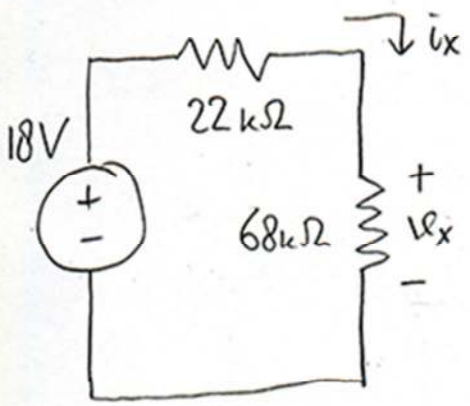
MAE 140 Fall 2015 — Hw 2 Solution

2.26 Find v_x and i_x!



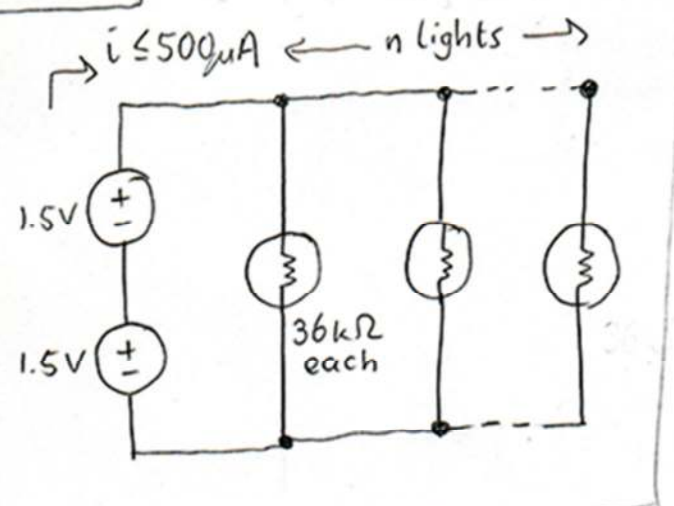
Use voltage divider to find v_x

$$\hookrightarrow v_x = \left(\frac{68k\Omega}{22k\Omega + 68k\Omega}\right) \cdot 18V = \underline{\underline{13.6V}}$$

Use Ohm's Law on 68kΩ resistor to find i_x

$$i_x = \frac{v_x}{68k\Omega} = \frac{13.6V}{68k\Omega} = \underline{\underline{20\ mA}}$$

2.28 Find how many lights to keep $i \leq 500\mu A$.



We have 2 1.5V batteries in series

$$\hookrightarrow v_s = 1.5V + 1.5V = 3V$$

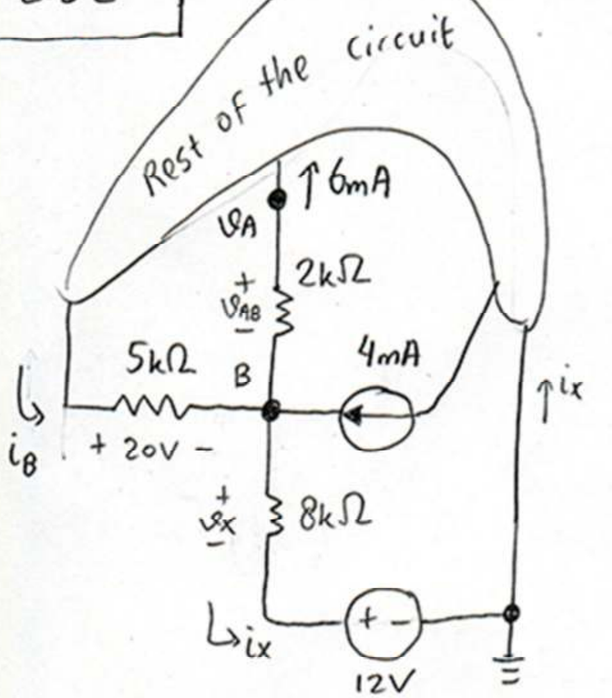
To get $i = 500\mu A$, we want a total resistance of

$$\hookrightarrow R_t = \frac{v_s}{i} = \frac{3V}{500\mu A} = \underline{\underline{6\ k\Omega}}$$

Parallel equivalent $\rightarrow$ $R_t = \Big(\underbrace{\frac{1}{36k\Omega} + \frac{1}{36k\Omega} + \cdots + \frac{1}{36k\Omega}}_{\text{Summed } n \text{ times}}\Big)^{-1}$

$$R_t = \left(\frac{n}{36k\Omega}\right)^{-1} = \frac{36k\Omega}{n} = 6k\Omega \longrightarrow n = \frac{36k\Omega}{6k\Omega} = \underline{\underline{6}}$$

2.32



a) Find v_x, i_x !

b) Show that the sum of current going into the circuit is zero !

c) Find v_A with respect to the ground ⏚ !

a) Use KCL at node B.

