Assignment - 1 EC23B1066

(1) Given, $q = 10\sin(4\pi t)$ mC
$v = 2\cos(4\pi t)$ V

To find: a) power delivered to the element at $t = 0.3$s
b) Calculate the energy delivered to the element b/w 0 & 0.6s

Soln a) $p(t) = v(t) \times i(t)$

$p(t) = 2\cos(4\pi t) \times 10(4\pi)\cos(4\pi t)$

$p(t) = 80\pi \cos^2(4\pi t)$

$p(t) = 80\pi \left(\frac{\cos(8\pi t) + 1}{2}\right)$

$p(0.3) = 80\pi \left(\frac{\cos(2.4\pi) + 1}{2}\right)$

$p(0.3) = 80\pi \times 0.6545 = 164.4959$ mW

b) $\mathcal{E} = \int_0^{0.6} 80\pi \left(\frac{\cos(8\pi t) + 1}{2}\right) dt$

$= 40\pi \int_0^{0.6} (\cos(8\pi t) + 1)\, dt$

$= 40\pi \times \frac{\sin(8\pi t)}{8\pi} + t \Big|_0^{0.6}$

$= 40\pi \times \left(\frac{0.5878}{8\pi} + 0.6\right)$

$= 40\pi \times 0.6234$

$= 78.3372$ mJ

(2) Given: Burner 1 : 20 minutes
Burner 2 : 40 minutes
Burner 3 : 15 minutes
Burner 4 : 45 minutes
Oven : 30 minutes

Soln Burner-1 $H = 1.2 \times \frac{20}{60} = 0.4$ kwh

Burner-2 $H = 1.2 \times \frac{40}{60} = 0.8$ kwh

Burner 3 $H = 1.2 \times \frac{15}{60} = 0.3$ kWh

Burner 4 $H = 1.2 \times \frac{45}{60} = 0.9$ kWh

Oven $H = 1.8 \times \frac{30}{60} = 0.9$ kWh

Total Energy Uses $= (0.4 + 0.8 + 0.3 + 0.9 + 0.9)$

$= 3.3$ kWh

Total Cost $= 3.3 \times (0.12)$

$= ₹ 0.396$

(3)

a) Total Energy Consumed in kWh

$= 200 \times 18 + 800 \times 2 + 1200 \times 4$

$= 3600 + 1600 + 4800$

$= 10000$ Wh

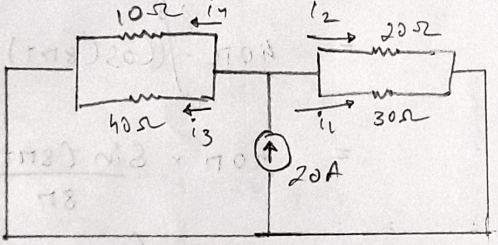
$= 10$ kWh

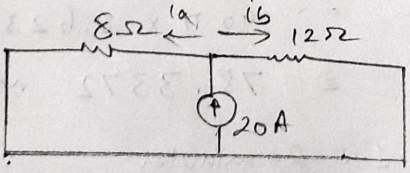
b) Average power per hours

$= \frac{10}{24}$ kW $= 0.4167$ kW

(4)

To find i_1 and i_4





Applying Current division

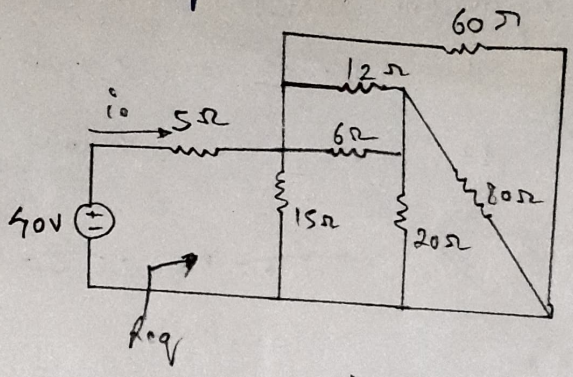
$i_a = \frac{12}{20} \times 20 = 12$

$i_b = \frac{8}{20} \times 20 = 8$

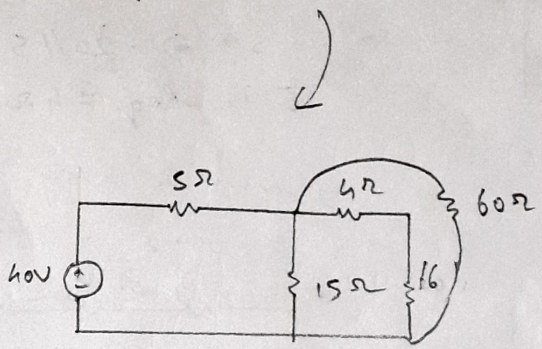
So $i_4 = \frac{40}{50} \times 12 = 9.6$ A

