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Electrical Technology

Ohms law $V = IR$

$R = \rho \times \frac{L}{A}$

Resistivity

Ag — 1.67 ρ

$\Omega = \rho \times \frac{m}{m^2}$

$\boxed{\rho = \Omega m}$

ρ 10^5 glass

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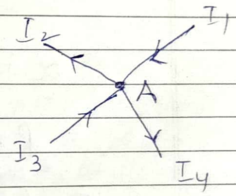
Kirchoff's Laws

① KCL

In any network, sum of the currents meeting at any point of the loop is zero.



$I_1 + I_3 - I_2 - I_4 = 0$

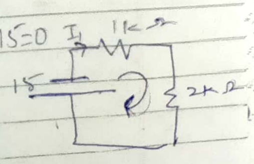
$I_1 + I_3 = I_2 + I_4$

② KVL

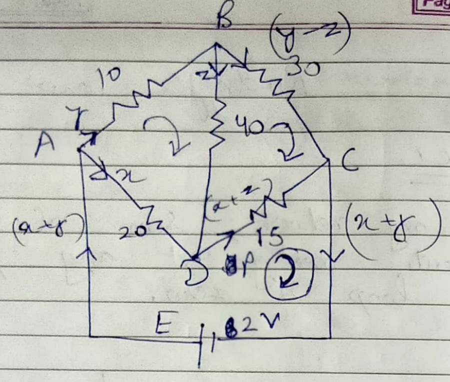
The algebraic sum of the product of current & resistances of the electrical components in a loop as well as the emf of that loop is zero.

$\Sigma IR + \Sigma emf = 0$

$+I_1 \times 1k\Omega + I_1(2k\Omega) - 15 = 0$



E3.1



$x + z - p = 0$

$p = x + z$

In loop ABDA,

$-10y - 40z + 20x = 0$

$\boxed{20x = y + 4z}$ —— (1)

In BCDB,

$-30(y-z) + 15(x+z) + 40z = 0$

$-30y + 30z + 15x + 15z + 40z = 0$

$15x - 30y + 85z = 0$

$3x - 6y + 17z = 0$ —— (2)

In ADCA,

$-20x - 15(x+z) + 2 = 0$

$20x + 15x + 15z - 2 = 0$

$35x + 15z - 2 = 0$ —— (3)

By (1) & (2),

$20x - y - 4z = 0$ $\times 6$

$3x - 6y + 17z = 0$

$12x - \cancel{6y} - 24z = 0$

$3x - \cancel{6y} + 17z = 0$

$9x - 41z = 0$ —— (4)

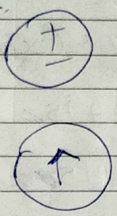
By (3) & (4),

$z = \frac{9}{785}$

$= 0.01146$ A

Dir^n is same as assumed

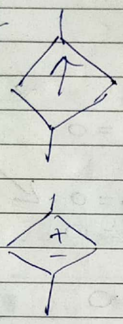
Independent



voltage source

current source.

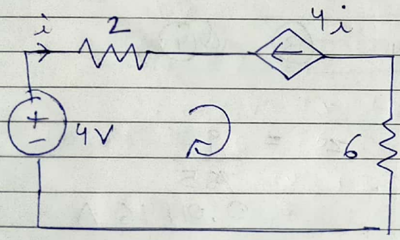
dependent



current source

voltage source.

1



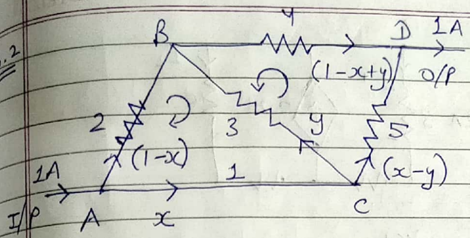
~~-8i + 4i~~

$-2i + 4i - 6i + 4 = 0$

or $-4i + 4 = 0$

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

Ex. 2



$-2(1-x) + 3y + x = 0$

$\Rightarrow -2 + 2x + 3y + x = 0$

$3x + 3y = 2$ —— (1)

$4(1-x+y) + 3y - 5(x-y) = 0$

$\Rightarrow 4 - 4x + 4y + 3y - 5x + 5y = 0$

$\Rightarrow -9x + 12y + 4 = 0$

or $9x - 12y = 4$ —— (2)

By (1) & (2),

(1) × 4 → $12x + \cancel{12y} = 8$

(2) → $9x - \cancel{12y} = 4$

$21x = 12$

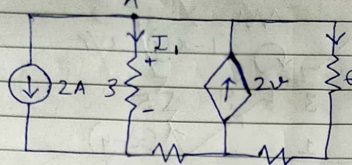
or $x = \frac{12}{21}$ $\Rightarrow \boxed{x = 0.571 A}$

$\cancel{3} \times \frac{12}{\cancel{21}\,7} + 3y = 2$

$3y = 2 - \frac{12}{7}$

or $\boxed{y = 0.0952 A}$

E 3.6



Applying KCL,

$-2 - I_1 + 2v - I_2 = 0$

$\Rightarrow 2v = I_1 + I_2 + 2$ — (1)

$v = 3I_1$

$\Rightarrow I_1 = \frac{v}{3}$

& $v = 6I_2$

or $I_2 = \frac{v}{6}$

Putting in (1),

$2v = \frac{2v}{6} + \frac{v}{6} + 2$

$2v = \frac{\cancel{3}v}{\cancel{6}_2} + 2$

$2v - \frac{v}{2} = 2$

$\frac{3v}{2} = 2$ or $\boxed{v = \frac{4}{3}}$

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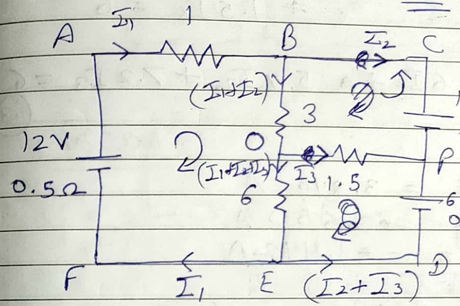
∴ Value of current source will be $2 \times \frac{4}{3}$

$= \frac{8}{3}$ A

$= 2.66$ A

E 3.5



In loop ABEFA,

$-0.5I_1 - 1I_1 - 3(I_1+I_2) - 6(I_1+I_2+I_3) + 12 = 0$

$-0.5I_1 - I_1 - 3I_1 - 3I_2 - 6I_1 - 6I_2 - 6I_3 + 12 = 0$

$10.5I_1 + 9I_2 + 12I_3 = 12$ — (1)

In loop OBCPO,

$+0.4I_2 - 1.5I_3 + 3(I_1+I_2) - 10 = 0$

$0.4I_2 - 1.5I_3 + 3I_1 + 3I_2 = 10$

$3I_1 + 3.4I_2 - 1.5I_3 = 10$ — (2)

In OPDEO,

$$-0.3(I_2+I_3)+6(I_1+I_2+I_3) + 1.5 I_3 = 6$$

$$-0.3I_2 - 0.3I_3 + 6I_1 + 6I_2 + 6I_3 + 1.5I_3 = 6$$

$$6I_1 + 5.7I_2 + 7.2I_3 = 6 \quad (3)$$

$I_1 \cancel{x} = 3.349$ A
I_2 y $= -0.650$ A
I_3 z $= -1.442$ A

The dir^n of I_2 & I_3 is opposite.

