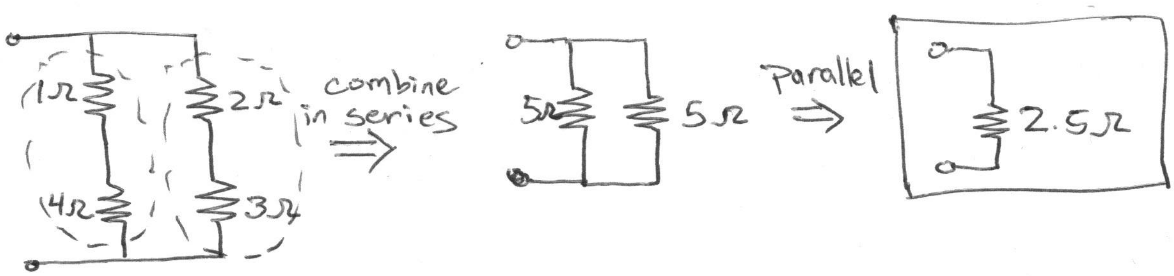
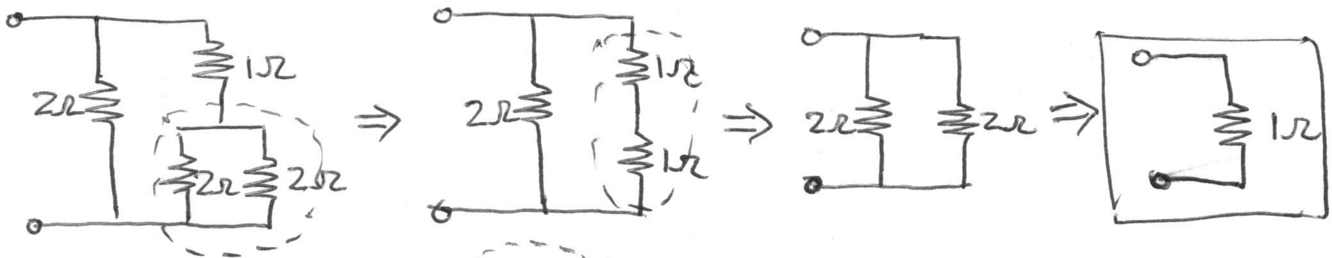
Ex 2.1

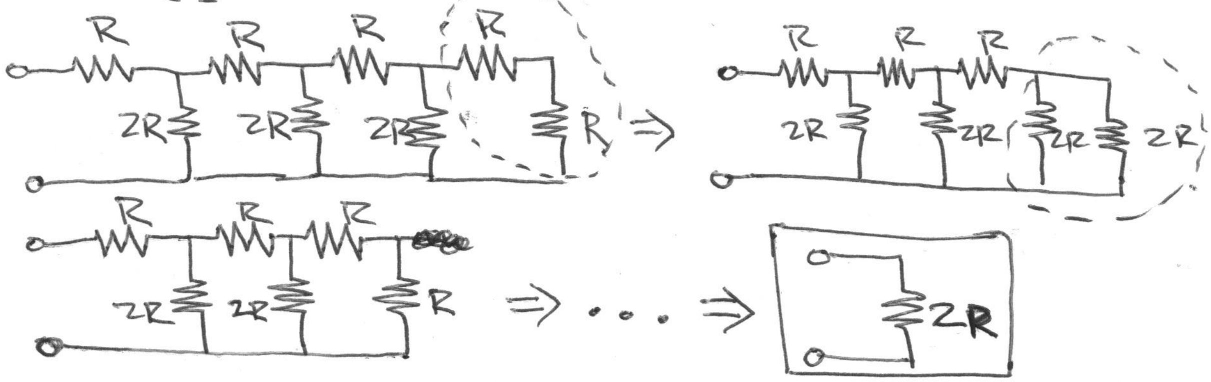
a)



