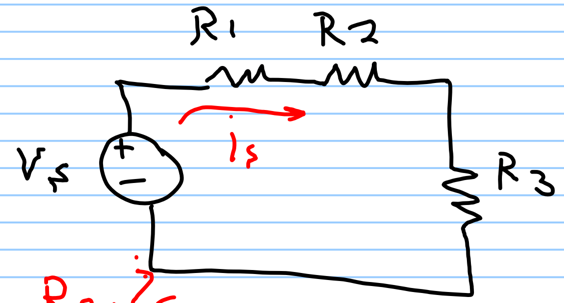
chapter 3 simple Resistive circuits

Resistors in series:-



KVL

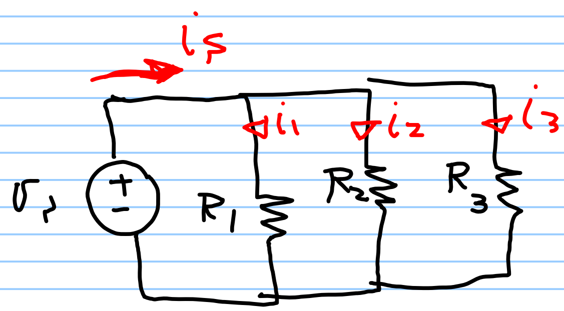
$-V_s + R_1 i_s + R_2 i_s + R_3 i_s = 0$

$V_s = (R_1 + R_2 + R_3)\, i_s$ } $V_s = R_{eq}\, i_s$

↳ $R_{eq} = R_1 + R_2 + R_3$

↳ series elements have the same current.

Resistors in Parallel:-



↳ parallel elements have the same voltage

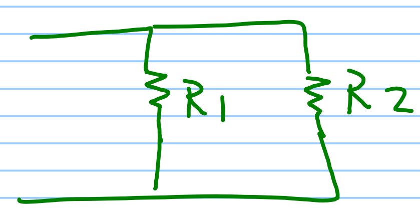
$i_1 = \frac{V_s}{R_1}, \quad i_2 = \frac{V_s}{R_2}, \quad i_3 = \frac{V_s}{R_3}$

$i_s = i_1 + i_2 + i_3$

$i_s = V_s\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$

$\therefore \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

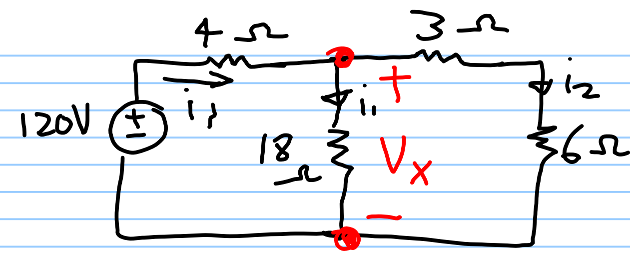
$\frac{1}{R_{eq}} = \sum_{i=1}^{N} \frac{1}{R_i}$



$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$

EX)