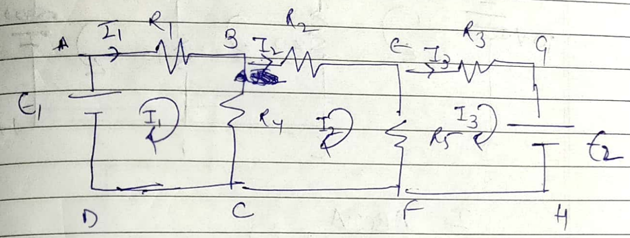
3.7

$$-4I_1 - 20I_1 + 12 = 0$$
$$24 I_1 = 12$$
$$I_1 = \frac{12}{24} = 0.5 \text{ A}$$

Current in 6Ω node,

$$9I_1 = 4.5 \text{ A}$$
$$R = 6\Omega$$
$$V = 4.5 \times 6$$
$$V = 27 \text{ V}$$

Maxwell's Current Loop Method



ABCDA

$$-I_1R_1 - (I_1-I_2)R_4 + E_1 = 0$$
$$I_1R_1 + (I_1-I_2)R_4 = E_1$$

In BEFCB,

$$-I_2R_2 - (I_2-I_3)R_5 - (I_2-I_1)R_4 = 0$$

In EGHFE,

$$-(I_3-I_2)R_5 - I_3R_3 - E_2 = 0$$

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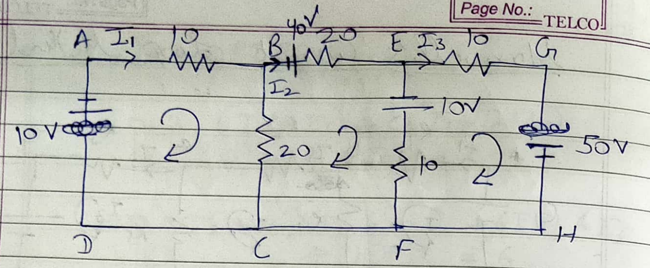
3.9



In ABCDA,

$$-10 I_1 - (I_1 - I_2)20 + 10 = 0$$

$$\Rightarrow 10 I_1 + 20 I_1 - 20 I_2 + 10 = 0$$

$$30 I_1 - 20 I_2 = -10 \quad \text{—— (1)}$$

In BEFCB,

$$+40 - 20 I_2 + 10 - 10(I_2 - I_3) - 20(I_2 - I_1) = 0$$

$$-20 I_2 - 10 I_2 + 10 I_3 - 20 I_2 + 20 I_1 + 50 = 0$$

$$20 I_1 - 50 I_2 + 10 I_3 = -50 \quad \text{—— (2)}$$

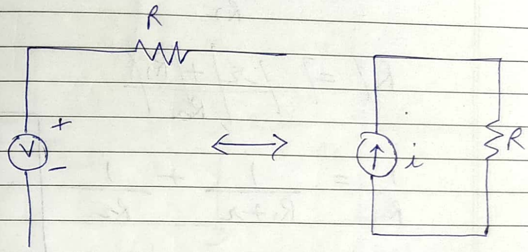
In EGHFE,

$$-10 I_3 - 10(I_3 - I_2) = 50$$

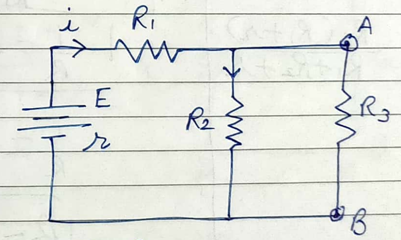
$$10 I_2 - 20 I_3 = -40 \quad \text{—— (3)}$$

$I_1 = 1A$
$I_2 = 2A$
$I_3 = 3A$

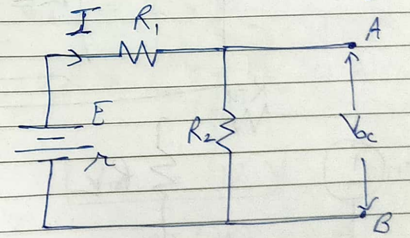
• Source Conversion



5/8/17 Thevenin's Theorem



Step 1



V_{oc} = V across R_2 = $I R_2$

$$V_{oc} = V_{Th} = \frac{E}{r + R_1 + R_2} \cdot R_2$$

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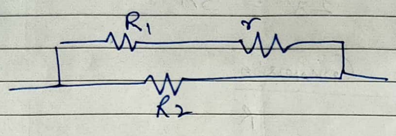
Step II Finding R_{Th}

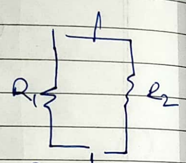


$\cancel{R = r + R_1 / R_2}$

$$\frac{1}{R} = \frac{1}{R_1 + r} + \frac{1}{R_2}$$

$$\frac{1}{R} = \frac{R_1 + R_2 + r}{R_2(R_1 + r)}$$

$$R_{Th} = \frac{R_2(R_1 + r)}{R_1 + R_2 + r}$$



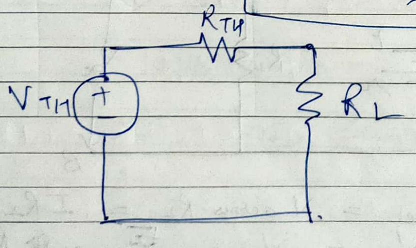
$$\frac{1}{R} = \frac{R_1 + R_2}{R_1 R_2}$$

$$\boxed{\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}}$$

$$\frac{1}{R} = \frac{R_1 + R_2}{R_1 R_2}$$

$$\boxed{R = \frac{R_1 R_2}{R_1 + R_2}}$$

Step III



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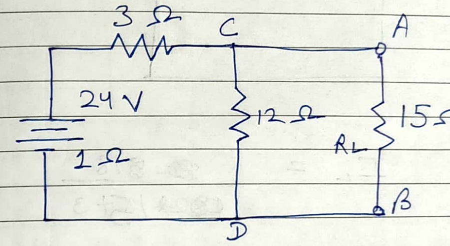
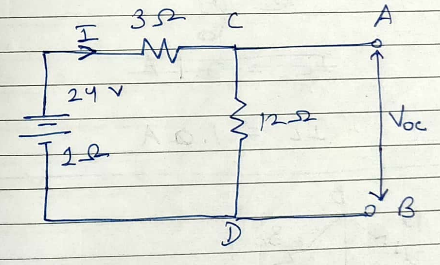
$$\boxed{I_L = \frac{V_{TH}}{R_{TH} + R_L}}$$

