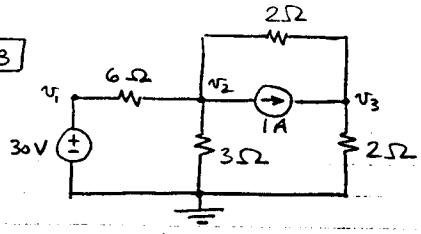
2.8



For node v_1, by KVL, $v_1 = 30\ V$

By KCL at node v_2,

$$\frac{v_2-30}{6}+\frac{v_2}{3}+\frac{v_2-v_3}{2}+1=0$$

$$v_2-30+2v_2+3v_2-3v_3+6=0$$

$$6v_2-3v_3=24$$

$$2v_2-v_3=8 \quad (1)$$

By KCL at node v_3,

$$\frac{v_3-v_2}{2}+\frac{v_3}{2}=1$$

$$v_3-v_2+v_3=2$$

$$-v_2+2v_3=2 \quad (2)$$

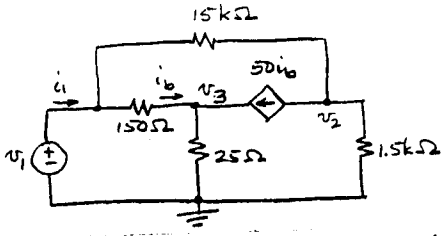
$(1)\times 2$: $\quad 4v_2-2v_3=16$

$$3v_2=18$$

$$\therefore v_2=6\ V$$

$$v_3=2v_2-8=2(6)-8=4\ V$$

2.14



By KCL at node v_3,

$$i_b+50i_b=\frac{v_3}{25}$$

$$51i_b=\frac{v_3}{25}$$

$$51\frac{v_1-v_3}{150}=\frac{v_3}{25}$$

$$51v_1-51v_3=6v_3$$

$$51v_1=57v_3$$

$$v_3=\frac{51}{57}v_1$$

By KCL at node v_2,

$$50i_b+\frac{v_2-v_1}{15k}+\frac{v_2}{1.5k}=0$$

$$50\left(\frac{v_1-v_3}{150}\right)+\frac{v_2-v_1}{15k}+\frac{v_2}{1.5k}=0$$

$$5kv_1-5kv_3+v_2-v_1+10v_2=0$$

$$4999v_1-5000v_3=-11v_2$$

$$4999v_1-5000\left(\frac{51}{57}\right)v_1=-11v_2$$

$$525v_1=-11v_2$$

$$\therefore \frac{v_2}{v_1}=\frac{525}{-11}=-47.7$$

(b) By KCL,

$$i_1=\frac{v_1-v_2}{15k}+\frac{v_1-v_3}{150}$$

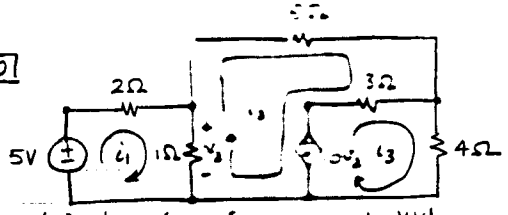
$$i_1=\frac{v_1-(-47.7v_1)}{15k}+\frac{v_1-\frac{51}{57}v_1}{150}$$

$$\frac{i_1}{v_1}=\frac{48.7}{15k}+\frac{6/57}{150}=3.24m+0.702m$$

$$\frac{i_1}{v_1}=3.94m$$

$$\frac{v_1}{i_1}=\frac{1}{3.94m}=254\ \Omega$$

2.20



For mesh i_1, by KVL,

$$5=2i_1+1(i_1-i_2)$$

$$3i_1-i_2=5$$

For mesh i_2, by KVL,

$$5-v_a+3(i_2-i_3)-10v_b-v_b=0$$

$$5-v_a+3i_2-3i_3-11[1(i_1-i_2)]=0$$

$$-11i_1+14i_2-3i_3=0$$

For mesh i_3, by KVL,

$$3(i_3-i_2)+4i_3+10v_b=0$$

$$3i_3-3i_2+4i_3+10[1(i_1-i_2)]=0$$

$$10i_1-13i_2+7i_3=0$$

$$D=\begin{vmatrix}3&-1&0\\-11&14&-3\\10&-13&7\end{vmatrix}=392+30-117-77=235$$

$$D_1=\begin{vmatrix}5&-1&0\\0&14&-3\\0&-13&7\end{vmatrix}=665-195=470$$

$$\therefore i_1=\frac{D_1}{D}=\frac{470}{235}=2\ A$$

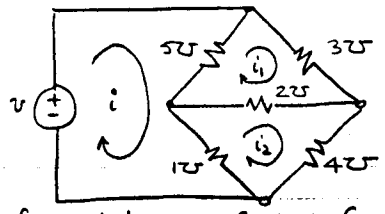
$$D_2=\begin{vmatrix}3&5&0\\-11&0&-3\\10&0&7\end{vmatrix}=-150+385=235$$