↳ $-4mA + 6mA - i_B + i_x = 0$

$i_B = \frac{20V}{5k\Omega} = 4mA$

↳ $i_x = 4mA + 4mA - 6mA = \underline{\underline{2mA}}$

↳ $v_x = i_x \cdot 8k\Omega = 2mA \cdot 8k\Omega = \underline{\underline{16V}}$

b) Current going into the circuit :

↳ $6mA + i_x - i_B - 4mA = 6mA + 2mA - 4mA - 4mA = \underline{\underline{0}}$

c) Find v_B then use it to find v_A.

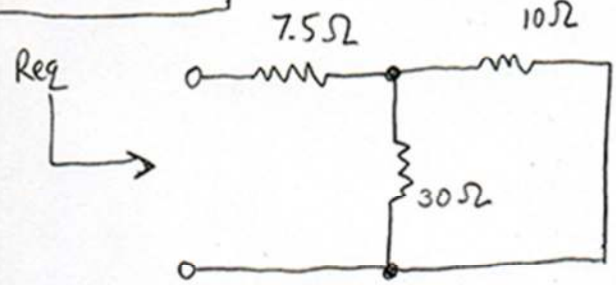
Voltage at B → $v_B = 12V + v_x = 12V + 16V = \underline{\underline{28V}}$

Find v_A → $v_A = v_B + v_{AB} = 28V + (-6mA) \cdot 2k\Omega$

$v_A = 28V - 12V = \underline{\underline{14V}}$

2-35

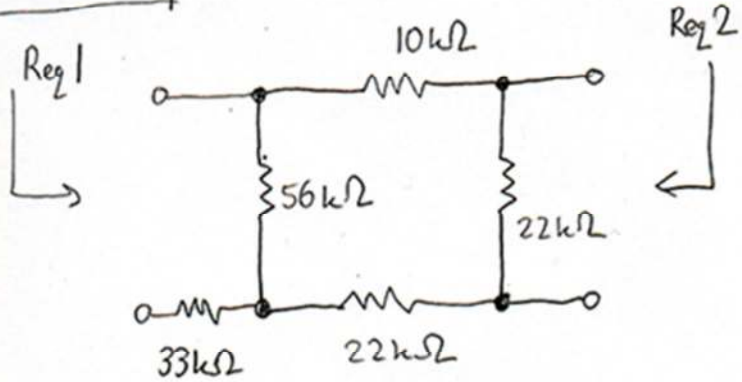
Find R_{eq}!

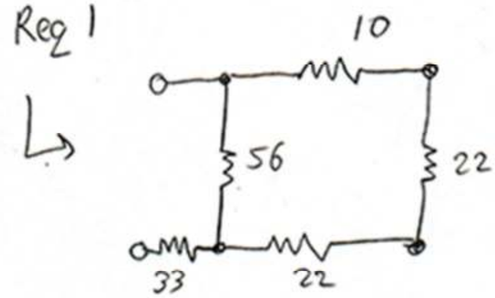


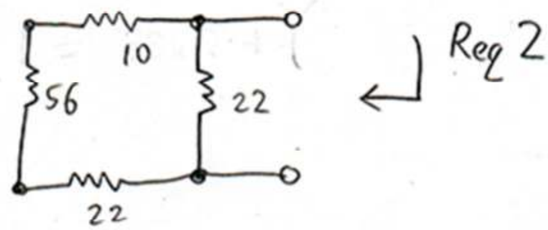
$$R_{eq} = 7.5\Omega + (30\Omega \parallel 10\Omega)$$
$$= 7.5\Omega + \left(\frac{1}{30\Omega} + \frac{1}{10\Omega}\right)^{-1}$$
$$= 7.5\Omega + \frac{30\Omega}{4} = \underline{\underline{15\Omega}}$$

2-38

Find $R_{eq}1$ and $R_{eq}2$!





