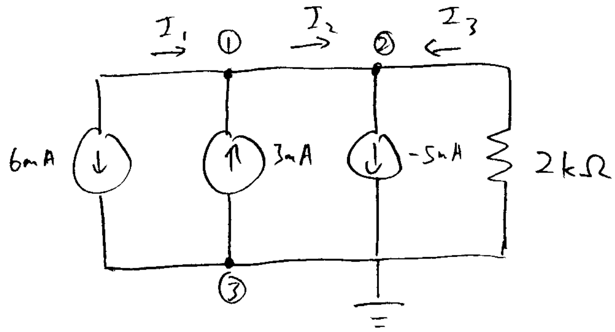
EE 42/100 Problem Set 2 Solutions

2.



by inspection, $I_1 = -6\,mA$

at node ①: $I_1 + 3\,mA = I_2$

$I_2 = -3\,mA$

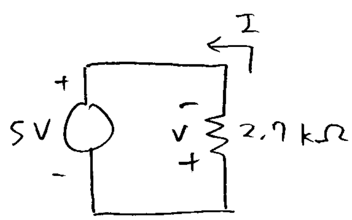
at node ②: $I_2 + I_3 = -5\,mA$

$I_3 = -2\,mA$

Kirchhoff's Current Law

$\boxed{I_1 = -6\,mA,\ I_2 = -3\,mA,\ I_3 = -2\,mA}$

3. (a)

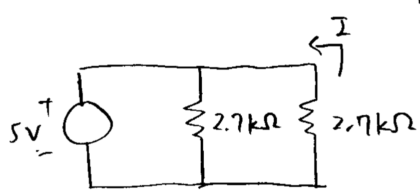


$I = \frac{V}{R}$ (Ohm's Law)

$V = -5V,\ R = 2.7\,k\Omega$

$\boxed{I = -1.85\ mA}$

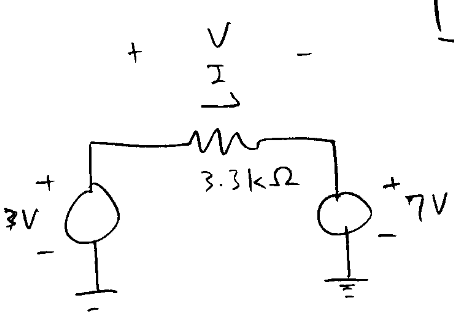
(b)



this is the same as part (a) because the resistors are in parallel with voltage source → same voltage across resistor as in part (a)

$\boxed{I = -1.85\ mA}$

(c)

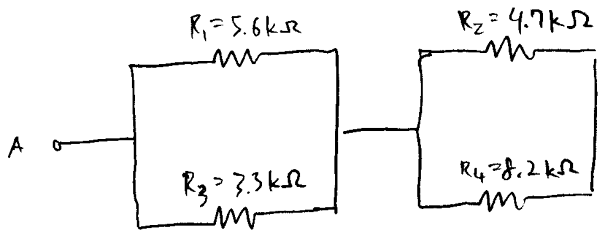


$I = \frac{V}{R}$

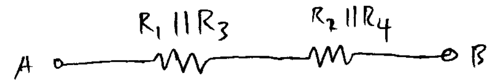
$V = 3V - 7V = -4V$

$\boxed{I = -1.21\ mA}$

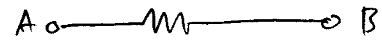
4.



$\Rightarrow$



$\Downarrow$



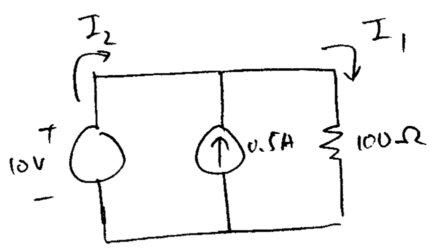
$(R_1 \| R_3) + (R_2 \| R_4) = R_{eq}$

$$R_1 \| R_3 = \left(\frac{1}{R_1} + \frac{1}{R_3}\right)^{-1} = \frac{R_1 R_3}{R_1 + R_3} = 2.07 k\Omega$$

$$R_2 \| R_4 = \left(\frac{1}{R_2} + \frac{1}{R_4}\right)^{-1} = \frac{R_2 R_4}{R_2 + R_4} = 2.99 k\Omega$$

$$R_{eq} = (R_1 \| R_3) + (R_2 \| R_4) = \boxed{5.06 k\Omega}$$

5.