$$\therefore i_2=\frac{D_2}{D}=\frac{235}{235}=1\ A$$

$$D_3=\begin{vmatrix}3&1&5\\-11&14&0\\10&-13&0\end{vmatrix}=715-950=-235$$

$$\therefore i_3=\frac{D_3}{D}=\frac{-235}{235}=-1\ A$$

2.24



By KVL for mesh i,

$$v=\tfrac{1}{5}(i-i_1)+\tfrac{1}{1}(i-i_2)$$

$$5v=i-i_1+5i-5i_2$$

$$6i-i_1-5i_2=5v$$

By KVL for mesh i_1,

$$\tfrac{1}{3}i_1+\tfrac{1}{2}(i_1-i_2)+\tfrac{1}{5}(i_1-i)=0$$

$$10i_1+15i_1-15i_2+6i_1-6i=0$$

$$-6i+31i_1-15i_2=0$$

By KVL for mesh i_2,

$$\tfrac{1}{4}i_2+\tfrac{1}{1}(i_2-i)+\tfrac{1}{2}(i_2-i_1)=0$$

$$i_2+4i_2-4i+2i_2-2i_1=0$$

$$-4i-2i_1+7i_2=0$$

$$D=\begin{vmatrix}6&-1&-5\\-6&31&-15\\-4&-2&7\end{vmatrix}=1302-60-60-620-180-42=340$$

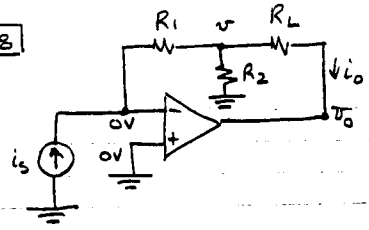
$$D_i=\begin{vmatrix}5v&-1&-5\\0&31&-15\\0&-2&7\end{vmatrix}=1085v-150v=935v$$

$$\therefore i=\frac{D_i}{D}=\frac{935v}{340}$$

Hence,

$$G=\frac{i}{v}=\frac{935}{340}=\frac{11}{4}=2.75\ \mho$$

2.28



(a) By KCL at the inverting input, $i_s = \frac{-v}{R_1} \Rightarrow v = -R_1 i_s$

By KCL at node v, $\frac{v}{R_1} + \frac{v}{R_2} + \frac{v - v_o}{R_L} = 0$

$$\frac{-R_1 i_s}{R_1} - \frac{R_1 i_s}{R_2} - \frac{R_1 i_s}{R_L} = \frac{v_o}{R_L}$$

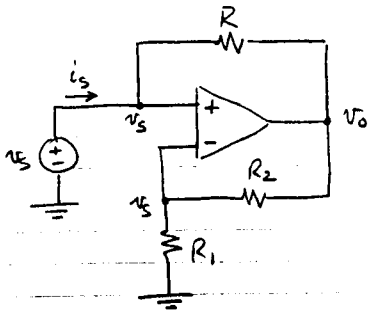
$$\therefore v_o = -R_L i_s - \frac{R_1 R_L}{R_2} i_s - R_1 i_s = -\left(R_L + R_1 + \frac{R_1 R_L}{R_2}\right) i_s$$

(b) $i_o = \frac{v - v_o}{R_L} = \frac{-R_1 i_s + R_L i_s + R_1 i_s + \frac{R_1 R_L}{R_2} i_s}{R_L}$

$$i_o = \frac{\left(R_L + \frac{R_1 R_L}{R_2}\right) i_s}{R_L}$$

$$i_o = \left(1 + \frac{R_1}{R_2}\right) i_s$$

2.30



(a) By KCL at the inverting input of the op amp,

$$\frac{v_s}{R_1} + \frac{v_s - v_o}{R_2} = 0$$

$$R_2 v_s + R_1 v_s - R_1 v_o = 0$$

$$(R_1 + R_2) v_s = R_1 v_o$$

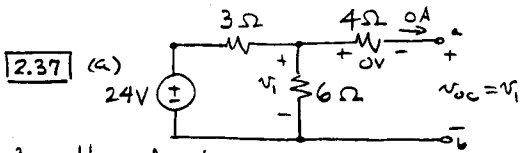
$$\therefore v_o = \frac{R_1 + R_2}{R_1} v_s = \left(1 + \frac{R_2}{R_1}\right) v_s$$

