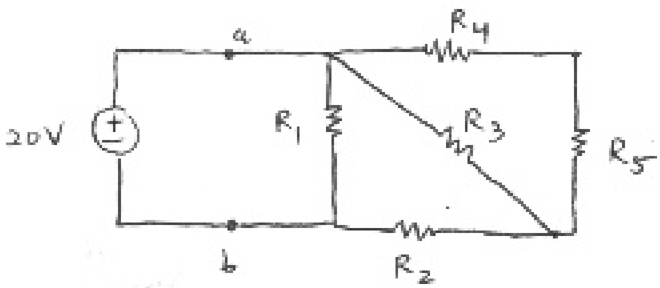
HW # 4 Solutions 10/4/99, EECS 210 John Choi

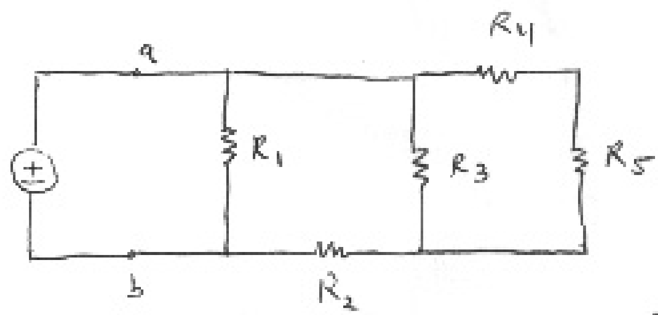
① $\underline{3.7}$

ⓐ Find R_{ab}.

let $\underline{\text{circuit } 3.7a}$ be :

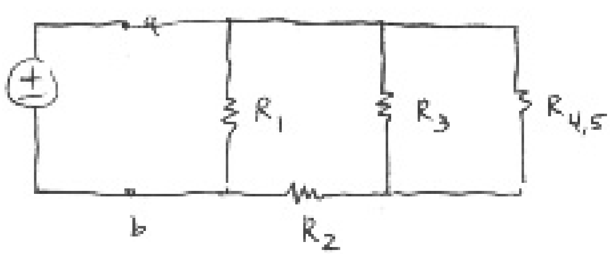


⇒



• Note that R_4 and R_5 are in series.

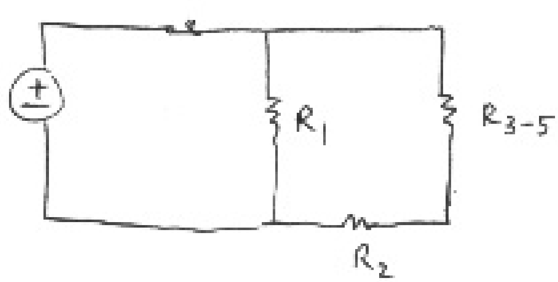
⇒



where
$$R_{4,5} = R_4 + R_5 = 10 + 6 = \underline{16\ \Omega}$$

• Note that R_3 and $R_{4,5}$ are in parallel.

⇒

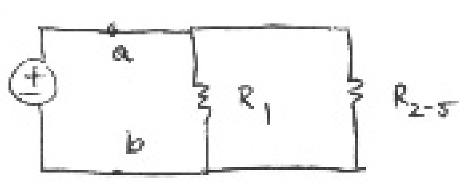


where
$$R_{3-5} = \frac{R_3 \cdot R_{4,5}}{R_3 + R_{4,5}} = \frac{48 \cdot 16}{48 + 16} = \frac{48 \cdot 16}{64}$$

$$R_{3-5} = \underline{12\ \Omega}$$

• Note that R_2 and R_{3-5} are in series.

⇒



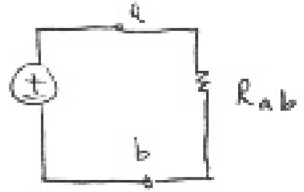
where
$$R_{2-5} = R_2 + R_{3-5} = 18 + 12 = \underline{30\ \Omega}$$

① 3.7

ⓐ continued.

Note that R_1 and R_{2-5} are in parallel.

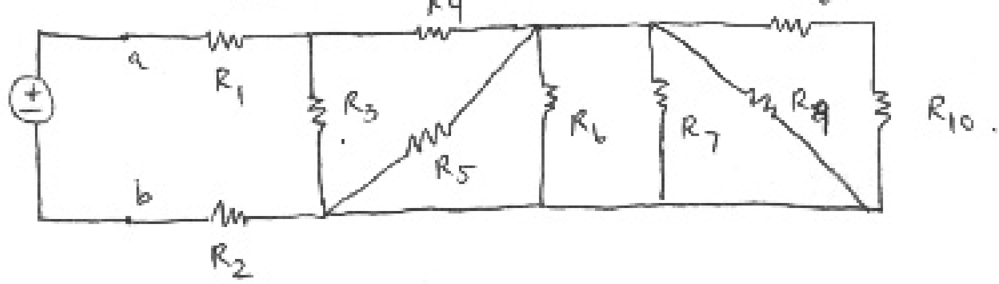
$\Rightarrow$



$$R_{ab} = \frac{R_1 \cdot R_{2-5}}{R_1 + R_{2-5}} = \frac{15 \cdot 30}{15 + 30} = \frac{15 \cdot 30}{45}$$

$$\boxed{R_{ab} = 10\ \Omega}$$

ⓐ. circuit 3.7 b :



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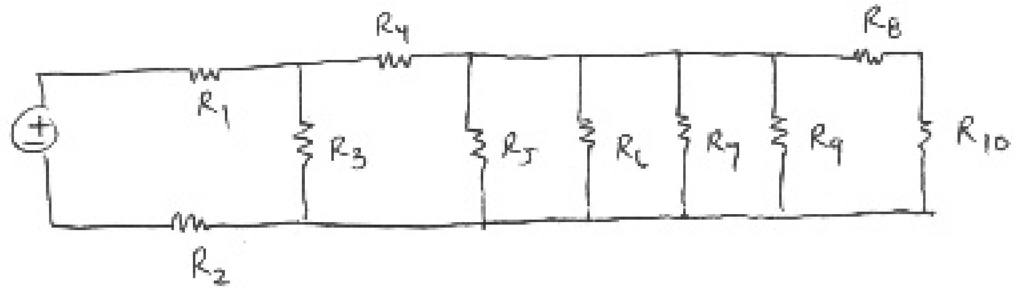
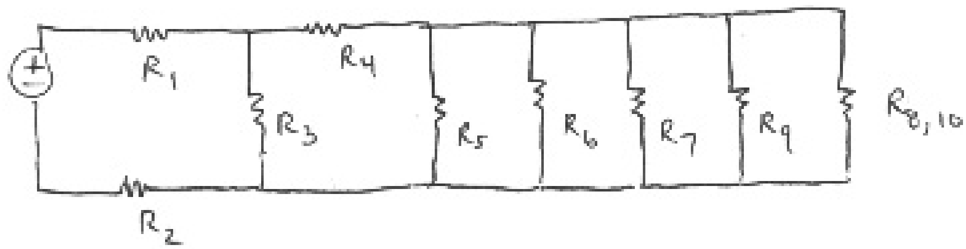