$i_1 = \frac{20}{50} \times 8 = 3.2$ A

(5) To find R_{eq} & i_o in the circuit



Sol^n

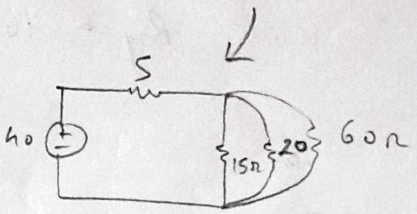


$\Rightarrow 20 \| 80$

$R_{eq} = 16\Omega$

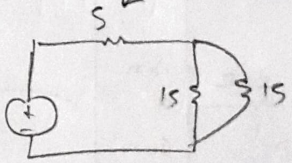
$\Rightarrow 6 \| 12$

$R_{eq} = 4$



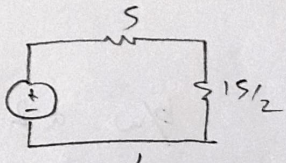
$\Rightarrow 20 \| 60$

$R_{eq} = 15$



$\Rightarrow 15 \| 15$

$R_{eq} = 15/2$



$\rightarrow$ 5 series with $15/2$

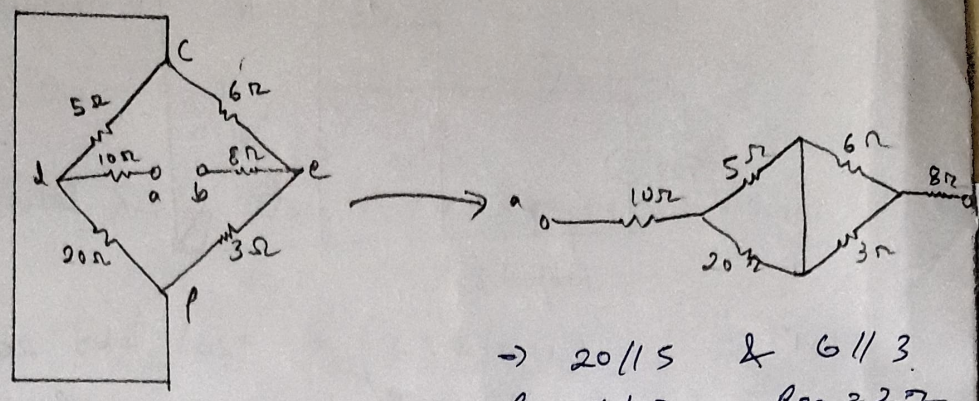
$R_{eq} = 12.5$

$R_{eq} = 12.5$

$I_o = \dfrac{40}{25/2} = \dfrac{16}{5}$

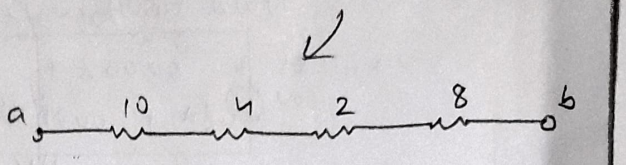
(6) Find the equivalent resistance in the circuit

a)



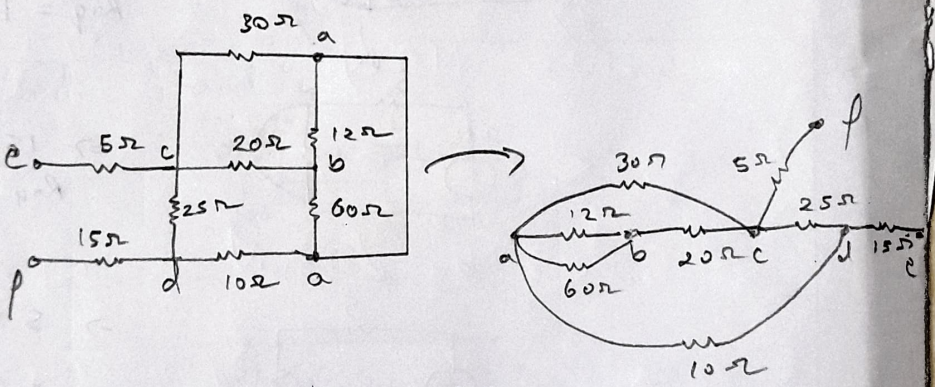
→ 20 // 5 & 6 // 3

$R_{eq} = 4\Omega$ $R_{eq} = 2\Omega$



$R_{eq} = 10 + 4 + 2 + 8 = 24\Omega$

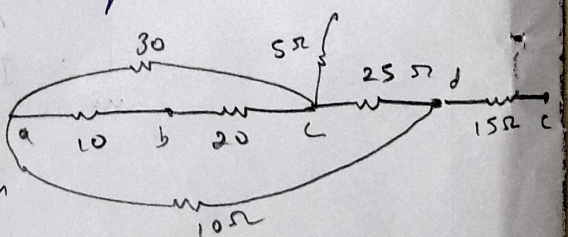
b)



