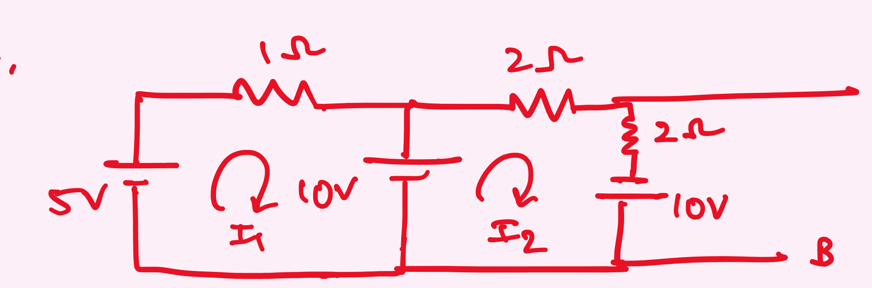


$3 + \left(\frac{1}{3}+\frac{1}{6}\right)^{-1} = 3 + 2 = 5\Omega$

Q.



A.



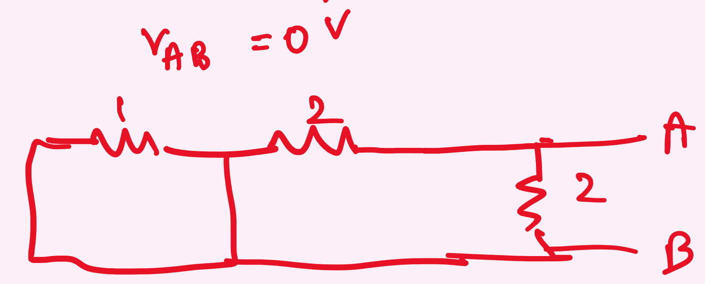
$1I_1 - 0I_2 = -5$

$0I_1 + 4I_2 = 20$

$I_2 = 5$

$V_{AB} - 2(I_2) + 10 = 0$

$V_{AB} = 0V$



$R_{TH} = 2 + 2 = 4\Omega$