- Note R_8 and R_{10} are in series

$\Rightarrow$

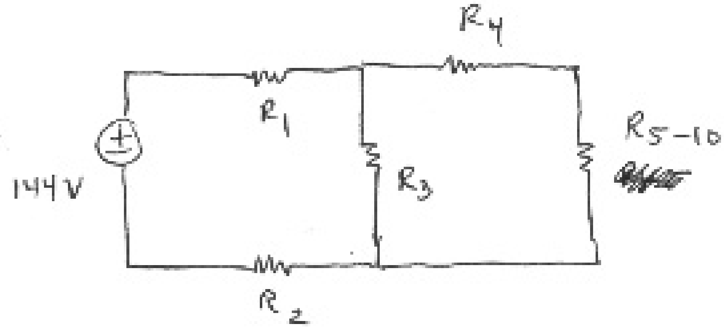


$$R_{8,10} = R_8 + R_{10} = 6 + 14 = \underline{20\ \Omega}$$

- Note that R_5, R_6, R_7, R_9, $R_{8,10}$ are in parallel.

① 3.7

ⓐ continued.

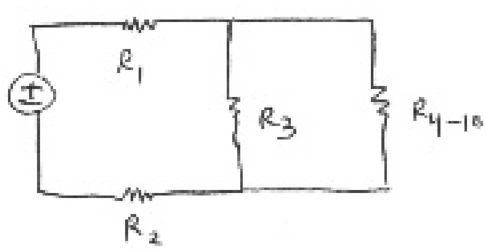
⇒ 

where $$\frac{1}{R_{5-10}} = \frac{1}{R_5} + \frac{1}{R_6} + \frac{1}{R_7} + \frac{1}{R_9} + \frac{1}{R_{8,10}}$$

$$= \frac{1}{12} + \frac{1}{4} + \frac{1}{20} + \frac{1}{15} + \frac{1}{20}.$$

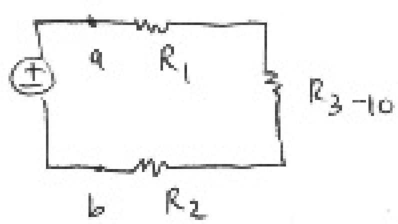
$$= \frac{30}{60}. \Rightarrow \underline{R_{5-10} = 2\,\Omega} //.$$

Note R_4 and R_{5-10} are in series.

⇒ 

$$R_{4-10} = R_4 + R_{5-10}$$
$$= 16 + 2$$
$$= \underline{18\,\Omega} //$$

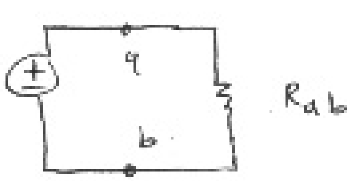
Note R_3 and R_{4-10} are in parallel.

⇒ 

$$R_{3-10} = \frac{R_3 \cdot R_{4-10}}{R_3 + R_{4-10}}$$

$$= \frac{18 \cdot 18}{18 + 18} = \underline{9\,\Omega} //$$

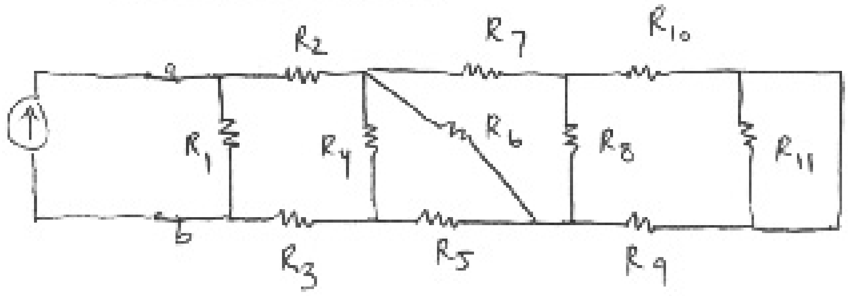
Note R_1, R_{3-10}, R_2 are in series.

⇒ 

$$R_{ab} = R_1 + R_{3-10} + R_2$$
$$R_{ab} = 8 + 9 + 10 = \boxed{27\,\Omega}$$

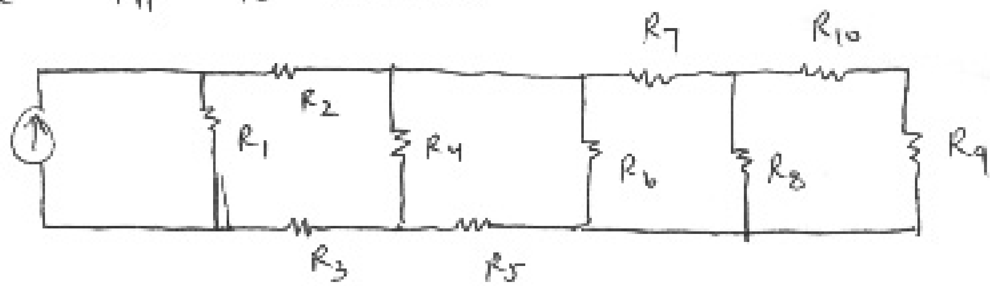
① 3.7

circuit 3.7c :



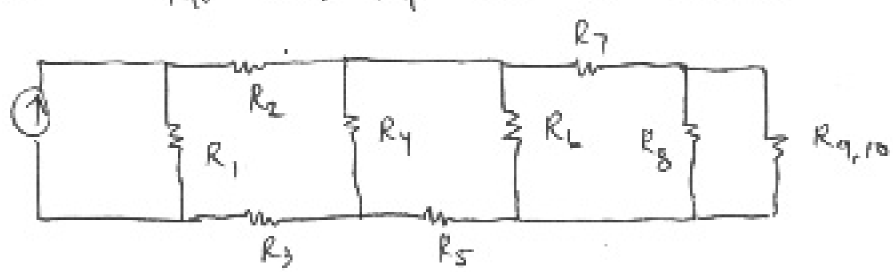
Note R_{11} is shorted.