b/w a & b

→ 12 // 60

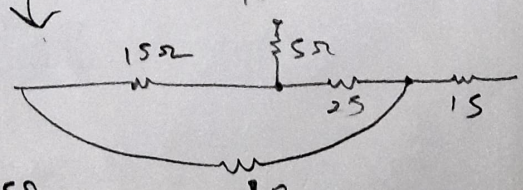
$R_{eq} = 10$

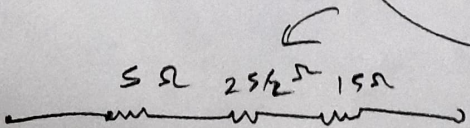


10 & 20Ω in series

then 30Ω // 30Ω

= 15Ω

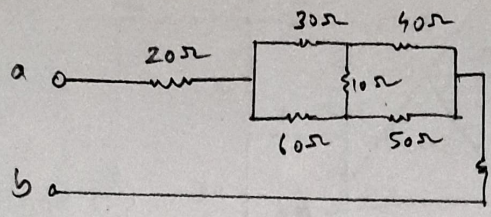




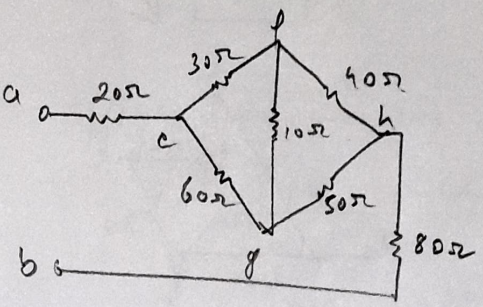
$R_{eq} = \frac{65}{2}$

(7) To obtain equivalent resistance

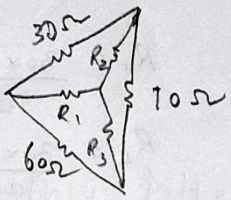
a)



Re-draw



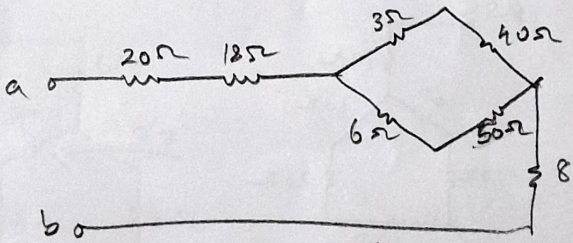
Using Delta → Star on c f g

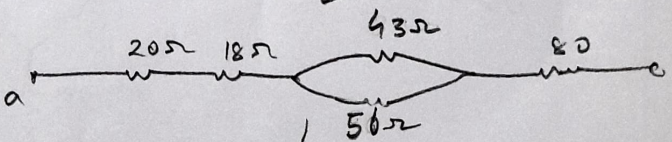


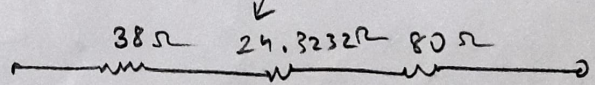
$$R_1 = \frac{30 \times 60}{30+60+10} = 18\ \Omega$$

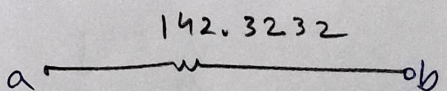
$$R_2 = \frac{30 \times 10}{100} = 3\ \Omega$$

$$R_3 = \frac{60 \times 10}{100} = 6\ \Omega$$



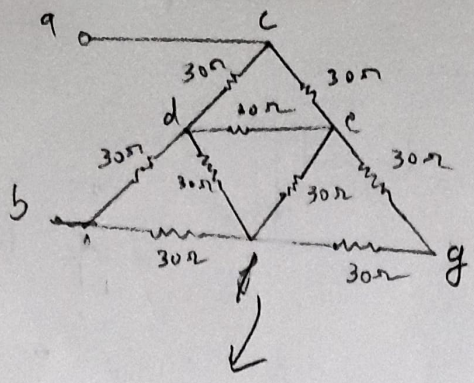


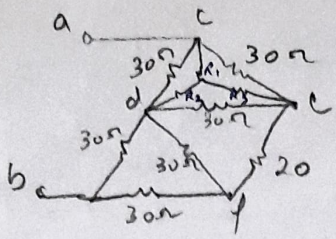




$R_{eq} = 142.3232$

b)