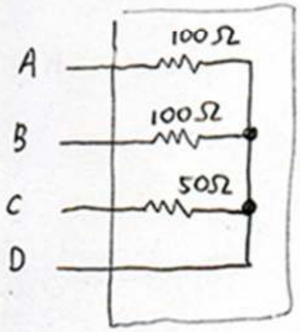


$$R_{eq}1 = \left((10k\Omega + 22k\Omega + 22k\Omega) \parallel 56k\Omega\right) + 33k\Omega$$
$$= (54k\Omega \parallel 56k\Omega) + 33k\Omega = \left(\frac{1}{54k\Omega} + \frac{1}{56k\Omega}\right)^{-1} + 33k\Omega$$
$$= 27.49\,k\Omega + 33\,k\Omega = \underline{\underline{60.49\,k\Omega}}$$

$$R_{eq}2 = \left(22k\Omega \parallel (10k\Omega + 56k\Omega + 22k\Omega)\right) = (22k\Omega \parallel 88k\Omega)$$
$$= \left(\frac{1}{22k\Omega} + \frac{1}{88k\Omega}\right)^{-1} = \underline{\underline{17.6\,k\Omega}}$$

2-41

Connect ABCD such that $R_{eq} = 100\Omega, 200\Omega, 150\Omega, 50\Omega, 25\Omega, 33.3\Omega, 133.3\Omega$



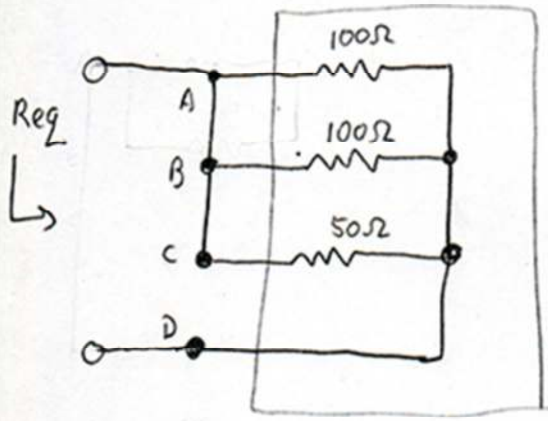
$100\Omega \rightarrow$ Connect AD

$200\Omega \rightarrow$ Connect AB

$150\Omega \rightarrow$ Connect AC

$50\Omega \rightarrow$ Connect CD

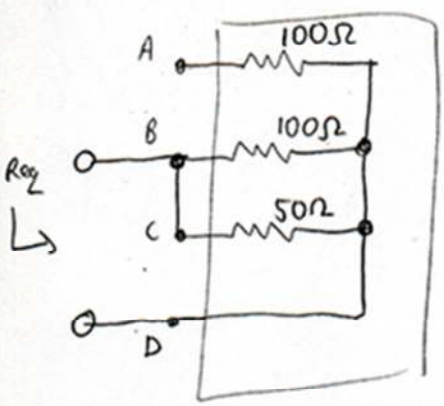
$25\Omega \rightarrow$ Connect AB, Connect BC, Connect DA



$$R_{eq} = \left(\frac{1}{100\Omega} + \frac{1}{100\Omega} + \frac{1}{50\Omega}\right)^{-1}$$

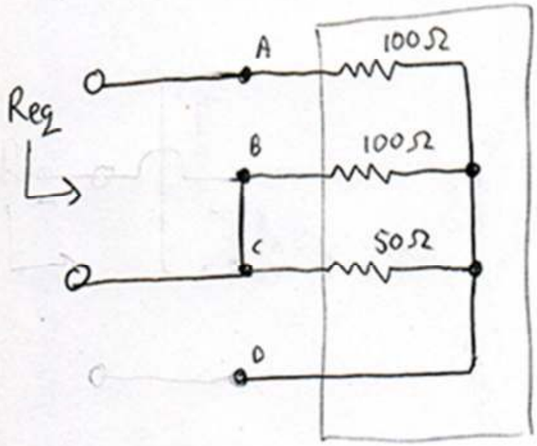
$$= \underline{\underline{25\Omega}}$$

$33.3\Omega \rightarrow$ Connect BC, Connect BD

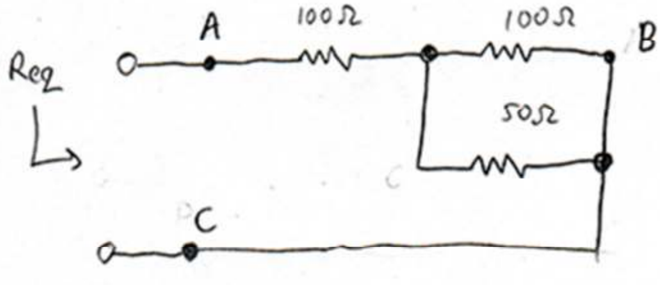


$$R_{eq} = \left(\frac{1}{100\Omega} + \frac{1}{50\Omega}\right)^{-1} = \underline{\underline{33.3\,\Omega}}$$