⇒



Note R_{10} and R_9 are in series.

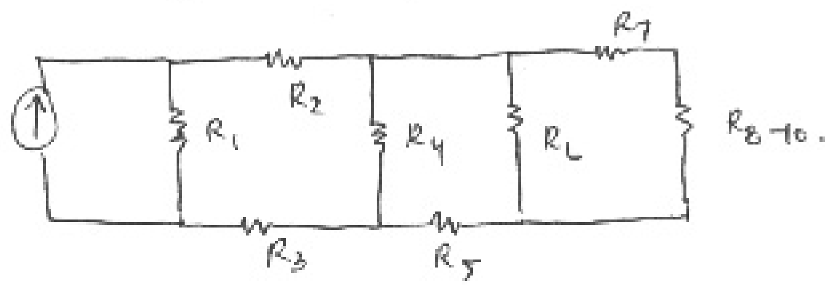
⇒



$$R_{9,10} = R_{10} + R_9 = 6 + 10 = \underline{16\Omega}$$

Note. R_8 and $R_{9,10}$ are in parallel.

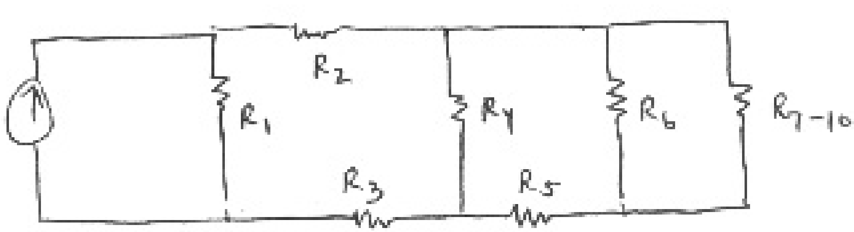
⇒



$$R_{8-10} = \frac{R_8 \cdot R_{9,10}}{R_8 + R_{9,10}} = \frac{48 \cdot 16}{48+16} = \underline{12\Omega}$$

Note R_7 and R_{8-10} are in series.

⇒

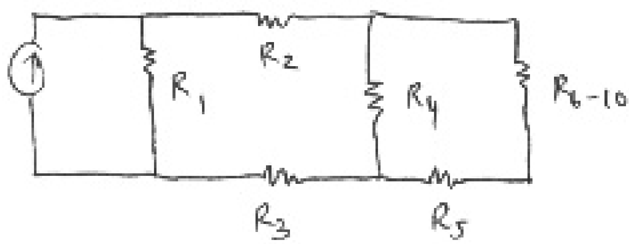


$$R_{7-10} = R_7 + R_{8-10} = 8 + 12 = \underline{\underline{20\Omega}}$$

① 3.7

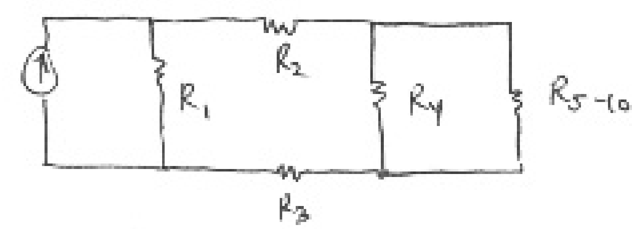
ⓐ continued.

Note R_6 and R_{7-10} are in parallel.

⇒ 

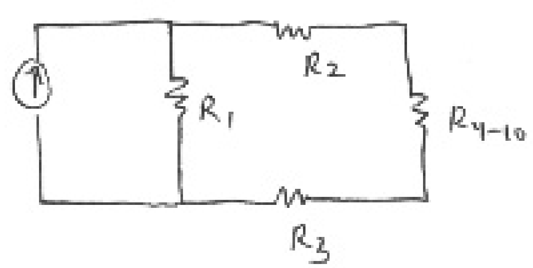
$$R_{6-10} = \frac{R_6 \cdot R_{7-10}}{R_6 + R_{7-10}} = \frac{30 \cdot 20}{30 + 20} = \underline{12\ \Omega}$$

Note R_5 and R_{6-10} are in series.

⇒ 

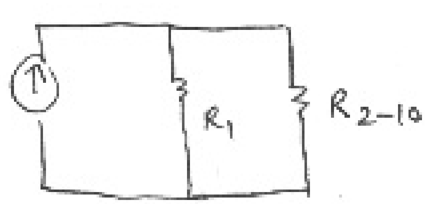
$$R_{5-10} = R_5 + R_{6-10} = 18 + 12 = \underline{30\ \Omega}$$

Note R_4 and R_{5-10} are in parallel.

⇒ 

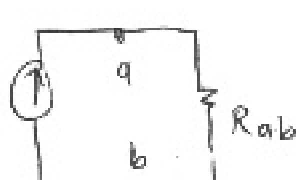
$$R_{4-10} = \frac{R_4 \cdot R_{5-10}}{R_4 + R_{5-10}} = \frac{15 \cdot 30}{15 + 30} = 10\ \Omega.$$

Note R_2, R_{4-10}, R_3 are in series.

→ 

$$R_{2-10} = R_2 + R_{4-10} + R_3 = 20 + 10 + 10 = \underline{40\ \Omega}$$

Note R_1 and R_{2-10} are in parallel.

→ 

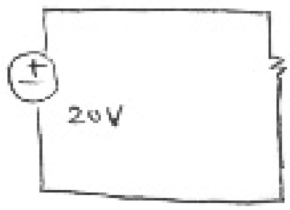
$$R_{ab} = \frac{R_1 \cdot R_{2-10}}{R_1 + R_{2-10}} = \frac{60 \cdot 40}{60 + 40} = \boxed{24\ \Omega}$$

① 3.7

ⓑ. Find power delivered by each source.

ckt 3.7 a :

Recall



$R_{ab} = 10\Omega$

$P = -IV$ | $V = IR \Rightarrow I = \frac{V}{R}$

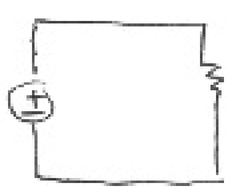
$P = -\left(\frac{V}{R}\right)V$

$P = -\frac{V^2}{R}$.