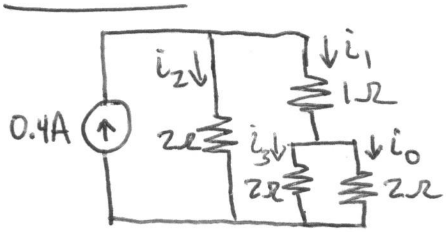
b)



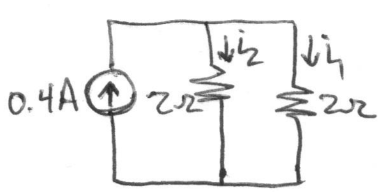
c)



Prob 2.2



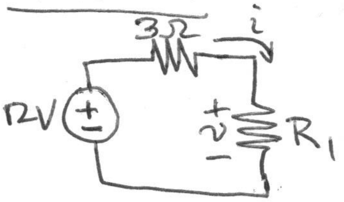
Since the two parallel resistors have the same value, and have the same voltage across them, the have the same current, so $i_o = i_3$.
By KCL $i_1 = i_o + i_3 = 2i_o$.



Redrawing the circuit, we see $i_1 = i_2$, so $i_1 = \frac{1}{2}(0.4A)$
$= 0.2A$,
$\Rightarrow i_o = \frac{1}{2} i_1 = 0.1A$

$\boxed{i_o = 0.1A}$

Prob 2.4



Find the value of R_1 which satisfies each condition.

a) $v = 3V$

Using the voltage divider formula,

$$v = 12V\left(\frac{R_1}{R_1 + 3\Omega}\right)$$

$$3V = \frac{12V R_1}{R_1 + 3\Omega}, \quad 9 + 3R_1 = 12R_1 \quad \boxed{R_1 = 1\Omega}$$

b) $v = 0V$

$$0 = \frac{12R_1}{R_1 + 3\Omega}, \quad 0(R_1 + 3\Omega) = 12R_1, \quad 12R_1 = 0, \quad \boxed{R_1 = 0\Omega}$$

c) $i = 3A$

Adding the resistances in series and the applying Ohm's law we get:

$$i = \frac{12}{3 + R_1}, \quad 3 = \frac{12}{3 + R_1}, \quad 9 + 3R_1 = 12 \quad \boxed{R_1 = 1\Omega}$$

d) $P_{R_1} = 12W$

$$P_{R_1} = iv \qquad i = \frac{12}{3 + R_1} \quad v = 12\frac{R_1}{R_1 + 3}, \quad iv = 144\frac{R_1}{R_1^2 + 6R_1 + 9}$$

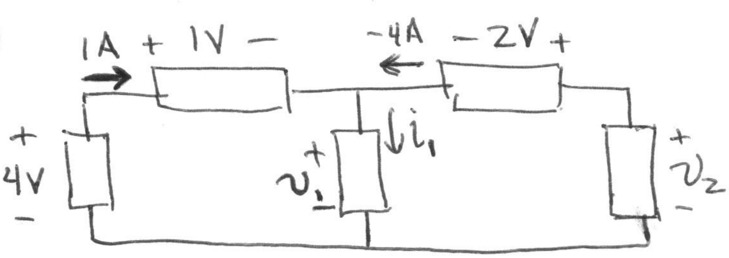
$$12 = 144\frac{R_1}{R_1^2 + 6R_1 + 9}, \quad R_1^2 + 6R_1 + 9 = 12R_1, \quad R_1^2 - 6R_1 + 9 = 0$$

$$(R_1 - 3)^2 = 0 \Rightarrow \boxed{R_1 = 3\Omega}$$

Note: This is the maximum power that can be delivered to R_1. This fact will be explored at some point this semester.