$133.3\,\Omega \rightarrow$ Connect BC, Connect AC or AB



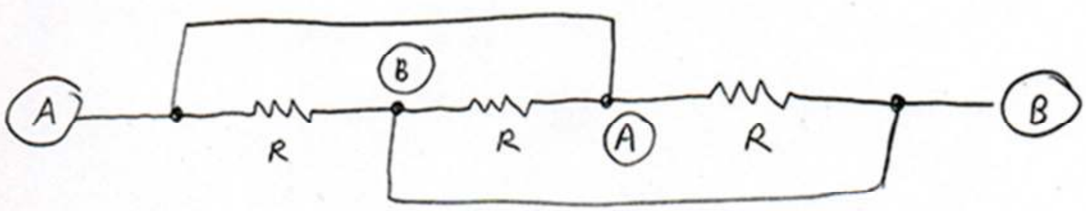
This circuit becomes



$$R_{eq} = 100\,\Omega + (100\,\Omega \parallel 50\,\Omega) = 100\,\Omega + \left(\frac{1}{100\,\Omega} + \frac{1}{50\,\Omega}\right)^{-1} = 100\,\Omega + 33.3\,\Omega$$

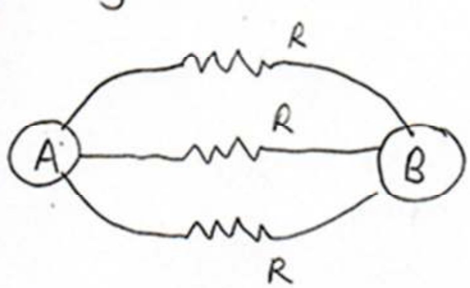
$$= \underline{133.3\,\Omega}$$

2-53 Find Resistance between terminals A and B!



Label the Shorted nodes.

Redrawing this, we have

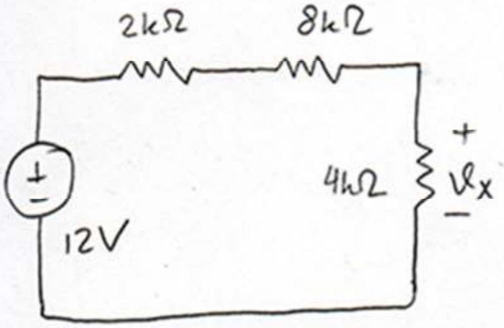


$$\rightarrow \quad R_{eq} = R \parallel R \parallel R = \left(\frac{1}{R} + \frac{1}{R} + \frac{1}{R}\right)^{-1}$$

$$R_{eq} = \frac{R}{3}$$

2-54

Use voltage division to find v_x !

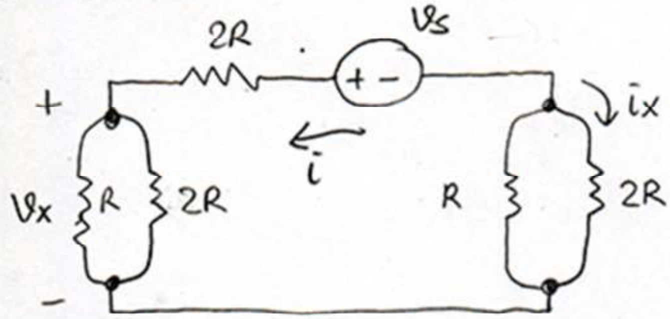


$$\hookrightarrow v_x = \left(\frac{4k\Omega}{2k\Omega + 8k\Omega + 4k\Omega}\right) \cdot 12V$$

$$= \left(\frac{4}{14}\right) 12V = \underline{\underline{3.43\ V}}$$

2-70

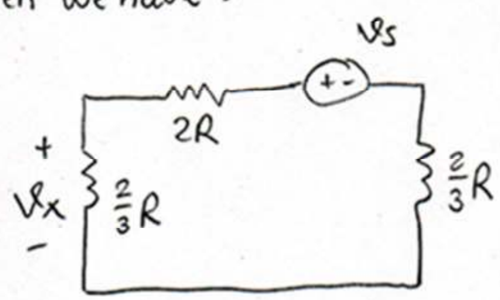
Use circuit reduction to find v_x, i_x !