$\Rightarrow P_s = -\frac{V_s^2}{R_{ab}} = -\frac{(20\ V)^2}{10\Omega} = \boxed{-40\ W}$ (40 W delivered power.)

ckt 3.7 b :

144V



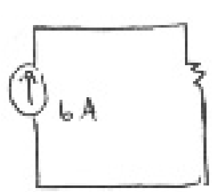
$R_{ab} = 27\Omega$

$P = -IV$

$P = -\frac{V^2}{R} \Rightarrow P_s = -\frac{V_s^2}{R_{ab}}$

$= -\frac{(144)^2}{27} = \boxed{-768\ W}$ (768 W delivered power.)

ckt 3.7 c :



$R_{ab} = 24\Omega$

$P = -IV$

$P = -I(IR)$

$P = -I^2R$

$\Rightarrow P_s = -I_s^2 R_{ab}$

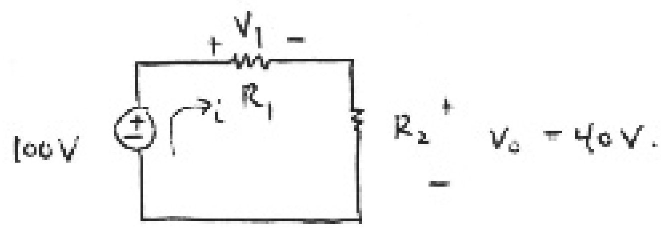
$= -(6A)^2(24\Omega) = \boxed{-864\ W}$

(864 W delivered)

3.18

(a). Specify R_1, R_2.

If no load resistor,



by KVL : $-100 + V_1 + 40 = 0$

$V_1 = 100 - 40 = \underline{60\ V}$ //.

$V_o = i R_2$

$V_o = \left(\frac{100}{R_1 + R_2}\right) R_2 \triangleq 40\ V.$

Because

$100 = i(R_1 + R_2)$

$i = \frac{100}{R_1 + R_2}$ //

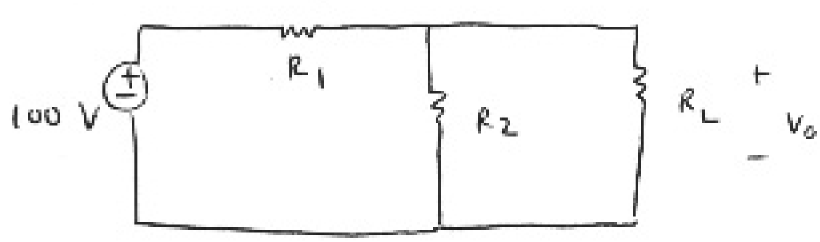
$\Rightarrow \frac{R_2}{R_1 + R_2} = \frac{2}{5}$

$5R_2 = 2R_1 + 2R_2$

$3R_2 = 2R_1$

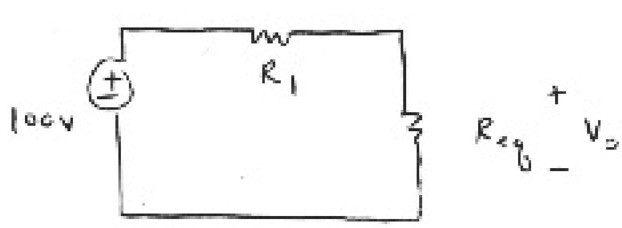
$\hookrightarrow \boxed{R_1 = \frac{3}{2} R_2}$

- Now with R_L,



let $R_{eq} = \frac{R_2 \cdot R_L}{R_2 + R_L}$

$\Rightarrow$



3.18 (a)

From simple circuit analysis,

$$V_o = 100 \cdot \frac{R_{eq}}{R_1 + R_{eq}}$$

$$V_o \geq 36 \text{ V} \quad \text{(given in problem).}$$

$$\Rightarrow \quad 100 \cdot \frac{R_{eq}}{R_1 + R_{eq}} \geq 36$$

$$100 R_{eq} \geq 36 R_1 + 36 R_{eq}$$

$$64 R_{eq} \geq 36 R_1$$

$$\Leftrightarrow \quad \cancel{36} R_1 \leq \left(\frac{64}{36}\right) R_{eq}$$

$$R_1 \leq \left(\frac{64}{36}\right)\left[\frac{R_2 \cdot R_L}{R_2 + R_L}\right]$$

$$R_1 \leq \left(\frac{64}{36}\right)\left[\frac{\frac{2}{3} R_1 R_L}{\frac{2}{3} R_1 + R_L}\right]$$

$$\left(\frac{2}{3} R_1 + R_L\right) \cancel{R_1} \leq \frac{16}{9}\left(\frac{2}{3} \cancel{R_1} R_L\right)$$

$$\frac{2}{3} R_1 \leq \frac{32}{27} R_L - R_L$$

$$R_1 \leq \frac{3}{2}\left(\frac{5}{27} R_L\right)$$

$$R_1 \leq \frac{5}{18} R_L$$

$$R_1 \leq \frac{5}{18} \cdot 54 \text{ k}\Omega$$

$$\boxed{R_1 \leq 15 \text{ k}\Omega}$$

3.18

ⓐ. We have derived that the requirement $R_1 \leq 15\ k\Omega$ must be upheld in order for $V_o \geq 36V$ when $R_L = 54\ k\Omega$.

Let us make a chart for different values of R_1 and R_2.

R_1	$R_2 = \frac{2}{3} R_1$	$R_{eq} = \frac{R_2 R_L}{R_2 + R_L}$	$V_o = V_S \frac{R_{eq}}{R_{eq} + R_1}$	$P_{R_1} = \frac{V_1^2}{R_1}$	$P_{R_2} = \frac{V_o^2}{R_2}$
15 kΩ	10 kΩ	8.4375 kΩ	36 V	0.2731 W	0.1296 W
12 kΩ	8 kΩ	6.968 kΩ	36.94 V	0.3413 W	0.162 W
9 kΩ	6 kΩ	5.4 kΩ	37.5 V	0.4551 W	0.216 W
6 kΩ	4 kΩ.	3.724 kΩ	38.30 V	0.6827 W	0.324 W
3 kΩ	2 kΩ.	1.93 kΩ.	39.15 V	1.365 W	0.648 W
..					