Prob 2.6

a)



By KVL

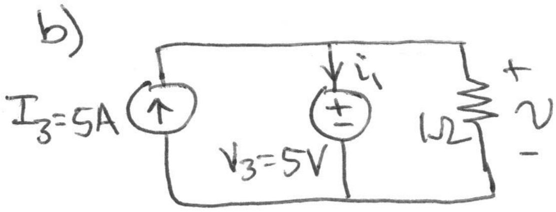
$$4V - 1V - v_1 = 0V \Rightarrow \boxed{v_1 = 3V}$$

$$v_1 + (-2V) - v_2 = 0V \Rightarrow \boxed{v_2 = 1V}$$

By KCL

$$1A + (-4A) = i_1 \Rightarrow \boxed{i_1 = -3A}$$

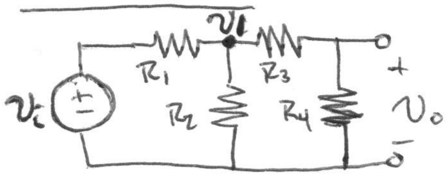
b)



By KVL $\boxed{v=5V}$ (the voltage source is in parallel with the resistor, and elements in parallel have the same voltage across their terminals)

Applying Ohm's law to the resistor, $i_R = \frac{5V}{1\Omega} = 5A$, and by KCL, $i_1 + i_R = I_3$, $i_1 = 5A - 5A = \boxed{0A = i_1}$

Prob 2.10



$$v_o = v_1\left(\frac{R_4}{R_3+R_4}\right) \quad v_1 = v_i\left(\frac{R_2}{R_1+R_2}\right)$$

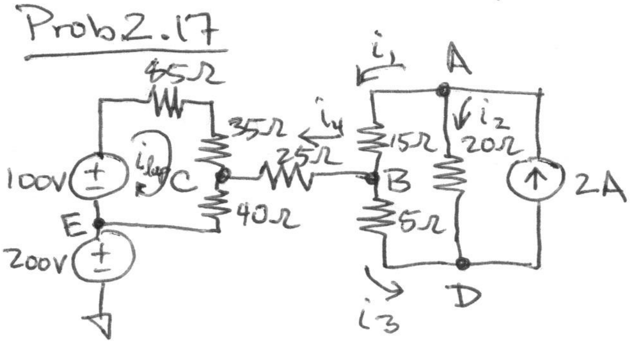
$$v_o = v_i\left(\frac{R_4}{R_3+R_4}\right)\left(\frac{R_2}{R_1+R_2}\right), \quad v_o = \frac{v_i}{1000}$$

$$1000 R_2R_4 = R_1R_3 + R_2R_3 + R_2R_4 + R_1R_4$$

$$999 R_2R_4 = R_1R_3 + R_2R_3 + R_1R_4, \text{ let } R_2=R_3=R_4=1\Omega.$$

Then $999 = R_1 + 1 + R_1$, $2R_1 = 998$, $\boxed{R_1 = 499\Omega}$. This problem is very unconstrained. There are a very large number of solutions and ways of going about this problem.

Prob 2.17



By KCL at node A $i_1 + i_2 = 2A$.

Also, by KCL (at node D)

$2A = i_2 + i_3 \Rightarrow i_1 = i_3$.

Then applying KCL at node B

$i_4 + i_3 = i_1 \Rightarrow i_4 = 0A$.

~~Using node voltage~~ Since no current is injected from i_4, the currents in all branches of the loop on the left are equal. By KVL,

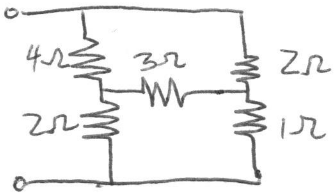
$100V = i_{loop}(85 + 35 + 40) \Rightarrow i_{loop} = \frac{1}{1.6}A$.

$V_{Cgnd} = V_{Egnd} + V_{CE}$, $V_{Egnd} = 200V$ (just a voltage source)