E3.12





$$V_{Th} = I \times 12$$

$$V_{Th} = \frac{24}{16} \times 12$$

$$\boxed{V_{Th} = 18\ V}$$

$$R_{Th} = \frac{12(4)}{16}$$

$$\boxed{R_{Th} = 3\ \Omega}$$

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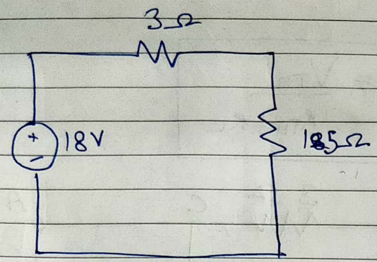
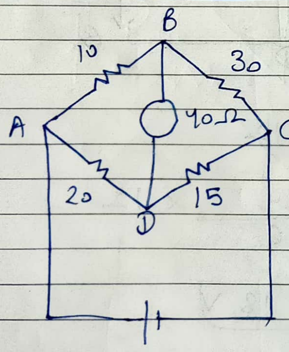


$I_L = \dfrac{18}{15+3}$

$= \dfrac{1}{10}$

~~$I_L = 0.1\ A$~~

$I_L = 1.0\ A$



$4+8+12$ V

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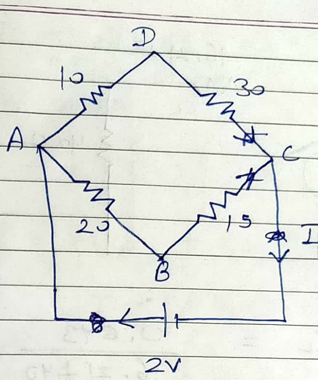
Step 1



$V_{Th} = I \times$

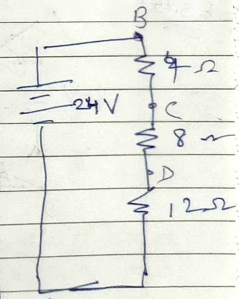
$V_D = 2 \times \dfrac{30}{10+30} = \dfrac{2\times30}{40} = 1.5\ V$

$V_B = 2 \times \dfrac{15}{35} = 0.857\ V$

$V_{Th} = V_D - V_B$

$= 0.643\ V$

Voltage Divider

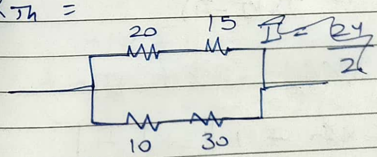


$V_8 = \dfrac{24\times8}{(4+8+12)} = 8$

$V_{12} = \dfrac{24\times12}{4+8+12} = 12$

$V_4 = 4V$

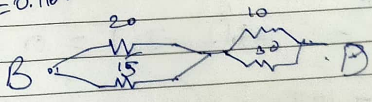
Step II $R_{Th} =$



$\dfrac{1}{R_1} = \dfrac{1}{20} + \dfrac{1}{15} = 0.1166$

$R_1 = 8.71$

$R_2 = 7.5$



$R_{Th} = \dfrac{20\times15}{20+15} + \dfrac{30\times10}{30+10}$

$R_{Th} = 16.21\ \Omega$

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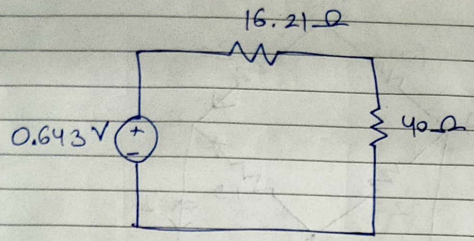
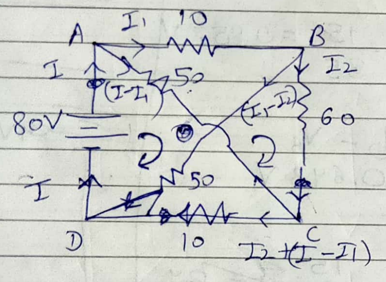


$$I_L = \frac{0.643}{16.21+40}$$

$$I_L = 0.0114 \text{ A}$$

8/17
3.15



In BDCB,

$$-I_2\times 60 - 10[I_2+I-I_1]$$

$$+50(I_1-I_2) = 0$$

$$-60I_2 - 10I_2 - 10I + 10I_1 + 50I_1 - 50I_2 = 0$$

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$$50I_1 - 120I_2 = 0$$

$\Rightarrow$ $5I_1 - 12I_2 = 0$ ——— (1)

In ACDA,

$$-50(I-I_1) - 10(I_2+I-I_1)$$

$$+80 = 0$$

$\Rightarrow$ $50I - 50I_1 + 10I_2 + 10I - 10I_1 = 80$

$$50I - 40I_1 + 10I_2 = 80$$

$\Rightarrow$ $5I - 4I_1 + I_2 = 8$ ——— (2)

In ABDA,

~~+50(I1 − I2) − 50 I1~~

$$-10I_1 - 50(I-I_2) + 80 = 0$$

$+10I_1 + 50I - 50I_2 = 80$ ——— (3)

$$I_1 + 5I - 5I_2 = 8$$

In ABCA,

$$-10I_1 - 60I_2 - 50(I-I_1) = 0$$

$$+10I_1 + 60I_2 + 50I - 50I_1 = 0$$

$50I - 40I_1 + 60I_2 = 0$ ——— (4)

$$5I - 4I_1 + 6I_2 = 0$$

$5I_1 - 12 I_2 = 0$

$3I - 4I_1 + I_2 = 8$

$I_1 + 5I - 5I_2 = 8$

$5I - 4I + 6I_2 = 0$

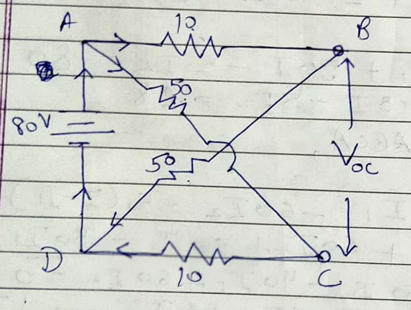
(4) − (2)