So, we can see that for $R_1 \leq 15k\Omega$ and the corresponding R_2 $\left(R_2 = \frac{2}{3} R_1 \right)$, the design specifications are met.

ⓑ. if we select $R_1 = 15k\Omega$ and $R_2 = 10k\Omega$, then, we can use resistors with power rating = 1 W

since $P_{R_1} = 0.2731\ W < 1\ W$ AND

$P_{R_2} = 0.1296\ W < 1\ W.$

3.19

Power rating for resisters - 0.5 W

From 3.18 chart, $8.192\,k\Omega \le R_1 \le 15\,k\Omega$.

will meet this requirement. (where $P_{R_1} = \frac{V_1^2}{R_1} \le 0.5\,W \Rightarrow R_1 \ge 8.192\,k\Omega$

We would like to find the smallest R_L possible before R_1 or R_2 is at its dissipation limit.

For the ensuing analysis we will use $R_1 = 15\,k\Omega$ and $R_2 = 10\,k\Omega$.

$$\Rightarrow \quad P_{R_1} = \frac{V_1^2}{R_1} \le 0.5\,W$$

$$V_1^2 \le 0.5 R_1$$

$$V_1 \le \sqrt{0.5(15{,}000)}$$

$$V_1 \le 86.6\,V$$

by KVL,

$$-V_S + V_1 + V_0 = 0$$

$$V_0 = V_S - V_1$$

$$V_0 = 100 - V_1$$

$$V_0 \ge 100 - 86.6\,V$$

$$V_0 \ge 13.4\,V$$

Recall that $V_0 = V_S \frac{R_{eq}}{R_1 + R_{eq}} \ge 13.4$

$$\frac{R_{eq}}{R_1 + R_{eq}} \ge \frac{13.4}{100}$$

$$R_{eq} \ge 0.134 R_1 + 0.134 R_{eq}.$$

$$0.866 R_{eq} \ge 0.134(15{,}000)$$

$$R_{eq} \ge 2321\,\Omega$$

3.19

Recall that

$$R_{eq} = \frac{R_2 R_L}{R_2 + R_L} \geq 2321\,\Omega.$$

$$\Rightarrow \quad \frac{10000\, R_L}{10{,}000 + R_L} \geq 2321$$

$$10{,}000\, R_L \geq 2321(10^4) + 2321\, R_L$$

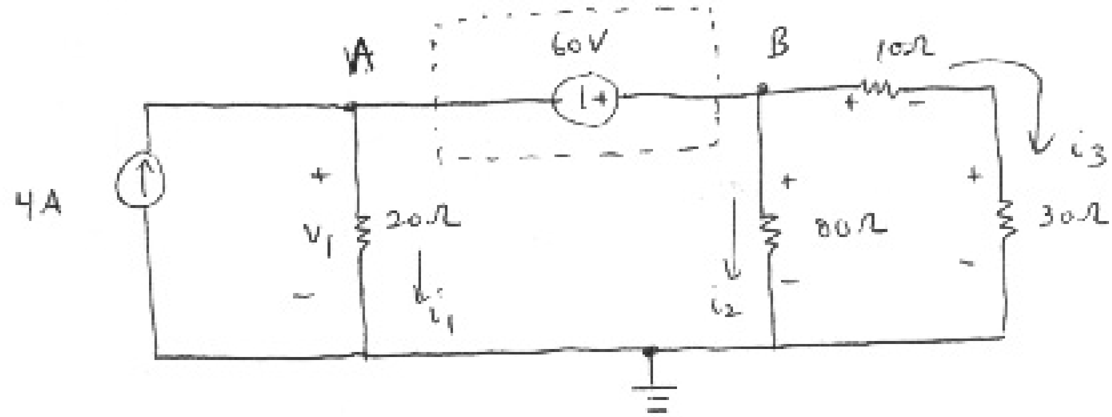
$$7679\, R_L \geq 2321 \times 10^4$$

$$R_L \geq 3022.5\,\Omega.$$

So, $R_L \simeq 3\,k\Omega$ is the smallest possible value when $R_1 = 15\,k\Omega$ and $R_2 = 10\,k\Omega$.

4.3

Use the node-voltage method to find v_1 and the power delivered by the 60 V source.



- Use a super-node
- Sum currents leaving supernode.

① $$-4 + \frac{V_A}{20} + \frac{V_B}{80} + \frac{V_B}{10+30} = 0$$

② Note that $V_B - V_A = 60$ V.

Simplifying ① ⇒ $-320 + 4V_A + V_B + 2V_B = 0$

$$4V_A + 3V_B = 320$$

$$4V_A + 3(V_A + 60) = 320$$

$$7V_A = 140$$

$$\boxed{V_A = 20 \text{ V}}$$

$$\Rightarrow V_B = V_A + 60$$

$$\boxed{V_B = 80 \text{ V}}$$

$\therefore$ $\boxed{V_1 = V_A = 20 \text{ V}}$

4.3

Power delivered by 60 V source?

$$P_{60V} = -IV$$

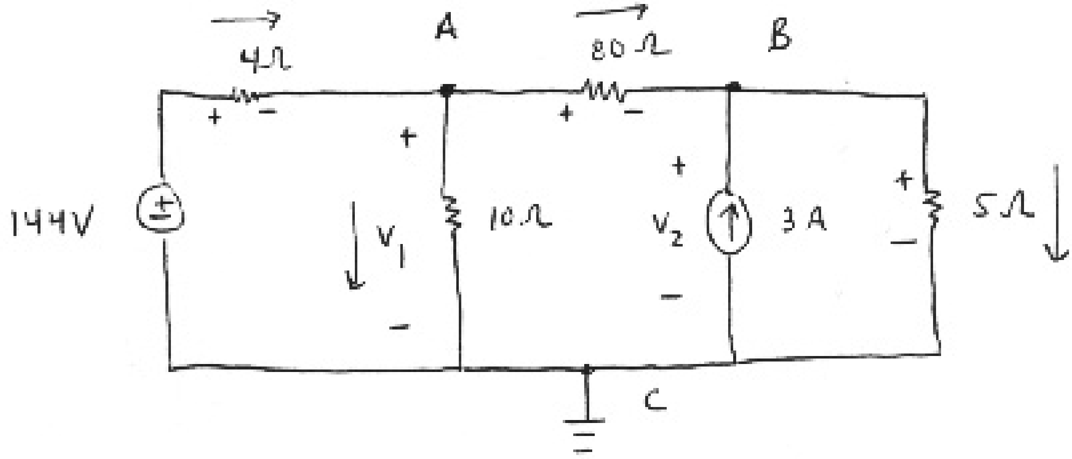
$$= -(i_2 + i_3)(60V)$$

$$= -\left(\frac{V_B}{80} + \frac{V_B}{10+30}\right)(60)$$

$$= -(1+2)60$$

$$= \boxed{-180\ W} \quad \left(\begin{array}{c}180\ W \\ \text{delivered}\end{array}\right)$$

4.9 Use node-voltage method to find v_1 and v_2



Step 1: Sum currents going away from node A.