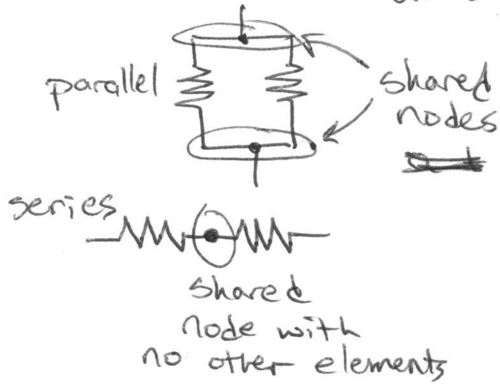
$V_{CE} = i_{loop}(40\Omega) = 25V$

so, $V_{Cgnd} = 200 + 25 = \boxed{225V}$

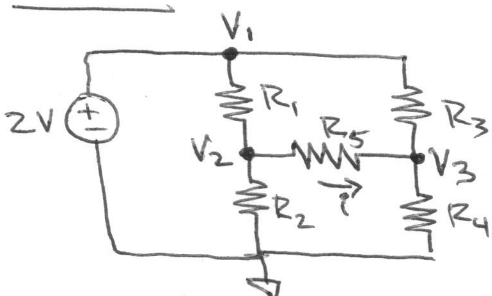
Ex 2.3d



Series and parallel combinations cannot be used to solve this problem because none of the elements are in series/parallel. For two elements to be in parallel, both terminals of both devices must meet at a node (one node per pair of terminals), which does not apply for any of the elements. To be in series, two elements must meet at a node, and no other elements have a terminal at the shared node. Since no element in this network meets either definition, series and parallel combination techniques cannot be used to simplify this circuit.



Ex 3.1



(gnd is arbitrarily chosen)

Node voltage eqns

$V_1 = V$

① $\dfrac{V_1 - V_2}{R_1} = \dfrac{V_2 - V_3}{R_5} + \dfrac{V_2}{R_2}$

② $\dfrac{V_1 - V_3}{R_3} + \dfrac{V_2 - V_3}{R_5} = \dfrac{V_3}{R_4}$

$$\frac{V_1 - V_2}{R_1} = \frac{V_2}{R_2} + \frac{V_3}{R_4} + \frac{V_3 - V_1}{R_3} \Rightarrow V_1\left(\frac{1}{R_1} + \frac{1}{R_3}\right) = V_2\left(\frac{1}{R_1} + \frac{1}{R_2}\right) + V_3\left(\frac{1}{R_4} + \frac{1}{R_3}\right)$$

$$2 \cdot \frac{5}{6} = \frac{3}{4} V_2 + \frac{5}{6} V_3 \Rightarrow V_2 = \frac{4 \cdot 5}{3 \cdot 6}(2 - V_3)$$

$$= \frac{40}{18} - \frac{20}{18} V_3$$

substituting into ② we have

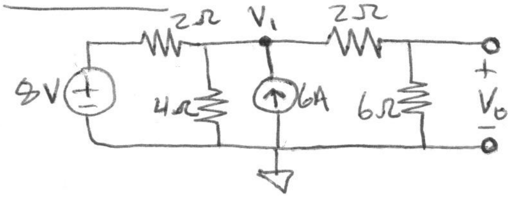
$$\frac{V_1}{R_3} + \frac{40}{18} - \frac{20}{18} V_3 = V_3\left(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}\right)$$

$$\frac{52}{18} = V_3\left(\frac{33+20}{18}\right) \Rightarrow \boxed{V_3 = \frac{52}{53} V} \text{ and } V_2 = \frac{10}{9}\left(2 - \frac{52}{53}\right)$$

$$\boxed{V_2 = \frac{60}{53} V}$$

$$i = \frac{V_2 - V_3}{R_5} = \frac{60 - 52}{53} = \boxed{\frac{8}{53} A}$$

Prob 3.3



Node voltage eqns

① $\dfrac{V_0}{6} = \dfrac{V_1 - V_0}{2} \Rightarrow \dfrac{2}{3}V_0 = \dfrac{V_1}{2} \Rightarrow V_0 = \dfrac{3V_1}{4}$