$60 \parallel \frac{60}{2}$

$\frac{60}{3}$

Delta → star on cde

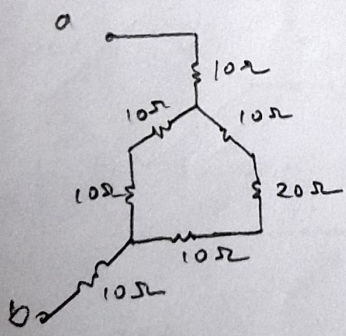
$$R_1 = \frac{30 \times 30}{90} = 10\,\Omega$$

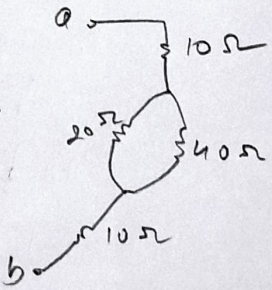
$$R_2 = \frac{30 \times 30}{90} = 10\,\Omega$$

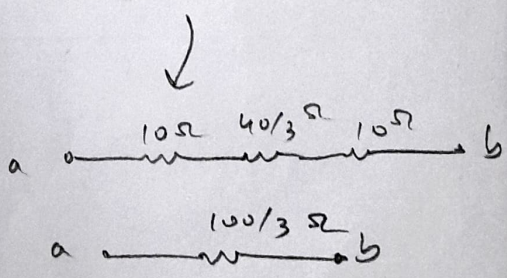
$$R_3 = \frac{30 \times 30}{90} = 10\,\Omega$$