$5 I_2 = -8$

$I_2 = \frac{8}{5}$

$\boxed{I_2 = 1.6\ A}$

Finding Thevenin's Voltage



In loop ABDA,

V. at B $= 80 \times \frac{50}{50+10}$

(using Voltage Divider formula)

$V_B = \frac{80 \times 50}{60}$

$V_B = 66.66\ V$

In ACDA,

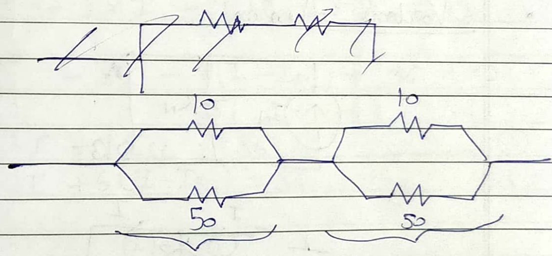
$V_C = 80 \times \frac{10}{60}$

$V_C = 13.33\ V$

V Across B & C,

$V_{Th} = V_B - V_C = 53.33\ V$

Step II



$\left[\frac{1}{R_1} = \frac{1}{10} + \frac{1}{50}\right] + \left[\frac{1}{R_2} = \frac{1}{10} + \frac{1}{50}\right]$

$\Rightarrow 1 / \left(\frac{60}{500} + \frac{60}{500}\right)$

$\cancel{R_{Th} = 0.24}$

$R_{Th} = 4.166\ \Omega = \frac{25}{6}\ \Omega$

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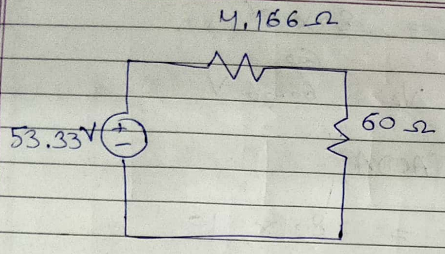
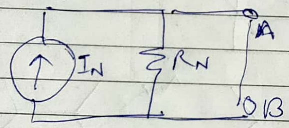
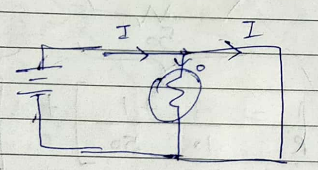


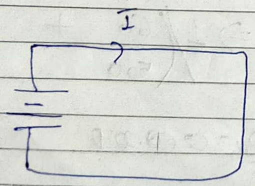
$$I_L = \frac{53.33}{60+4.166}$$

$$\boxed{I_L = 0.83\,A}$$

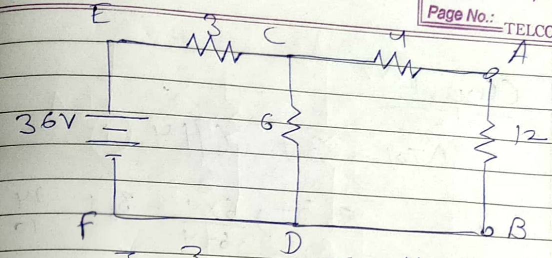
- Norton's Theorem

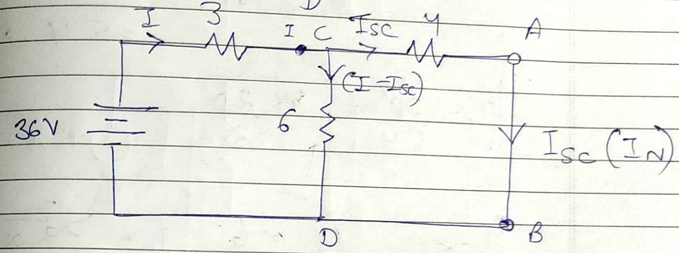






E3.16





$I = \; -3 \times I - 4 I_{sc} + 36 = 0$

$-3I - 6(I - I_{sc}) + 36 = 0$

$3I + 4 I_{sc} = 36$ —— ①

$3I + 6(I - I_{sc}) = 36$ —— ②

② − ①

$6(I - I_{sc}) - 4I_{sc} = 0$

$6I - 6I_{sc} - 4I_{sc} = 0$

$6I = 10 I_{sc}$

$3I = 5 I_{sc}$ —— ③

$-4 I_{sc} + 6(I - I_{sc}) = 0$

$6I - 6I_{sc} - 4I_{sc} = 0$

$6I = 10 I_{sc}$

Current

$R_{TOT} = 3 + 6 \parallel 4$

$= 3 + \frac{6 \times 4}{6+4} = 3 + \frac{24}{10}$

$= 5.4\ \Omega$

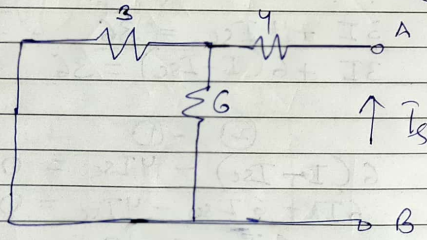
$I = \frac{36}{5.4} = \frac{20}{3}$

$I_{SC(4\Omega)} = I \times \frac{6}{6+4} = \frac{\cancel{20}^{2}}{3} \times \frac{\cancel{6}^{2}}{\cancel{10}}$