find i_s, i_1, i_2



$$R_{eq} = [[(3+6)] \parallel 18] + 4$$

$$= 10\ \Omega$$

$$\therefore i_s = \frac{V_s}{R_{eq}} = \frac{120}{10} = 12\ A \quad (1)$$

$$\left\{ i_1 = \frac{9}{9+18} * 12 \right.$$

$$\left. i_2 = \frac{18}{18+9} * 12 \right\}$$

CDR

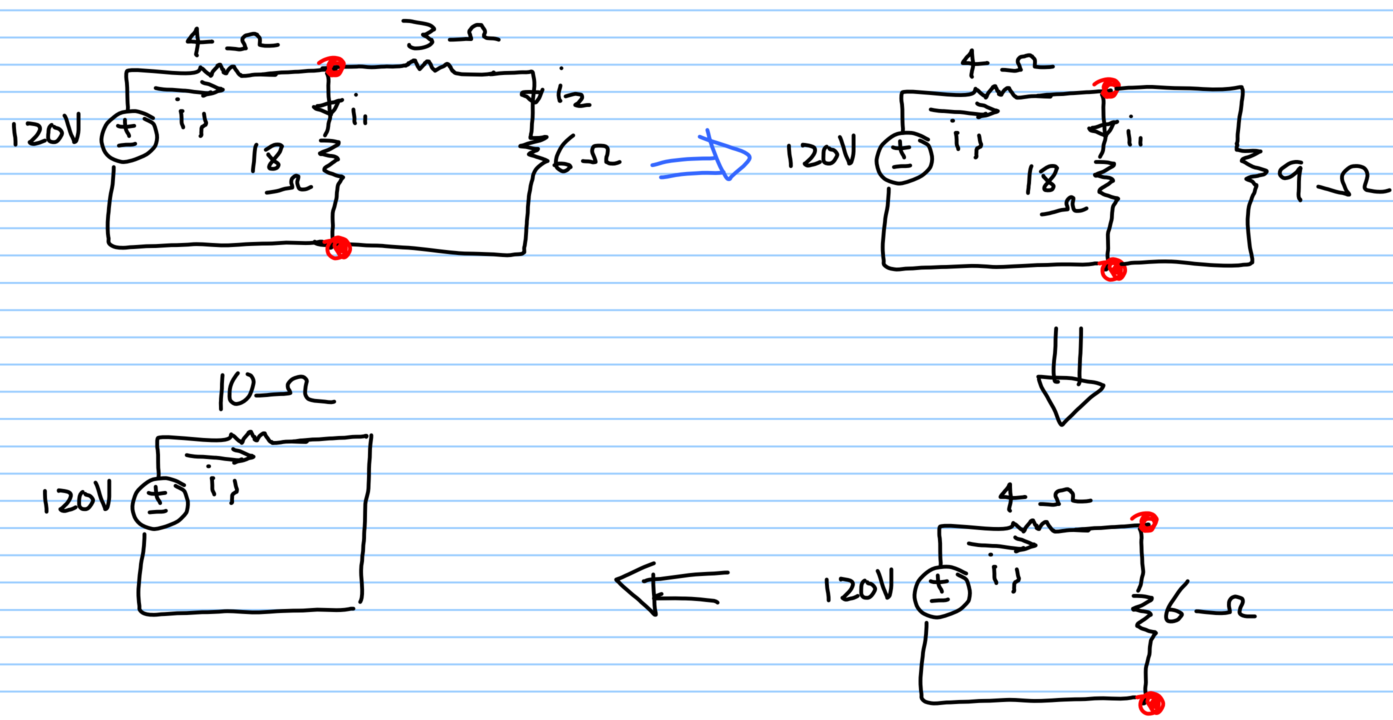
$$-120 + 4 \times 12 + V_x = 0 \quad \text{(KVL)}$$

$$V_x = 72V$$

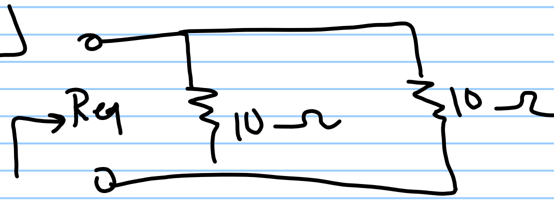
$$\therefore i_1 = \frac{V_x}{18} = \frac{72}{18} = 4A$$

$$\therefore i_2 = i_s - i_1 = 12 - 4 = 8A$$

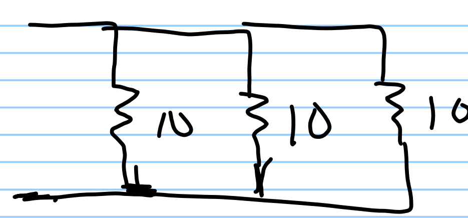
OR $$i_2 = \frac{V_x}{3+6} = \frac{72}{9} = 8A$$



EX



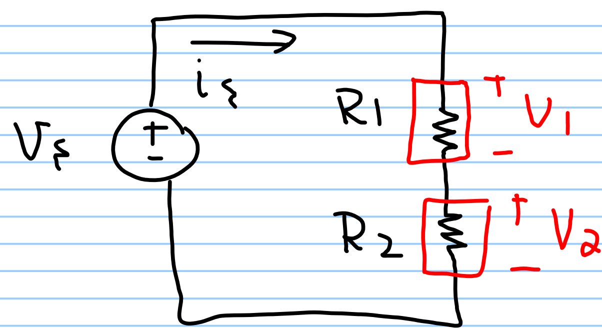
$$R_{eq} = \frac{10 \times 10}{10+10} = 5$$
$$= 10/2$$



$$R_{eq} = \frac{10}{3}$$

The Voltage Divider Rule VDR

- applied when the voltage is divided betwn series elements.