Delta → star on dbf

$$R_1 = R_2 = R_3 = \frac{30 \times 30}{90} = 10\,\Omega$$

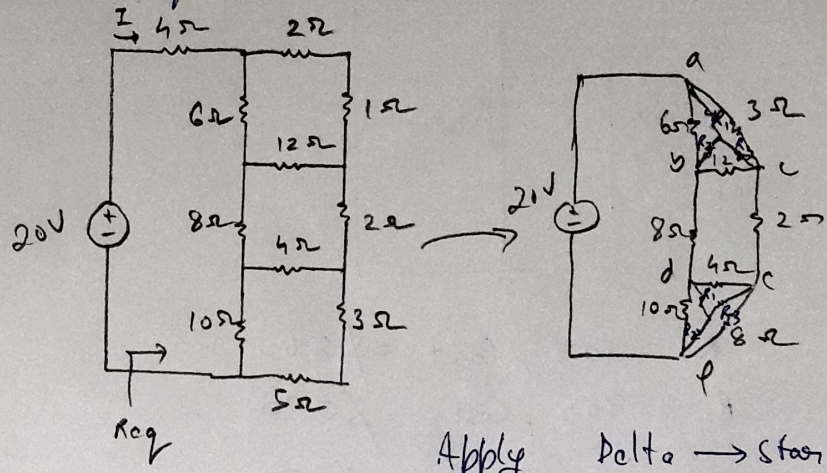






$R_{eq} = 100/3\,\Omega$

(8) To find R_{eq} & I in the circuit



Apply Delta → Star on abc

$$R_1 = \frac{6 \times 3}{21} = 6/7$$

$$R_2 = \frac{36 \times 12}{21} = 24/7$$

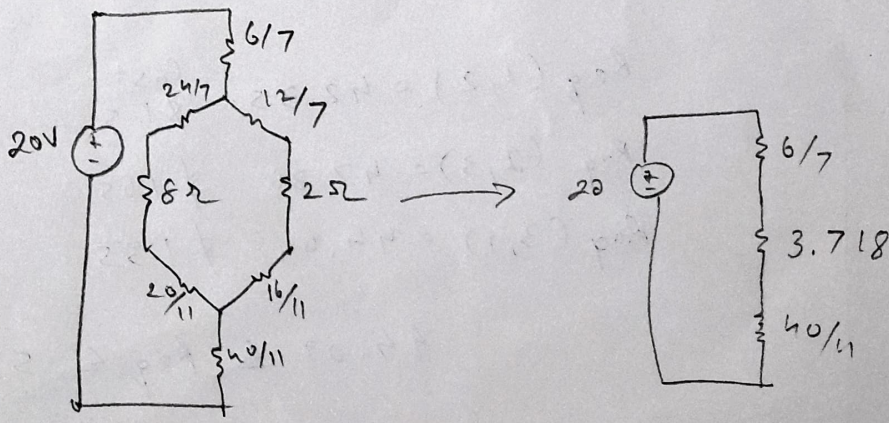
$$R_3 = \frac{12 \times 3}{21} = 12/7$$

Apply Delta → Star on dcf

$$R_1 = \frac{4 \times 10}{22} = \frac{20}{11}$$

$$R_2 = \frac{10 \times 8}{22} = \frac{40}{11}$$

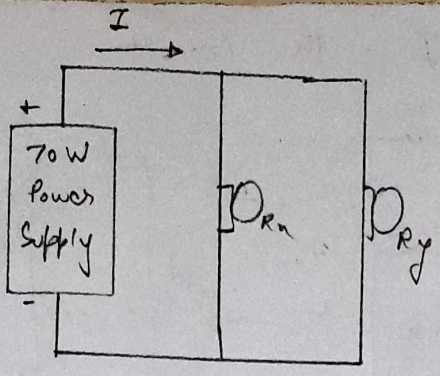
$$R_3 = \frac{4 \times 8}{22} = \frac{16}{11}$$



$$R_{eq} = 8.2115$$

$$I = \frac{V}{R_{eq}} = \frac{20}{8.2115} = 2.4356A$$

(9)



$R_1 = 80\Omega$, Cost = \$0.60

$R_2 = 90\Omega$, Cost = \$0.90

$R_3 = 1000\Omega$, Cost = \$0.75

$I = 1.2\,A \pm 5$ [System should be designed for minimum cost such that lies within the range]

i) Let $I = 1.2 + \frac{5}{100} \Rightarrow \frac{95}{100} I = 1.2 \Rightarrow I = 1.263\,A$

$P = I^2 R_{eq}$, $R_{eq} = \frac{70}{(1.26)^2} = 44.1\,\Omega$

ii) Let $I = 1.2 - \frac{5I}{100}$, $I = 1.14\,A$

$R_{eq} = \frac{70}{(1.14)^2} = 53.86\,\Omega$

$R_1 = 80$
$R_2 = 90$
$R_3 = 100$

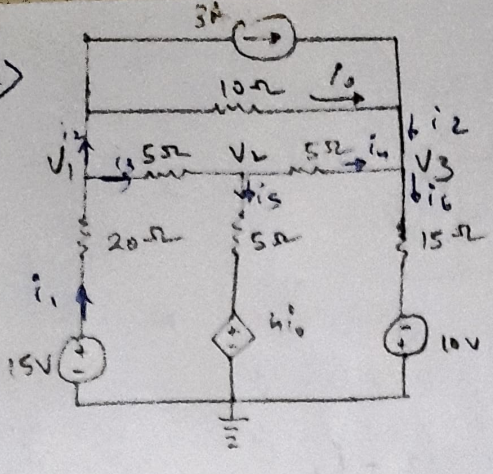
	Cost
$R_{eq}(1,2) = 42.35$	\$1.5
$R_{eq}(2,3) = 47.36$	\$1.65
$R_{eq}(3,1) = 44.44$	\$1.35

$44.09 \leq R_{eq} \leq 53.86\,\Omega$

Since R_1 & R_3 cost is minimum and it lies in range, we should use that.

(10)

a)



$$i_0 = \frac{V_1 - V_3}{10}$$

$$i_1 = \frac{15 - V_1}{20}$$

$$i_2 = 3 + \frac{V_1 - V_3}{10}$$

$$i_3 = \frac{V_1 - V_2}{5}$$

$$i_4 = \frac{V_2 - V_3}{5}$$

$$i_5 = \frac{V_2 - 4i_0}{5}$$

$$i_6 = \frac{V_3 + 10}{15}$$

$$i_5 = \frac{V_2 - 4\left(\frac{V_1 - V_3}{5}\right)}{5}$$

Using KCL at node 1

$$i_1 = i_2 + i_5$$

$$\frac{15 - V_1}{20} = 3 + \frac{V_1 - V_3}{10} + \frac{V_1 - V_2}{5}$$

$$\frac{15 - V_1}{20} - \frac{V_1 + V_3}{10} - \frac{V_1 + V_2}{5} = 3$$

$$-V_1 + 15 + 2V_3 - 2V_1 + 4V_3 - 4V_1 = 60$$

$$-7V_1 + 4V_2 + 2V_3 = 45$$

Using KCL at node 2

$$i_3 = i_4 + i_5$$

$$\frac{V_1 - V_2}{5} = \frac{V_2 - V_3}{5} + \frac{5V_2 - 2V_1 + 2V_3}{25}$$

$$5V_1 - 5V_2 = 5V_2 - 5V_3 + 5V_2 - 2V_1 + 2V_3$$

$$7V_1 - 15V_2 + 3V_3 = 0$$

Using KCL at node 3

$$i_6 = i_4 + i_2$$

$$\frac{V_3 + 10}{15} = \frac{V_2 - V_3}{5} + 3 + \frac{V_1 - V_3}{10}$$

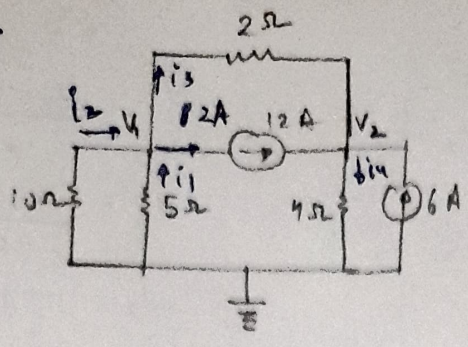
$$2V_3 + 20 + 6V_3 - 6V_2 + 3V_3 - 3V_1 = 90$$