$I_{(6\Omega)} = I \times \frac{4}{6+4}$

$= 4A$

II



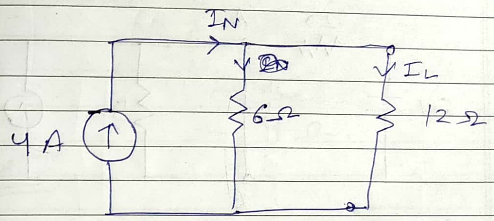
Get R 3||4

$4 + 3 \parallel 6$

$4 + \frac{3 \times 6}{3+6}$

$= 4 + \frac{18}{9}$

$= 6\ \Omega$



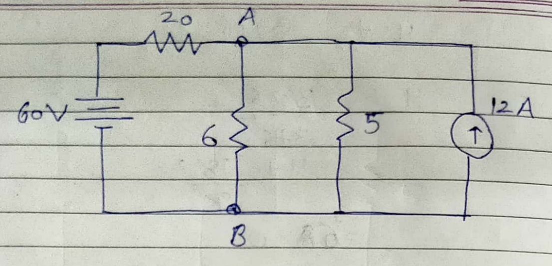
$\frac{4}{\frac{6 \times 12}{6+12}}$

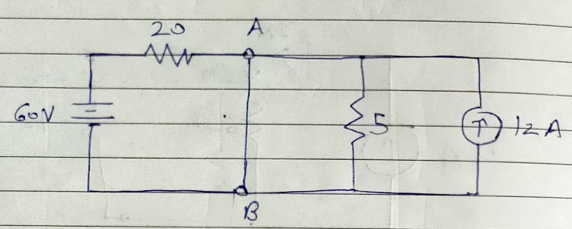
$I_L = \frac{4 \times 6}{6+12}$

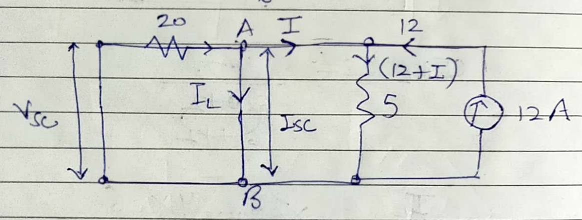
$= 4 \times \frac{6}{18}$

$= 1.33\ A$

E3.17







Step I

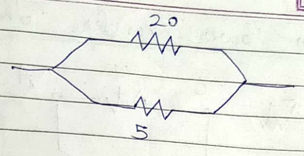
$\cancel{I_{sc}}$ $I_L = \frac{V_{sc}}{R}$

$I_L = \frac{\cancel{60}\ 3}{\cancel{20}}$

$I_L = 3A$

$\therefore \quad I_{sc} = I_L + 12 = 3 + 12$
$= 15\ A$

Step II

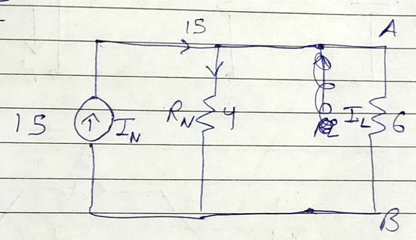


$R_{sc} = \frac{20 \times 5}{20+5} = \frac{60}{17}$

$R_{sc} = \frac{100}{25}$

$= 4\ \Omega$

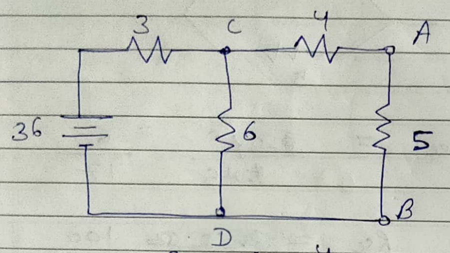
Step III

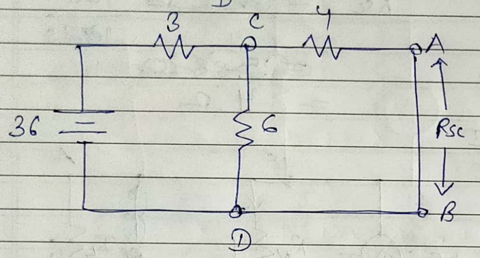


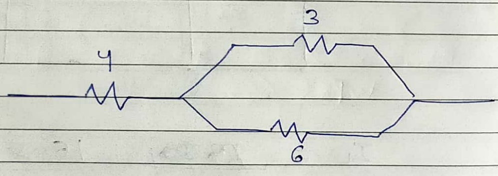
$I_L = \cancel{\frac{4}{4+6}}$ $15 \times \frac{4}{4+6}$ 9A