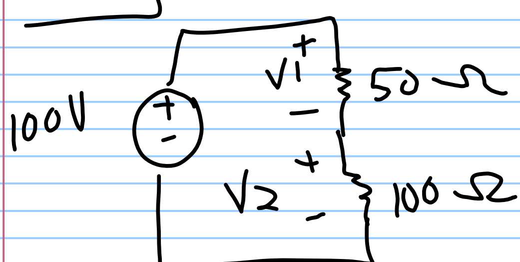
$$\rightarrow i_s = \frac{V_s}{R_1+R_2}$$

$$\therefore V_1 = i_s R_1 \qquad \therefore V_2 = i_s R_2$$

$$\boxed{V_1 = \frac{R_1}{R_1+R_2} V_s} \qquad \boxed{V_2 = \frac{R_2}{R_2+R_1} V_s}$$

$$V_1 = \frac{R_1}{R_{eq}} V_s \qquad V_2 = \frac{R_2}{R_{eq}} V_s$$

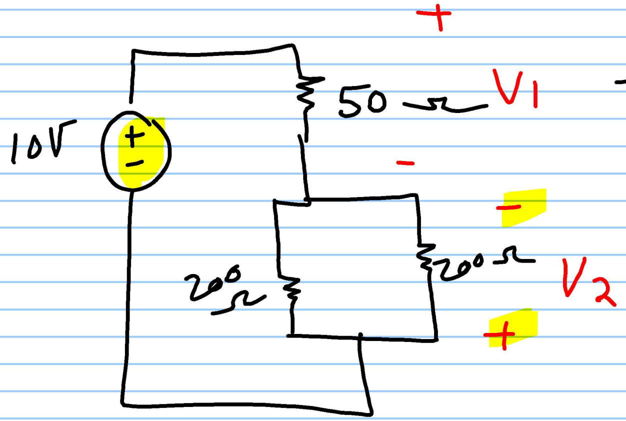
EX



$$V_1 = \frac{50}{50+100} * 100 = 33.33\,V$$

$$V_2 = \frac{100}{100+50} * 100 = 66.66\,V = 2 \times V_1$$

EX1

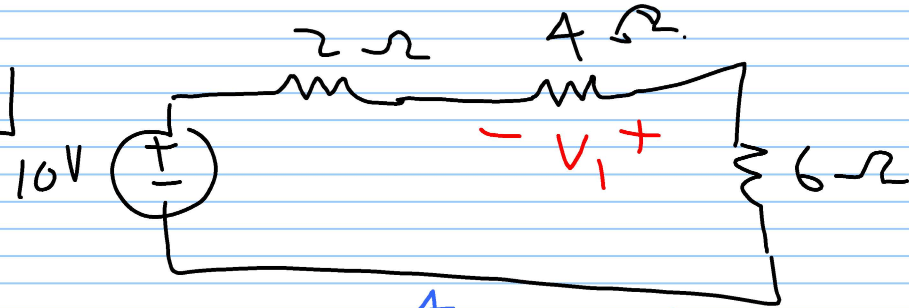