$$-3V_1 - 6V_2 + 11V_3 = 70$$

$\therefore V_1 = -7.2$

$V_2 = -2.77$, $V_3 = 2.88$

b)



at node 1

$$i_1 + i_2 = 12 + i_3$$

$$\frac{-V_1}{5} - \frac{V_1}{10} = 12 + \frac{V_1 - V_2}{2}$$

$$-\frac{V_1}{5} - \frac{V_1}{10} + \frac{V_2 - V_1}{2} = 12$$

$$-2V_1 - V_1 + 5V_2 - 5V_1 = 120$$

$$-8V_1 + 5V_2 = 120$$

at node 2

$$12 + i_3 + 6 = i_4$$

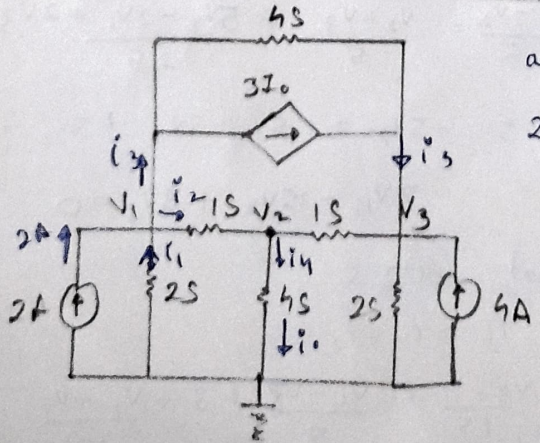
$$12 + \frac{V_1 - V_2}{2} + 6 = \frac{V_2}{4}$$

$$\frac{2V_1 - 2V_2}{4} - \frac{V_2}{4} = -18$$

$$2V_1 - 3V_2 = -72$$

$$V_1 = 0\,V \quad , \quad V_2 = 24\,V$$

c)



at node 1

$$2 - 2V_1 = V_1 - V_2 + 3(4V_2) + (V_1 - V_3)4$$

$$2 = 2V_1 - V_1 + V_2 - 12V_2 - 4V_1 + 4V_3 = 0$$

$$-7V_1 - 11V_2 + 4V_3 = -2$$

at node 2

$$V_1 - V_2 = V_2 - V_3 + 4V_2$$

$$V_1 - 6V_2 + V_3 = 0$$

At node 3

$$3(4v_2) + 4(v_1 - v_3) + v_2 - v_3 + 4 = 2v_3$$

$$12v_2 + 4v_1 - 4v_3 + v_2 - v_3 - 2v_3 = -4$$

$$4v_1 + 13v_2 - 7v_3 = -4$$

$$v_1 = 0.625$$

$$v_2 = 0.375$$

$$v_3 = 1.625$$

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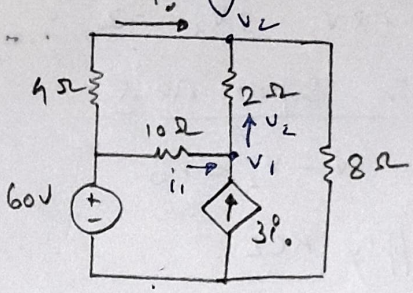
(11) Find i_o using nodal Analysis

a)



at node 1

$$\frac{60 - v_1}{10} + 3\left(\frac{60 - v_2}{4}\right) = \frac{v_1 - v_2}{2}$$

$$\frac{60 - v_1}{10} + \frac{180 - 3v_2}{4} + \frac{v_2 - v_1}{2} = 0$$

$$120 - 2v_1 + 900 - 15v_2 + 10v_2 - 10v_1 = 0$$

$$-12v_1 - 5v_2 = -1020$$

$$12v_1 + 5v_2 = 1020$$

at node 2

$$\frac{60 - v_2}{4} + \frac{v_1 - v_2}{2} = \frac{v_2}{8}$$

$$\frac{60 - v_2}{4} + \frac{v_1 - v_2}{2} - \frac{v_2}{8} = 0$$

$$120 - 2v_2 + 4v_1 - 4v_2 - v_2 = 0$$

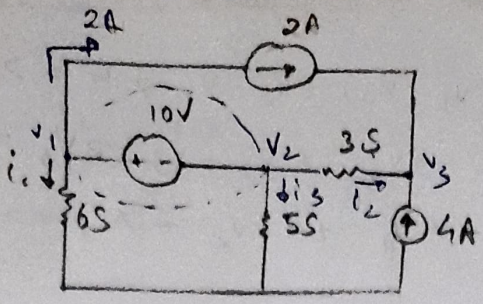
$$4v_1 - 7v_2 = -120$$

$$v_1 = 62.88$$

$$v_2 = 53.07$$

$$i_o = \frac{60 - 53.07}{4} = 1.733\ A$$

b)