$= \frac{6\cancel{0}}{1\cancel{0}} = 6\ A$

Maximum Power Transfer Theorem



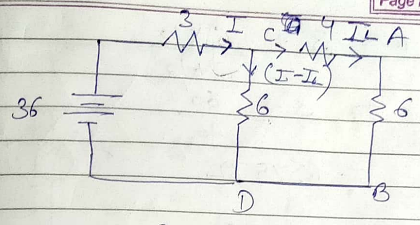




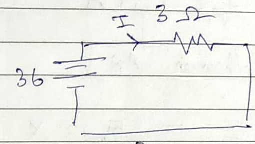
$$R_L = 4 + \frac{3 \times 6}{3+6}$$

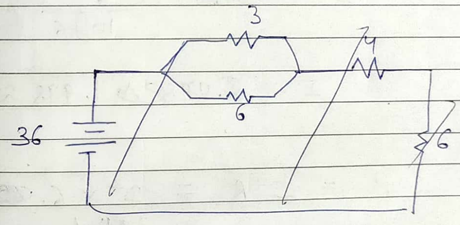
$$= 4 + \frac{18}{9}$$

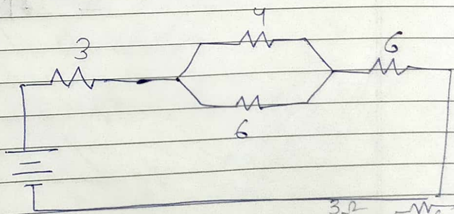
$$= 6\ \Omega$$

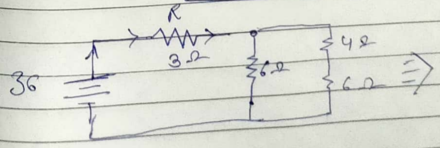


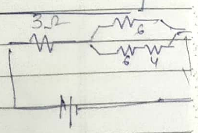
$$\frac{36}{3}$$











$$R = 3 + \frac{6 \times 10}{6+10}$$

$$= 3 + \frac{60}{16}$$

$$= 6.75\ \Omega$$

$$I = \frac{36}{6.75}$$

$$I = 5.33\ A$$

$\therefore$ Through AB,

$$I = 5.33 \times \frac{6}{10+6}$$

$$I = 1.998 \approx 2\ A$$

$$P = I^2 R = 2^2 \times 6.$$

$$= 24\ W$$

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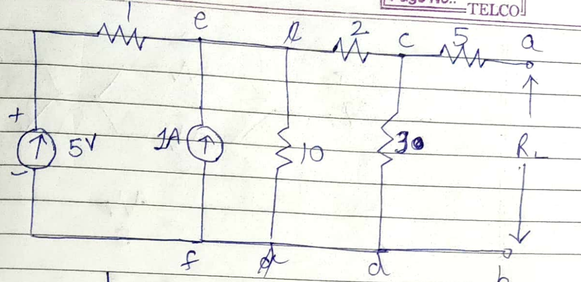
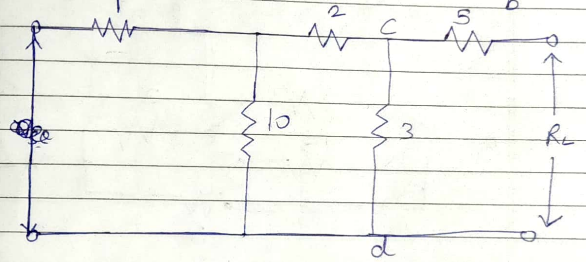
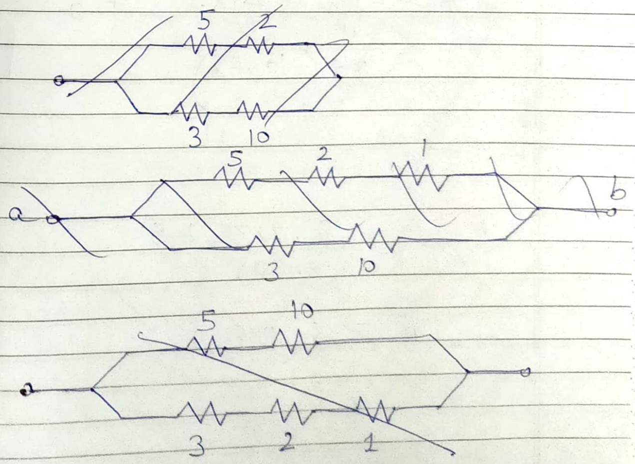
3.19







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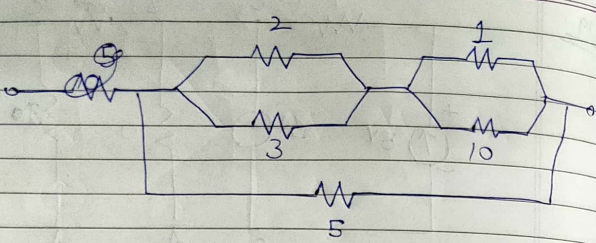

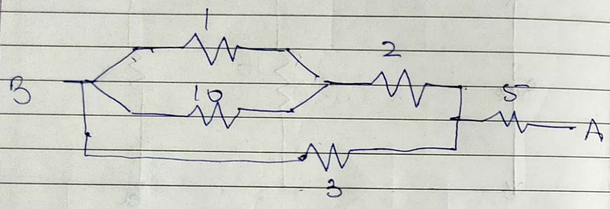

$$R = \frac{\left(\frac{10}{11} + 2\right) \times 3}{3 + \left(\frac{10}{11} + 2\right)} + 5$$

$$R = \frac{8.727}{5.909} + 5$$

$$R = 6.476\ \Omega$$

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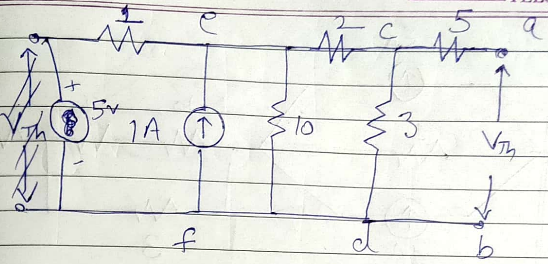
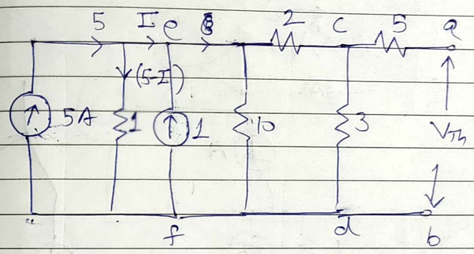
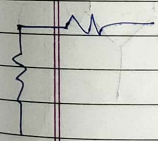
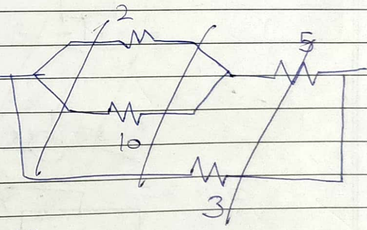


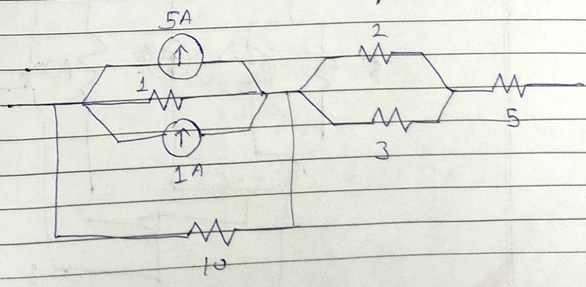


V/R

5A







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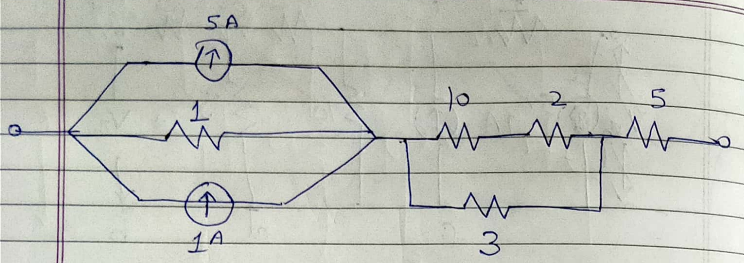