$$I_1 = \frac{V}{R} = \frac{10 V}{100\Omega} = 0.1 A \quad \text{(ohm's Law)}$$

$$I_2 + 0.5 A = I_1 \Rightarrow I_2 = -0.4 A \quad \text{(KCL)}$$

$$\boxed{I_1 = 0.1 A, \ I_2 = -0.4 A}$$

6. (a) R_1 and R_2 are parallel $\Rightarrow$ same voltage across R_1, R_2

Power dissipated through resistor $R = \dfrac{V^2}{R}$

$P = \dfrac{V^2}{R_1} + \dfrac{V^2}{R_2}$ = total power dissipated through both resistors

$$P = V^2 \left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$P (R_1 \| R_2) = V^2$$

$$P_1 = \frac{V^2}{R_1} = \frac{P(R_1 \| R_2)}{R_1}$$

$$= \boxed{P \cdot \frac{R_2}{R_1 + R_2}}$$ $\leftarrow$ power dissipated in R_1

(b) R_1, R_2 in series $\rightarrow$ same current through R_1, R_2

Power dissipated in resistor $R = I^2 R$

$$P = I^2 R_1 + I^2 R_2$$

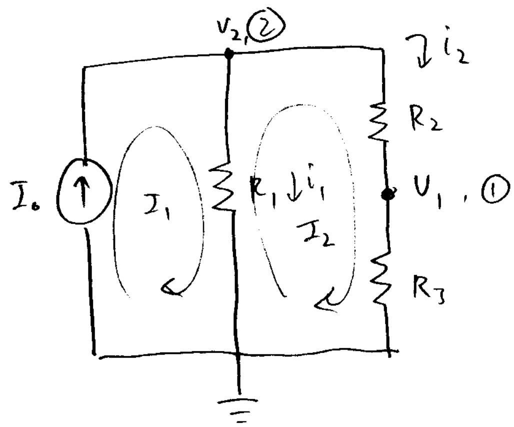
$$P = I^2 (R_1 + R_2)$$

$$I^2 = \frac{P}{R_1 + R_2}$$

$$P_1 = I^2 R_1$$

$$\boxed{P_1 = P \cdot \frac{R_1}{R_1 + R_2}}$$

7.



at node ①: $\frac{V_1}{R_3} = \frac{V_2 - V_1}{R_2}$

at node ②: $\frac{V_2}{R_1} + \frac{V_2 - V_1}{R_2} = I_0$

② − ① = $\frac{V_2}{R_1} = I_0 - \frac{V_1}{R_3}$

from ①: $V_1 = V_2 \cdot \frac{R_3}{R_2 + R_3}$ (which is just a voltage divider

$\frac{V_2}{R_1} = I_0 - \frac{V_2}{R_2 + R_3} \Rightarrow V_2 = I_0 \cdot \left(\frac{1}{R_1} + \frac{1}{R_2 + R_3}\right)^{-1}$

$V_2 = 2.61$ V

$V_1 = V_2 \cdot \frac{R_3}{R_2 + R_3} \Rightarrow \boxed{V_1 = 1.43 \text{ V}}$

* this can more easily be solved using the concepts of current and voltage dividers

8. by inspection: $I_1 = I_0$

around mesh current I_2: $(I_2 - I_1) R_1 + I_2 R_2 + I_2 R_3 = 0$

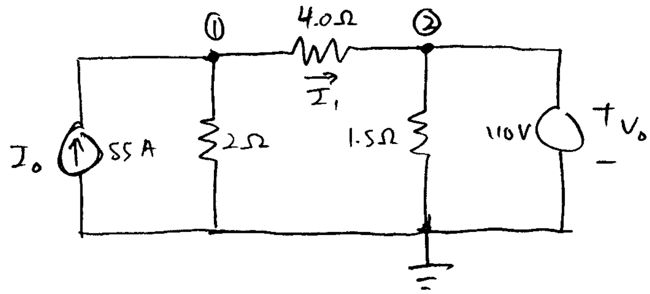
replacing $I_1 = I_0$: $(I_2 - I_0) R_1 + I_2 R_2 + I_2 R_3 = 0$

$$I_2 = I_0 \cdot \frac{R_1}{R_1 + R_2 + R_3}$$

by ohm's Law : $V_1 = I_2 R_3 = I_0 \frac{R_1 R_3}{R_1 + R_2 + R_3}$

$$\boxed{V_1 = 1.43 \text{ V}}$$

9.



at node ① : $I_0 = \frac{V_1}{2\Omega} + I_1$

$$I_1 = \frac{V_1 - V_2}{4.0\Omega}$$

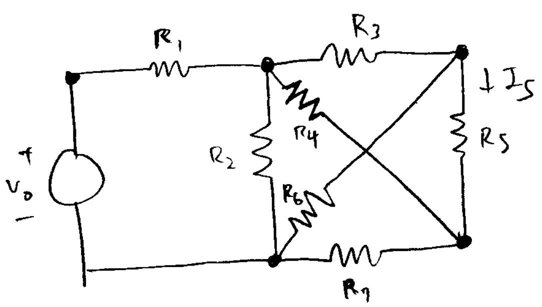
by inspection, $V_2 = V_0$ $\Rightarrow$ $I_0 = \frac{V_1}{2\Omega} + \frac{V_1 - V_0}{4.0\Omega}$

$$V_1 = \left(I_0 + \frac{V_0}{4.0\Omega}\right)\left(\frac{1}{2\Omega} + \frac{1}{4.0\Omega}\right)^{-1}$$

$$V_1 = 110\ V$$

$\therefore\ I_1 = \frac{V_1 - V_2}{4.0\Omega} = \boxed{\phi\ A}$

10.



(a) 5 nodes

(b) 8 branches

(c) mesh currents = branches − nodes + 1

= 8 − 5 + 1

4 mesh currents