(1) $$-\frac{(-V_A + 144)}{4} + \frac{V_A}{10} + \frac{V_A - V_B}{80} = 0$$

current going through 4Ω Resistor

current going through 10Ω resistor

current going through 80Ω Resistor

Step 2: Sum currents going away from node B.

current entering B from current source

(2) $$-\frac{(V_A - V_B)}{80} - 3 + \frac{V_B}{5} = 0$$

current entering B through 80Ω

current leaving B through 5Ω

∴ So we have 2 equations and 2 unknowns (V_A, V_B).

(1) ⇒ $$\frac{V_A}{4} + \frac{-144}{4} + \frac{V_A}{10} + \frac{V_A}{80} - \frac{V_B}{80} = 0$$

$$\Rightarrow 20V_A - 144(20) + 8V_A + V_A - V_B = 0$$

$$\underline{29V_A - V_B = 2880}$$

4.9 :

Eqn ② becomes :

$$-\frac{V_A}{80} + \frac{V_B}{80} - 3 + \frac{V_B}{5} = 0$$

$$-V_A + V_B - 240 + 16\,V_B = 0$$

$$-V_A + 17\,V_B - 240$$

$$V_A = 17V_B - 240.$$

Substitute into ① :

$$29\,V_A - V_B = 2880$$

$$29\,(17\,V_B - 240) - V_B = 2880$$

$$493\,V_B - 6960 - V_B = 2880$$

$$492\,V_B = 6960 + 2880$$

$$\boxed{V_B = 20 \text{ V}}$$

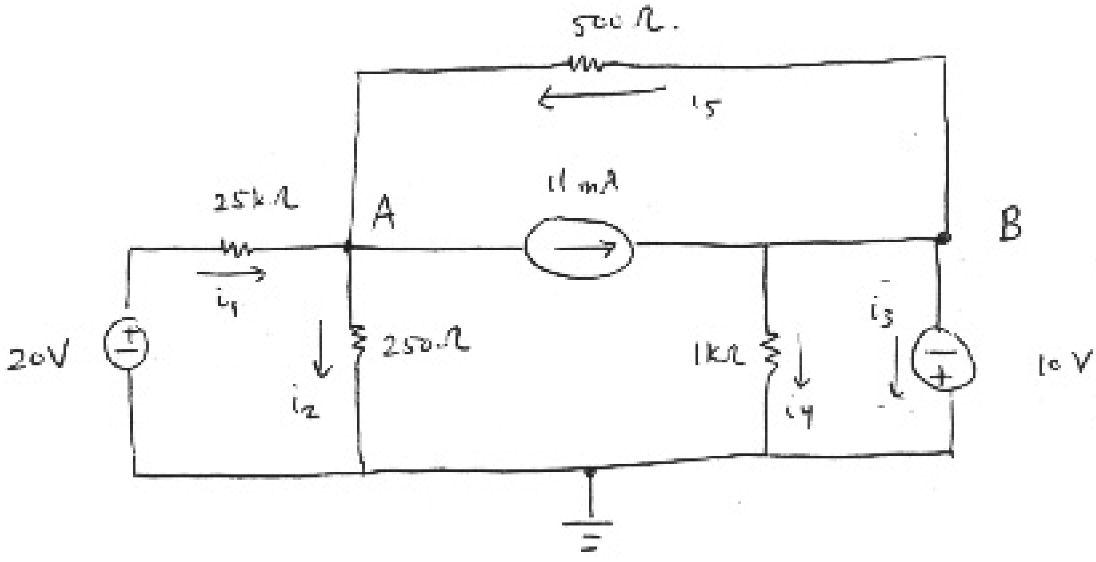
$$V_A = 17\,(20) - 240$$

$$\boxed{V_A = 100 \text{ V}}$$

Note,

$$\boxed{\begin{aligned} V_1 &= V_A = 20\text{ V}. \\ V_2 &= V_B = 100 \text{ V} \end{aligned}}$$

4.16 ⓐ Use node-voltage method to find i_1, i_2, i_3



Step 1: Sum the currents going away from node A.

(1) $$-\frac{(20 - V_A)}{25\,k\Omega} + \frac{V_A}{250} + 0.011 - \frac{(V_B - V_A)}{500} = 0$$

$-i_1$ $+i_2$ current source   current entering node A across 500 Ω.

Note: $0 - V_B = 10\text{ V}$

$$\boxed{V_B = -10\text{ V}}$$

We can now solve for V_A in (1).

(1) ⇒ $$\frac{-20}{25{,}000} + \frac{V_A}{25{,}000} + \frac{V_A}{250} + 0.011 - \frac{V_B}{500} + \frac{V_A}{500} = 0$$

$$V_A\left[\frac{1}{25{,}000} + \frac{1}{250} + \frac{1}{500}\right] = -0.011 + \frac{20}{25{,}000} + \frac{(-10)}{500}$$

$$V_A\left[1 + 100 + 50\right] = -275 + 20 - 500$$

$$\boxed{V_A = \left(\frac{1}{151}\right)(-755) = -5\text{ V}}$$

4.16

$$i_1 = \frac{20 - V_A}{25\,k\Omega}$$

$$= \frac{20 - (-5)}{25\,k\Omega}$$

$$\boxed{i_1 = \frac{25}{25\,k\Omega} = \underline{0.001\ A}}$$

$$\boxed{i_2 = \frac{V_A}{250} = \frac{-5}{250} = -0.02\ A}$$

$i_3 = ?$

By KCL at node B:

$$-i_3 + 0.011 - i_4 - i_5 = 0.$$

$$i_3 = 0.011 - i_4 - i_5$$

$$= 0.011 - \frac{V_B}{1000} - \frac{(V_B - V_A)}{500}$$

$$= 0.011 - \frac{(-10)}{1000} - \frac{(-10 - (-5))}{500}$$

$$\boxed{i_3 = 0.031\ A}$$

(b). Check that power dissipated (absorbed) equals power developed (delivered).