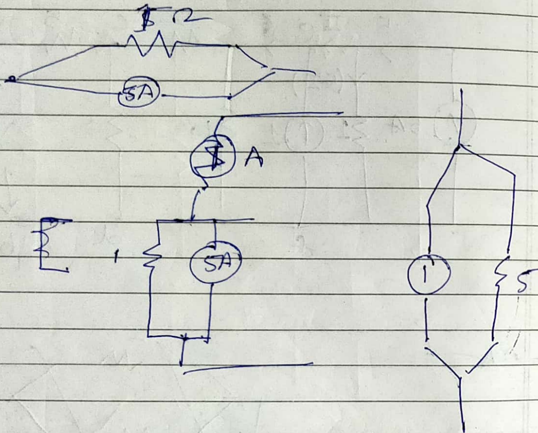

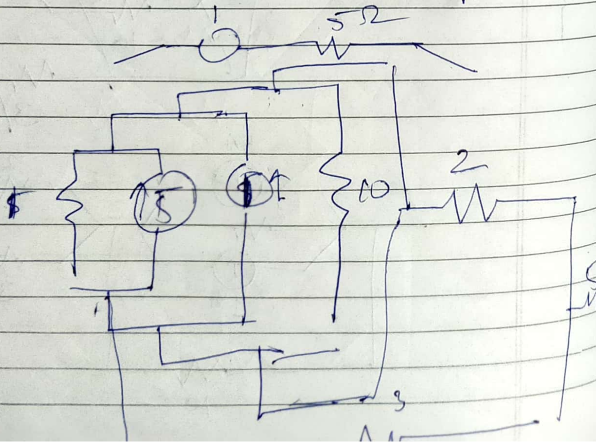

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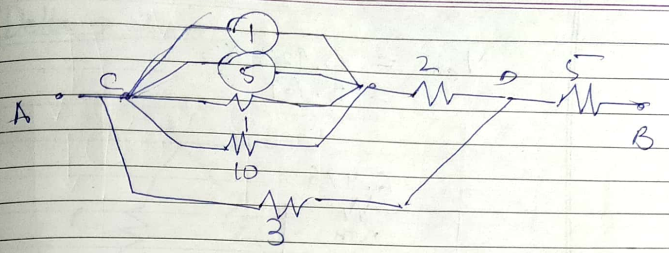
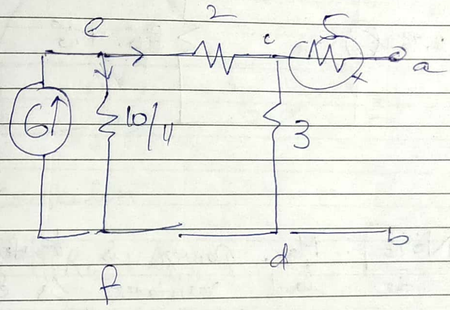




$I_{CD} = \cancel{30/ - \frac{6 \times 10}{11}}$

$\cancel{30}$

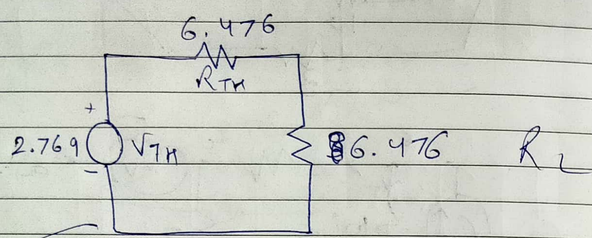
$= \cancel{24.54}\ A$

$6 \times \frac{10}{11}$ $\quad 6 \times 5$

$$= 6 \times \frac{10/11}{5 + 10/11}$$

$= \cancel{5.077A},\ 0.923\ A$

$V_{CD} = 0.923 \times 3$
$= 2.769$



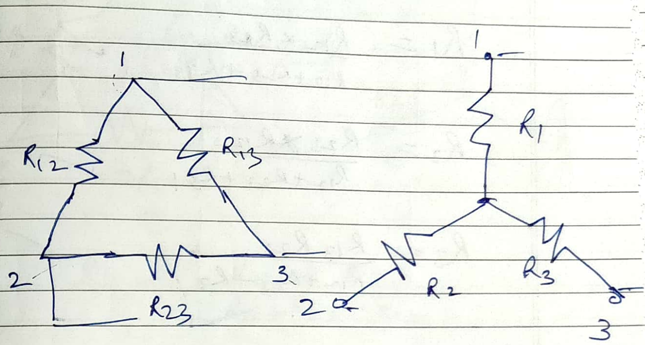
$\boxed{\text{NOTE}}$: Max. power is transferred when the load resistance is equal to the equivalent circuit resistance.

$I = \frac{2.769}{2 \times 6.476} = 0.2137\ A$

$P = I^2 R$
$= 0.295\ W$

20/8/17

Delta → Star



Δ connection

$R_{eq} = R_{13} \parallel (R_{12} + R_{23})$

$R_{eq} = \frac{R_{13}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{13}}$ — (1)

Y connection

$R_{eq} = R_1 + R_3$ — (2)

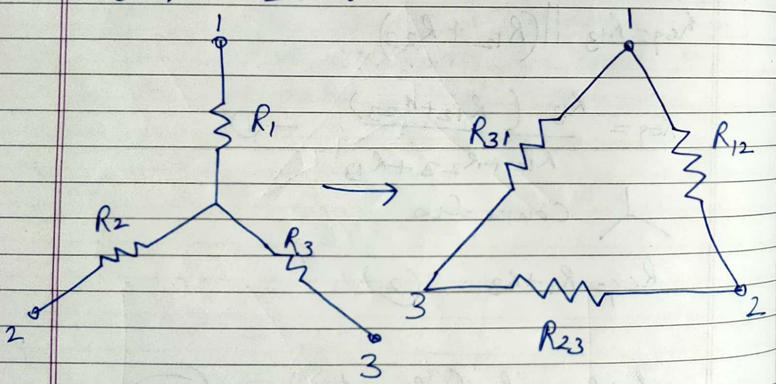
$R_1 + R_3 = \frac{R_{13}(R_{12}+R_{23})}{R_{12}+R_{13}+R_{23}}$ — (I)

$$R_1 = \frac{R_{12} \times R_{13}}{R_{12}+R_{23}+R_{13}}$$

$$R_2 = \frac{R_{23} \times R_{12}}{R_{12}+R_{23}+R_{31}}$$

$$R_3 = \frac{R_{13}\, R_{23}}{R_{12}+R_{23}+R_{31}}$$

Star — Delta



$$R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3}$$

$$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1}$$

$$R_{13} = R_1 + R_3 + \frac{R_1 R_3}{R_2}$$

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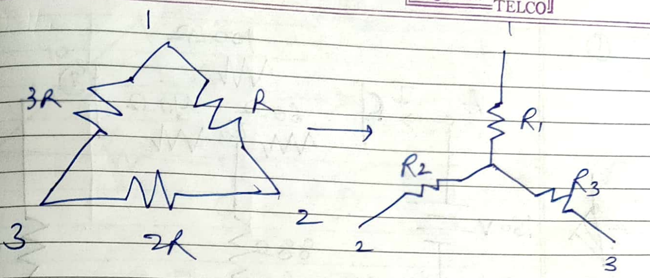
Q



$$R_1 = \frac{R_{12} \cdot R_{13}}{R_{12}+R_{23}+R_{13}}$$

$$= \frac{R \cdot 3R}{R+2R+3R} = \frac{3R^2}{6R} = \frac{1}{2}R$$

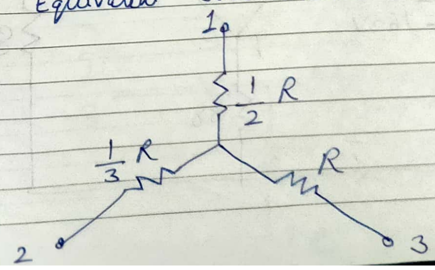
$$R_2 = \frac{R_{12} \cdot R_{23}}{R_{12}+R_{23}+R_{13}}$$