(b) $i_s = \frac{v_s - v_o}{R} = \frac{v_s - \frac{R_1 + R_2}{R_1} v_s}{R} = \frac{R_1 v_s - (R_1 + R_2) v_s}{R_1 R}$

$$i_s = \frac{-R_2 v_s}{R_1 R}$$

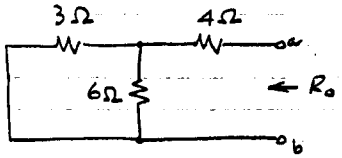
$$\therefore \frac{v_s}{i_s} = -\frac{R_1 R}{R_2}$$

2.37 (a)



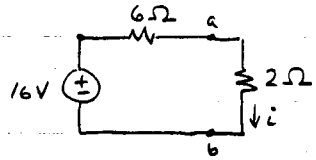
By voltage division,

$$v_{oc} = \frac{6}{3+6}(24) = \frac{2}{3}(24) = 16\ V$$



$$R_o = 4 + 3 \| 6 = 4 + \frac{(3)(6)}{3+6} = 4 + \frac{18}{9} = 6\ \Omega$$

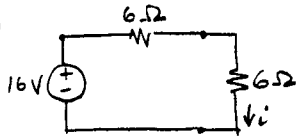
(b)



By KVL, $16 = 6i + 2i = 8i \Rightarrow i = \frac{16}{8} = 2\ A$

$$\therefore p_2 = 2i^2 = 2(2)^2 = 8\ W$$

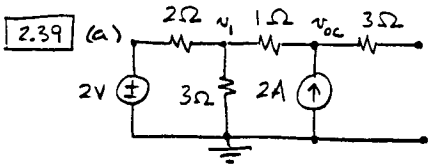
(c)



$$i = \frac{16}{6+6} = \frac{16}{12} = \frac{4}{3}\ A$$

$$p_6 = 6i^2 = 6\left(\frac{4}{3}\right)^2 = 10.7\ W$$

2.39 (a)



By KCL at node v_1,

$$\frac{v_1 - 2}{2} + \frac{v_1}{3} + \frac{v_1 - v_{oc}}{1} = 0$$

$$3v_1 - 6 + 2v_1 + 6v_1 - 6v_{oc} = 0$$

$$11 v_1 - 6 v_{oc} = 6$$

By KCL at node v_{oc},

$$\frac{v_1 - v_{oc}}{1} + 2 = 0$$

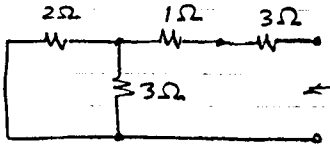
$$v_1 = v_{oc} - 2$$

$$\therefore 11(v_{oc} - 2) - 6 v_{oc} = 6$$

$$11 v_{oc} - 22 - 6 v_{oc} = 6$$

$$5 v_{oc} = 28$$

$$v_{oc} = \frac{28}{5} = 5.6\ V$$

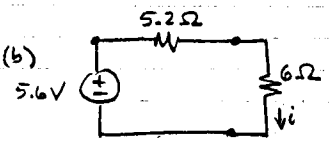


$R_o = 2 \| 3 + 1 + 3$

$$R_o = \frac{(2)(3)}{2+3} + 4$$

$$R_o = \frac{6}{5} + 4 = \frac{26}{5} = 5.2\ \Omega$$

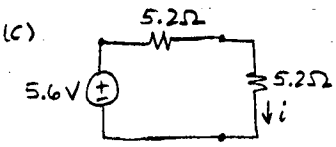
(b)



$$i = \frac{5.6}{5.2 + 6} = 0.5\ A$$

$$p_6 = 6i^2 = 6(0.5)^2 = 1.5\ W$$

(c)



$$i = \frac{28/5}{26/5 + 26/5} = \frac{28}{52} = \frac{7}{13}\ A$$

$$p_{5.2} = 5.2\left(\frac{7}{13}\right)^2 = 1.51\ W$$