$$P_{20V} = -(20V)(i_1)$$

$$= -(20V)(.001A)$$

$$P_{20V} = \underline{-0.02\ W;\ \text{0.02 W delivered}}$$

4.16

(b)

$$P_{11mA} = -VI$$
$$= -(V_B - V_A)\cdot 0.011\,A$$
$$= -(-10-(-5))\,0.011$$
$$= -(-5)\,0.011$$
$$P_{11mA} = 0.055\ W \quad \left(\begin{matrix}.055\,W \\ \text{absorbed}\end{matrix}\right)$$

$$P_{10V} = -VI$$
$$= -(V_S)(i_3)$$
$$= -(+10)(0.031\,A)$$
$$P_{10V} = -0.31\ W \quad \left(\begin{matrix}0.31\,W \\ \text{delivered}\end{matrix}\right)$$

$$P_{25k\Omega} = i_1^2 R$$
$$= (0.001)^2(25{,}000)$$
$$= .025\ W \quad \left(\begin{matrix}0.25\,W \\ \text{absorbed}\end{matrix}\right)$$

$$P_{250\Omega} = i_2^2(250)$$
$$= (-.02)^2(250) = 0.1\ W \quad \left(\begin{matrix}0.1\ W \\ \text{absorbed}\end{matrix}\right)$$

$$P_{500\Omega} = \frac{(V_B - V_A)^2}{500} = \frac{25}{500} = 0.05\ W \quad \left(\begin{matrix}0.05\,W \\ \text{absorbed}\end{matrix}\right)$$

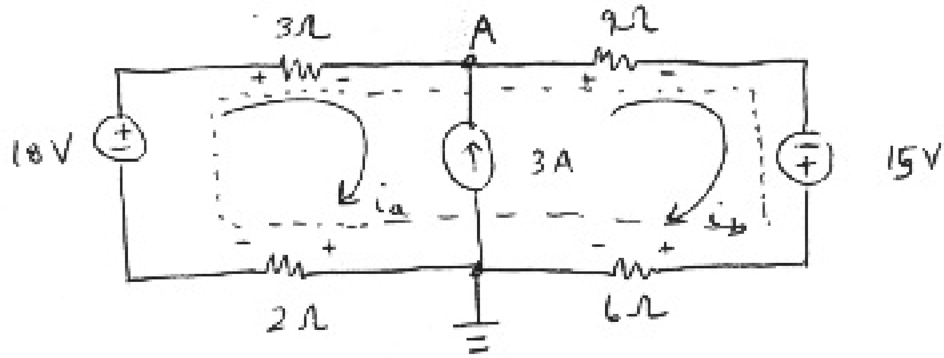
$$P_{1k\Omega} = \frac{V_B^{\,2}}{1000} = \frac{(100)}{1000} = 0.1\ W \quad \left(\begin{matrix}0.1\,W \\ \text{absorbed}\end{matrix}\right)$$

$$P_{\text{Total absorbed}} = 0.025\,W + 0.1\,W + 0.05\,W + 0.1\,W + 0.055\,W$$
$$= 0.33\ W$$

$$P_{\text{Total Delivered}} = -0.31 + -0.02 = -0.33\,W$$

$$P_{\text{Total absorbed}} + P_{\text{Total delivered}} = 0 \ \checkmark$$

4.27 : Use mesh-current method to find total power dissipated.



- We can use super-mesh concept to simplify the analysis (refer to p. 130 in text).

Step 1 : Express voltages across resistors in terms of mesh currents and sum voltages around perimeter of circuit.

① $-18 + i_a 3) + 9 i_b - 15 + 6 i_b + 2 i_a = 0$

$\Rightarrow \quad 5 i_a + 15 i_b = 33$

Step 2 : The relationship between the mesh currents is :

$i_b - i_a = 3\text{ A}$

② $\Rightarrow \quad i_b = i_a + 3$

$\Rightarrow$ Substitute ② into ①.

$\Rightarrow \quad 5 i_a + 15(i_a + 3) = 33$

$5 i_a + 15 i_a + 45 = 33$

$20 i_a = -12$

$\boxed{i_a = -\frac{3}{5}\text{ A}}$

4.27

So,

$$i_b = i_a + 3$$

$$i_b = -\frac{3}{5} + 3$$

$$i_b = 2\,{}^{2}/_{5}\ A$$

Now calculate power absorbed and delivered.

$$P_{18V} = -IV$$
$$= -i_a(18V) = -(-\tfrac{3}{5})(18) = +10.8\ W \quad \left(\begin{array}{c}10.8\ W\\ \text{absorbed}\end{array}\right).$$

$$P_{15V} = -IV$$
$$= -i_b(15V) = -(\tfrac{12}{5})(15) = -36\ W \quad \left(\begin{array}{c}36\ W\\ \text{delivered}\end{array}\right).$$

$$P_{3A} = -IV$$
$$= -(3A)\cdot V_A \ ;$$ where V_A is the node voltage at A

Note from circuit,

$$2i_a - 18 + 3i_a + V_A = 0$$

$$V_A = 18 - 2i_a - 3i_a$$

$$V_A = 18 - 5i_a = 18 - 5(-3/5) = 21V$$

$$\Rightarrow \quad P_{3A} = -3(21) = -63\ W \quad \left(\begin{array}{c}63\ W\\ \text{delivered}\end{array}\right).$$

$$\therefore \quad P_{\text{Total delivered}} = -36W - 63W = -99\ W \quad \left(\begin{array}{c}99\ W\\ \text{delivered}\end{array}\right)$$

$$P_{3\Omega} = i_a^2\,3 = (-\tfrac{3}{5})^2\,3 = \tfrac{9}{25}\cdot 3 = \tfrac{27}{25} = 1.08\ W \quad \left(\begin{array}{c}1.08\ W\\ \text{absorbed}\end{array}\right)$$

$$P_{2\Omega} = i_a^2\,2 = (-\tfrac{3}{5})^2\,2 = \tfrac{9}{25}\cdot 2 = \tfrac{18}{25} = 0.72\ W \quad \left(\begin{array}{c}0.72\ W\\ \text{absorbed}\end{array}\right).$$