find v_1

$$V_1 = \frac{50}{50 + \frac{200}{2}} * 10$$

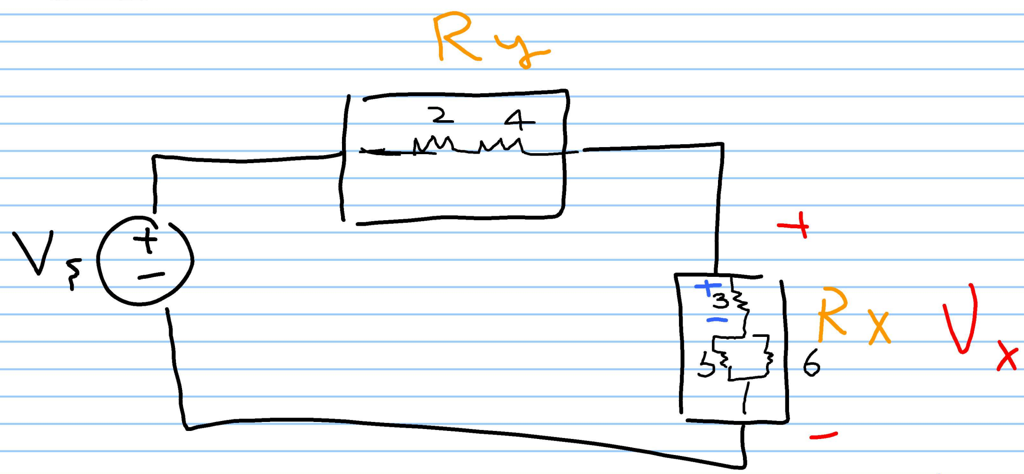
$$V_2 = \frac{-(200/2)}{(200/2) + 50} * 10$$

EX



find v_1

$$V_1 = -\frac{4}{4 + (2+6)} * 10$$

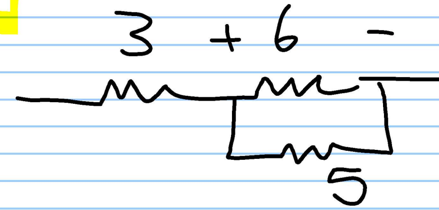


① $V_x = \frac{R_x}{R_x + R_y} V_s$ $\quad R_x = [3 + (6 // 5)]$

$R_y = (2 + 4)$

② find $V_{3\Omega}$ $\quad V_{3\Omega} = \frac{3}{3 + [2 + 4 + \frac{30}{11}]} V_s$

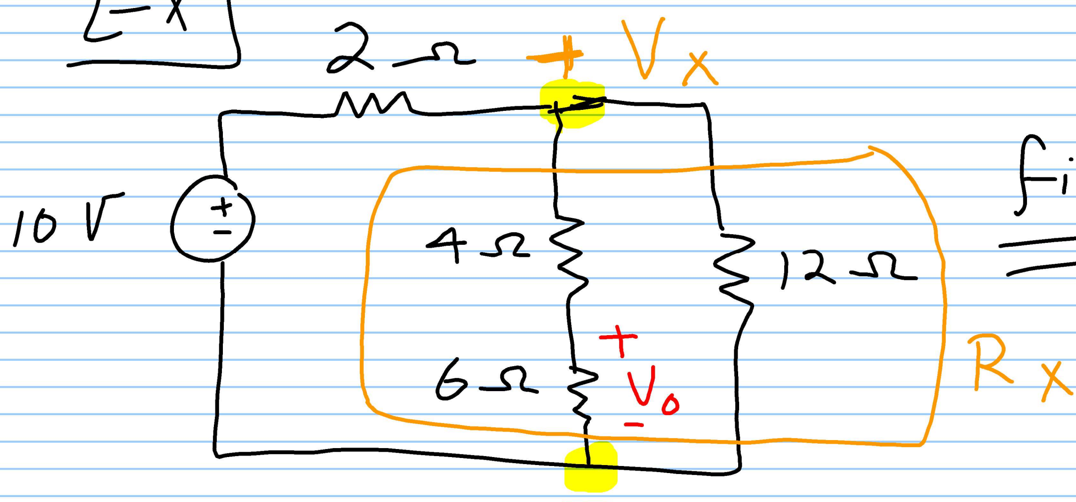
OR $V_{3\Omega} = \frac{3}{3+[6//5]} V_x$