at Supernode

$i_0 = 6V_1$

$i_2 = (V_2 - V_3)$

$i_3 = 5V_2$

$2 + i_0 + i_2 + i_3 = 0$

$2 + 6V_1 + 3(V_2 - V_3) + 5V_2 = 0$

$6V_1 + 8V_2 - 3V_3 = -2$

KVL in Super node

$V_1 - V_2 = 10$

at node 3 Apply KCL

$2 + i_2 + 4 = 0$

$2 + 3V_2 - 3V_3 + 4 = 0$

$3V_2 - 3V_3 = -6$

$V_1 = 4.9\ V$, $V_2 = -5.1\ V$, $V_3 = -3.1\ V$

$i_0 = 29.4\ A$

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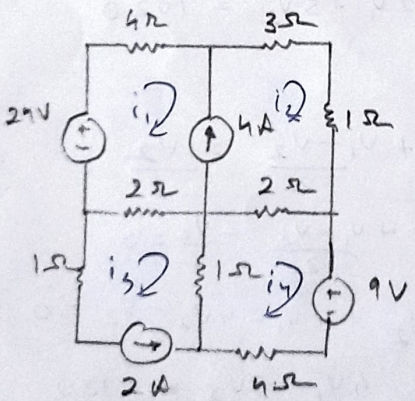
(12)



- Using KVL in mesh-1

$-24 + 4i_1 - 4 + 2(i_1 - i_3) = 0$

$6i_1 - 2i_3 = 28$

$\boxed{3i_1 - i_3 = 14}$

- In mesh -2

$3i_2 + 1i_2 + 2(i_2 - i_4) + 4 = 0$

$6i_2 - 2i_4 + 4 = 0$

$\boxed{3i_2 - i_4 + 2 = 0}$

- in mesh -3

$-2 + i_3 + 2(i_3 - i_1) + 1(i_3 - i_4) = 0$

$\boxed{-2i_1 + 4i_3 - i_4 = 2}$

• In mesh-4

$$9 + 4i_4 + (i_4 - i_3) + 2(i_4 - i_2) = 0$$

$$\boxed{-2i_2 - i_3 + 7i_4 = -9}$$

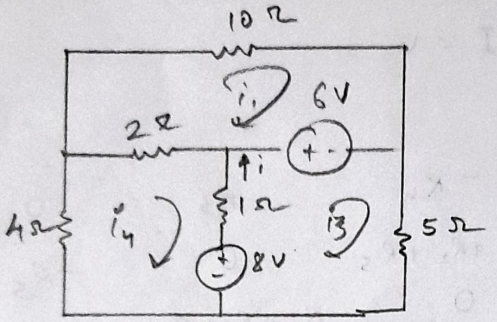
∴ $i_1 = 5.68A$, $i_2 = -1.05A$

$i_3 = 3.055A$, $i_4 = -1.15A$

$$i_0 = i_3 - i_4$$

$$i_0 = 4.2\ A$$

b)



• in loop-1

$$-6 + 2(i_1 - i_2) + 10i_1 = 0$$

$$12i_1 - 2i_2 = 6$$

• in loop-2

$$8 + 4(i_2) + 2(i_2 - i_1) + i_2 - i_3 = 0$$

$$8 - 2i_1 + 7i_2 - i_3 = 0$$

• in loop-3

$$5i_3 - 8 + (i_3 - i_2) + 6 = 0$$

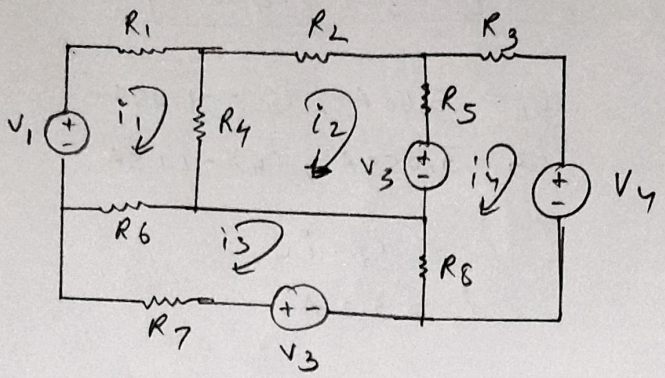
$$-i_2 + 6i_3 = 2$$

$i_1 = 0.33A$, $i_2 = -1.025$, $i_3 = 0.162$

$$i_0 = i_3 - i_2 = 0.162 + 1.025$$

$$\boxed{i_0 = 1.187A}$$

(13) By Inspection, obtain the mesh-current for the Circuit in fig.