② $\dfrac{V_1 - V_0}{2} = 6 + \dfrac{8 - V_1}{2} - \dfrac{V_1}{4}$

substituting ① into ②

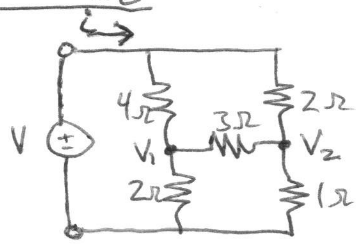
$$\frac{V_1}{2} - \frac{3}{8}V_1 = 6 + 4 - \frac{V_1}{2} - \frac{V_1}{4}$$

$$\frac{1}{8}V_1 + \frac{3}{4}V_1 = 10$$

$$\frac{7}{8}V_1 = 10 \Rightarrow V_1 = \frac{80}{7}V \Rightarrow \boxed{V_0 = \frac{60}{7}V \approx 8.57V}$$

Extra Problems

Ex2.3d



Using the hint given and applying a test voltage V across the terminals

$$i = \frac{V - V_1}{4\Omega} + \frac{V - V_2}{2\Omega} = \frac{V_1}{2\Omega} + \frac{V_2}{1\Omega}$$

$$3V = 3V_1 + 6V_2, \quad V = V_1 + 2V_2$$

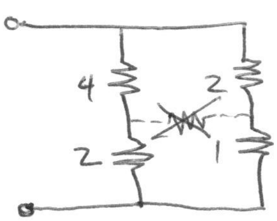
then applying node voltage at V_2,

$$\frac{V - V_2}{2\Omega} + \frac{V_1 - V_2}{3\Omega} = \frac{V_2}{1\Omega}$$

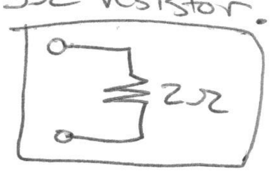
$$3V + 2V_1 = 11V_2$$

$$5V = 15V_2 \Rightarrow \boxed{V_2 = \frac{V}{3}}$$ substituting back

$$= \boxed{V_1 = V - \frac{2V}{3} = \frac{V}{3}}$$

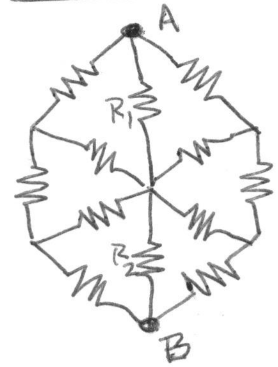


$\Rightarrow$



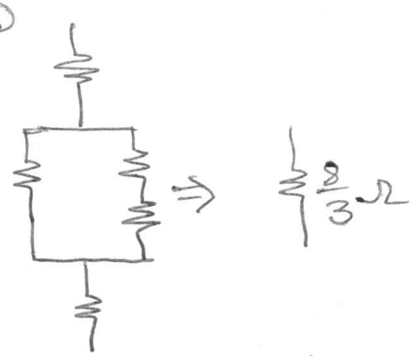
This means no current flows through the 3Ω resistor.

Prob 2.3



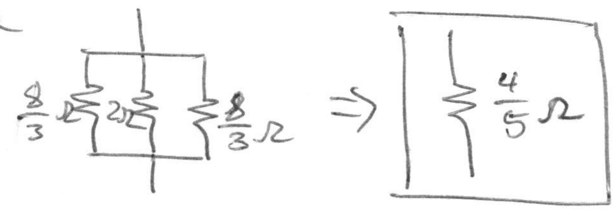
By symmetry and KCL, if a voltage is applied from A to B or B to A, current flow should be the same up to sign. This means the same current will flow in R_1 and R_2. Also, the two side branches are symmetric so no current flows between them. Hence the problem can be solved as three parallel branches.

① & ③



②

combining we have



Prob 2.10

I believe the solution given earlier is the simplest

Prob 3.1

Start with

$$R = 1 + aT$$
$$T = \beta P$$
$$P = I_0^2 R$$

So, $T = \beta I_0^2 R = \beta I_0^2 (1 + aT)$

$$T(1 - a\beta I_0^2) = \beta I_0^2$$

$$T = \frac{\beta I_0^2}{1 - a\beta I_0^2}$$

solving for when $1 - a\beta I_0^2 = 0$

$$I_0 = \sqrt{\frac{1}{a\beta}} = \sqrt{225} = \boxed{15\text{ A}}$$