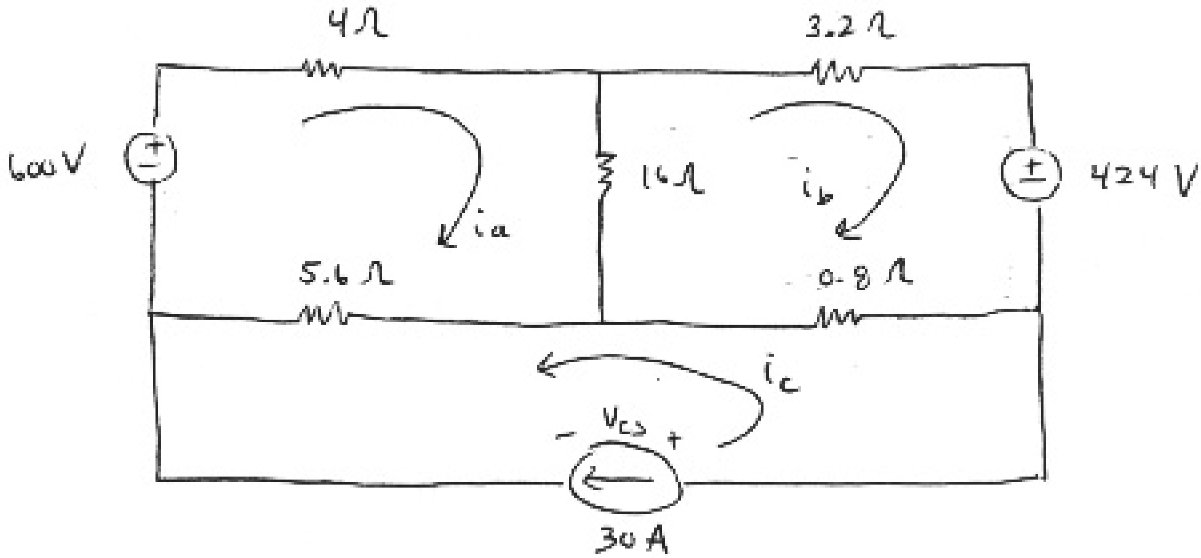
$$P_{9\Omega} = i_b^2(9) = (\tfrac{12}{5})^2\,9 = \tfrac{144}{25}\cdot 9 = 51.84\ W \quad \left(\begin{array}{c}51.84\ W\\ \text{absorbed}\end{array}\right)$$

$$P_{6\Omega} = i_b^2(6) = \tfrac{144}{25}\cdot 6 = 34.56\ W \quad \left(\begin{array}{c}34.56\ W\\ \text{absorbed}\end{array}\right)$$

$$P_{\text{Total Absorbed}} = 99\ W \ \checkmark$$

4.31:

(a) Use mesh-current to find how much power 30 A sourse delivers.



Step 1: Obtain mesh current equations from circuit.

- From top-left loop,

① $$-600 + i_a 4 + 16(i_a - i_b) + 5.6(i_a + i_c) = 0$$

$$\Rightarrow \boxed{-600 + 25.6\, i_a - 16\, i_b + 5.6\, i_c = 0}$$

- From top-right loop,

② $$3.2\, i_b + 424 + 0.8(i_b + i_c) + 16(i_b - i_a) = 0$$

$$\Rightarrow \boxed{424 - 16(i_a) + 20\, i_b + 0.8\, i_c = 0}$$

- From bottom loop,

③ $$\boxed{i_c = -30\text{ A}}$$

4.31 (a)

Substituting (3) into (1) and (2).

(1) $\Rightarrow$ $-600 + 25.6\,i_a - 16\,i_b + 5.6(-30) = 0$

$i_a = 0.625\,i_b + 30$

(2) $\Rightarrow$ $424 - 16\,i_a + 20\,i_b + 0.8(-30) = 0$

$20\,i_b = -400 + 16\,i_a$

$i_b = \frac{4}{5}\,i_a - 20$

$\Rightarrow$ So,

$i_a = 0.625\left(\frac{4}{5}\,i_a - 20\right) + 30$

$\boxed{i_a = 35\text{ A}}$

$i_b = \frac{4}{5}(35) - 20$

$\boxed{i_b = 8\text{ A}}$

Step 2: Find V_{cs}.

$V_{cs} = 0.8(i_c + i_b) + 5.6(i_c + i_a)$

$V_{cs} = 0.8(-30 + 8) + 5.6(-30 + 35)$

$= 0.8(-22) + 5.6(5)$

$\boxed{V_{cs} = 10.4\text{ V}}$

(cs: current source.)

$P_{cs} = -I \cdot V_{cs}.$

$= -(-30\text{A})(10.4)$

$\boxed{P_{cs} = +312\text{ W}\ \left(\overset{312\text{ W}}{\text{absorbed}}\right)}$

4.31

(b) Find power delivered.

$$P_{600V} = -IV$$
$$= -i_a(600\text{ V})$$
$$= -35A(600\text{ V})$$
$$= -21\text{ kW} \quad \left(\begin{array}{c}21\text{ kW}\\ \text{delivered.}\end{array}\right)$$

$$P_{424V} = -IV$$
$$= -(-i_b)(424\text{ V})$$
$$= (8\text{ A})(424\text{ V})$$
$$= 3.392\text{ kW} \quad \left(\begin{array}{c}3.392\text{ kW}\\ \text{absorbed.}\end{array}\right)$$

So, total power delivered is 21 kW.

(c). $P_{4\Omega} = (i_a^2)4 = 35^2 4 = 4900\text{ W}.$

$P_{5.6\Omega} = (i_a + i_c)^2 5.6 = 5^2(5.6) = 140\text{ W}$

$P_{3.2\Omega} = i_b^2(3.2) = 204.8\text{ W}$

$P_{0.8\Omega} = (i_b + i_c)^2(0.8) = 387.2\text{ W}$

$P_{16\Omega} = (i_b - i_a)^2(16) = 11.664\text{ kW}.$

Sum of power absorbed in all resistors = 17.296 kW.

Total power absorbed = 17.296 kW + 3.392 kW
= 21 kW.