$$RI = V$$

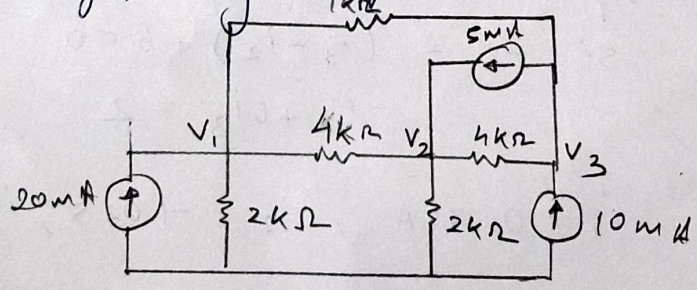
R → 4 × 4

$$\begin{bmatrix} R_1+R_4+R_6 & -R_4 & -R_6 & 0 \\ -R_4 & R_4+R_2+R_5 & 0 & -R_5 \\ -R_6 & 0 & R_6+R_8+R_7 & -R_8 \\ 0 & -R_5 & -R_8 & R_5+R_3+R_8 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix}$$

$$= \begin{bmatrix} V_1 \\ -V_2 \\ V_3 \\ -V_4+V_2 \end{bmatrix}$$

---

(14) For the Circuit shown in fig, find the node voltages by Inspection method.



$$GV = I$$

$$\begin{bmatrix} 7/4 & -1/4 & -1 \\ -1/4 & 1 & -1/4 \\ -1 & -1/4 & 5/4 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 5 \\ 5 \end{bmatrix}$$

$$\begin{bmatrix} 1.75 & -0.25 & -1 \\ -0.25 & 1 & -0.25 \\ -1 & -0.25 & 1.25 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 5 \\ 5 \end{bmatrix}$$

$V_1 = 36.48\ V$

$V_2 = 23.59\ V$

$V_3 = 37.85\ V$

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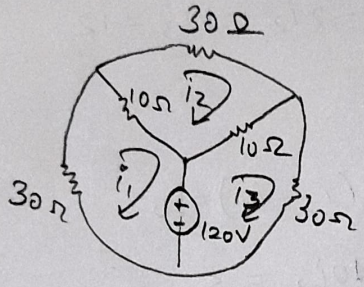
(15) (15) For the circuit shown in fig, find the mesh currents i_1, i_2, & i_3.

a)



$$RI = V$$

$$\begin{bmatrix} 40 & -10 & 0 \\ -10 & 50 & -10 \\ 0 & -10 & 40 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} -120 \\ 0 \\ 120 \end{bmatrix}$$

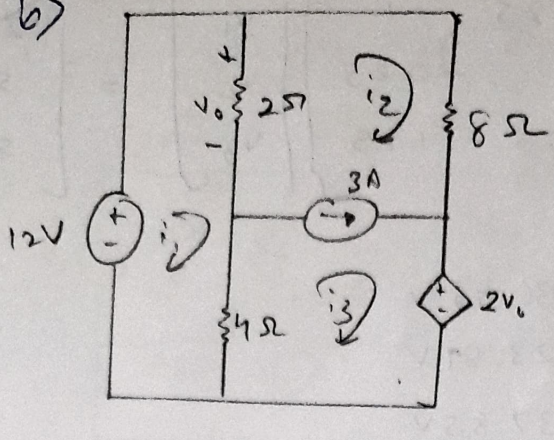
by Solving this

$i_1 = -3\ A$

$i_2 = 0$

$i_3 = 3\ A$

b)



$$V_o = -2(i_2 - i_1)$$
$$= 2(i_1 - i_2)$$

in Mesh loop - 1

$$-12 + 2(i_1 - i_2) + 4(i_1 - i_3) = 0$$
$$6i_1 - 2i_2 - 4i_3 = 12$$

in mesh loop - 2

$$8i_2 - 3 + 2(i_2 - i_1) = 0$$
$$-2i_1 + 10i_2 = 3$$

in mesh loop 3

$$4(i_3 - i_1) + 3 + 4(i_1 - i_2) = 0$$
$$-4i_2 + 4i_3 = -3$$

$$i_1 = 2.25\,A$$
$$i_2 = 0.75\,A$$
$$i_3 = 0\,A$$