$$= \frac{R \cdot 2R}{R+2R+3R} = \frac{2R^2}{6R} = \frac{1}{3}R$$

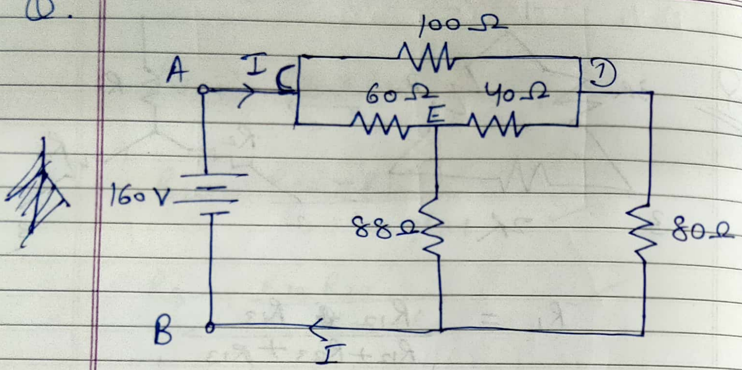
$$R_3 = \frac{R_{23} \cdot R_{13}}{R+2R+3R} = \frac{2R \cdot 3R}{R+2R+3R}$$

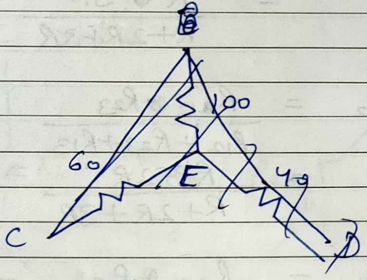
$$= \frac{6R^2}{6R} = R$$

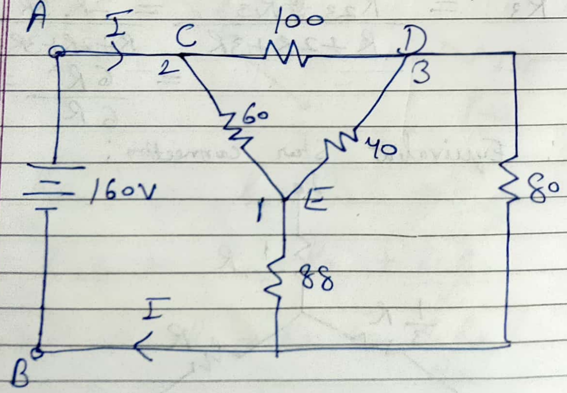
∴ Equivalent Star connection:

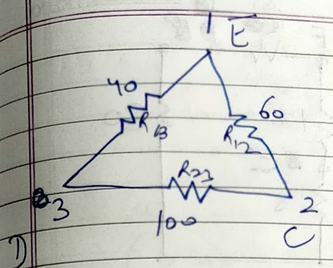


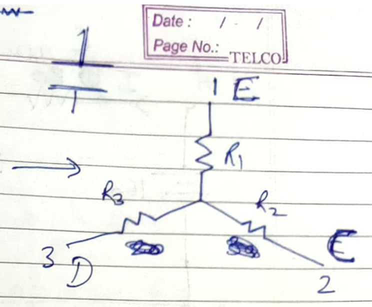
Q.











$$\cancel{R_1 = R_{12} + R_{13} + \frac{R_{12} \cdot R_{13}}{R_{23}}}$$

$$R_E = \frac{R_{12} \cdot R_{13}}{R_{12} + R_{23} + R_{31}} = \frac{60 \cdot 40}{60+40+100}$$

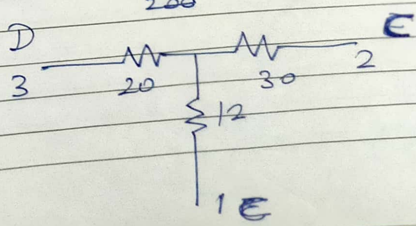
$$= \frac{2400}{200} = 12\,\Omega$$

$$R_C = \frac{R_{12} \cdot R_{23}}{R_{12} + R_{23} + R_{31}} = \frac{60 \cdot 100}{200}$$

$$= \frac{6000}{200} = 30\,\Omega$$

$$R_D = \frac{R_{13} + R_{23}}{R_{12} + R_{23} + R_{31}} = \frac{40 \cdot 100}{200}$$

$$= \frac{4000}{200} = 20\,\Omega$$



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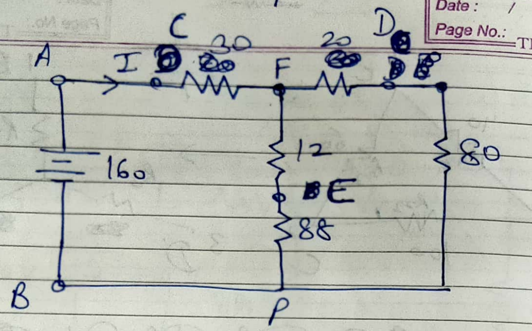
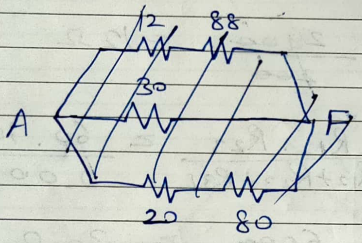
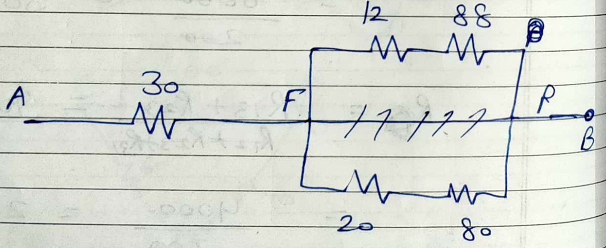


$$\Rightarrow 30 \,||\, (12+88) \,||\, (20+80)$$





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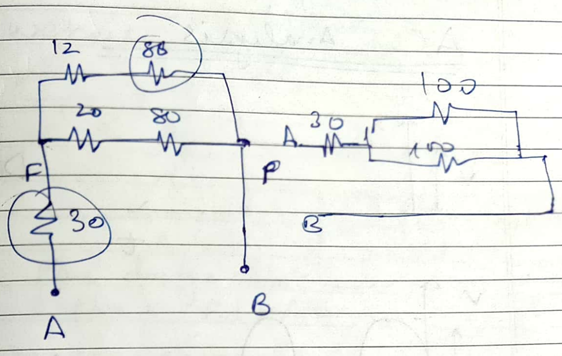

$$30 + (20+80) \,||\, (12+88)$$

$$30 + \frac{(20+80)\times(12+88)}{(20+80)+(12+88)}$$

$$= 30 + \frac{100 \times 100}{100+100}$$

$$= 30 + \frac{100\cancel{00}}{2\cancel{00}}$$

$$= 80\ \Omega$$

$$I = \frac{160}{80} = 2\,A$$