Find the R_{eq} for $(R \parallel 2R)$

$$\hookrightarrow R_{eq} = \left(\frac{1}{R} + \frac{1}{2R}\right)^{-1} = \frac{2}{3}R$$

Then we have =



Use Voltage divider to find v_x

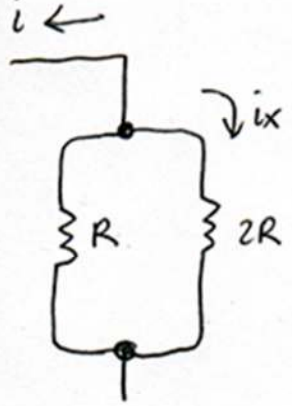
$$\hookrightarrow v_x = \left(\frac{2/3\,R}{2R + \frac{2}{3}R + \frac{2}{3}R}\right) v_s = \left(\frac{2}{10}\right) v_s$$

$$\underline{\underline{v_x = \frac{1}{5} v_s}}$$

Then solve for i

$$i = \frac{v_s}{2R + \frac{2}{3}R + \frac{2}{3}R} = \frac{3}{10}\,\frac{v_s}{R}$$

So, we have

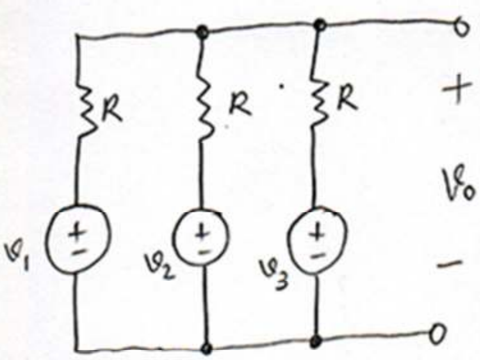


Use current divider to find i_x

$$i_x = \left(\frac{R}{R+2R}\right)(-i) = \frac{1}{3}\left(-\frac{3}{10}\frac{v_s}{R}\right)$$

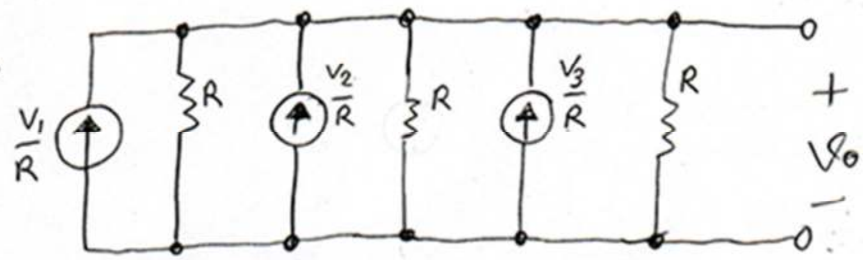
$$i_x = -\frac{1}{10}\frac{v_s}{R}$$

2.75 Use Source transformation to relate v_0 with v_1, v_2, v_3 !



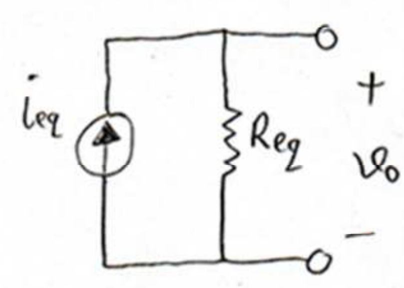
Transform the voltage sources into the current sources.

↳



Then we have 3 parallel current sources and 3 parallel resistances.

↳



$$i_{eq} = \frac{V_1}{R} + \frac{V_2}{R} + \frac{V_3}{R} = \frac{1}{R}\left(v_1 + v_2 + v_3\right)$$

$$R_{eq} = (R \parallel R \parallel R) = \frac{R}{3}$$

↳ $$v_0 = R_{eq} \cdot i_{eq} = \frac{1}{3}\left(V_1 + V_2 + V_3\right)$$