& find $V_{6\Omega}$

$$V_{6\Omega} = \frac{[6//5]}{[6//5] + 3} * V_x$$ ✓

Ex



find V_o

$$V_x = \frac{R_x}{R_x+2} \times 10$$, then

$$R_x = 10//12 = 5.45\ \Omega$$

$$V_o = \frac{6}{6+4} * V_x$$

$$\Rightarrow V_o = \frac{6}{6+4}\left(\frac{R_x}{R_x+2}\right) \times 10$$

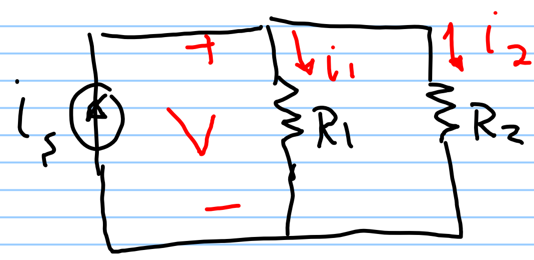
$$= \left(\frac{6}{10}\right)\left(\frac{5.45}{7.45}\right) * 10$$ ✓ $= 4.389\ V$

The current Divider Rule

CDR

$$V = i_1 R_1 = i_2 R_2$$

$$= i_s \times \frac{R_1 R_2}{R_1 + R_2}$$



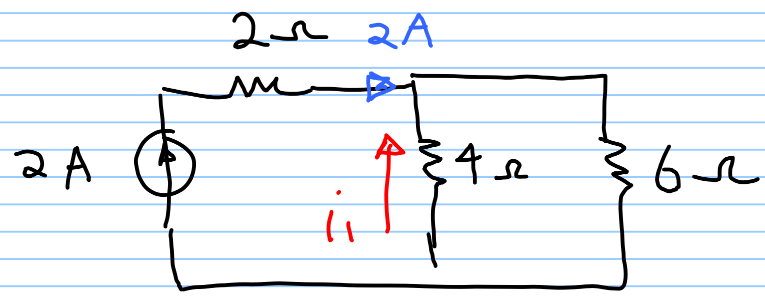
$$\therefore \quad i_1 = \frac{R_{eq}}{R_1} i_s \quad \text{OR}$$

$$= \frac{R_2}{R_2 + R_1} i_s$$

$$i_2 = \frac{R_{eq}}{R_2} i_s \quad \text{OR}$$

$$= \frac{R_1}{R_1 + R_2} i_s$$

EX find i_1

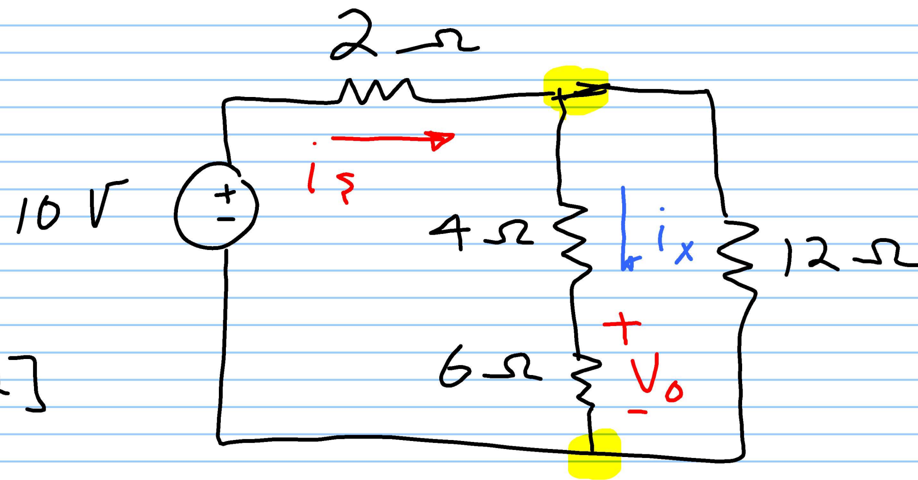


$$i_1 = -\frac{6}{6+4} \times 2$$

$$= -1.2\,A$$

EX

find v_o



① find I_s

$R_{eq} = 2 + [10 // 12]$

$= 2 + 5.45$

$= 7.45\ \Omega$

$\therefore\ i_s = \dfrac{10}{R_{eq}} = \dfrac{10}{7.45} = \underline{\underline{1.34\ A}}$

② find i_x

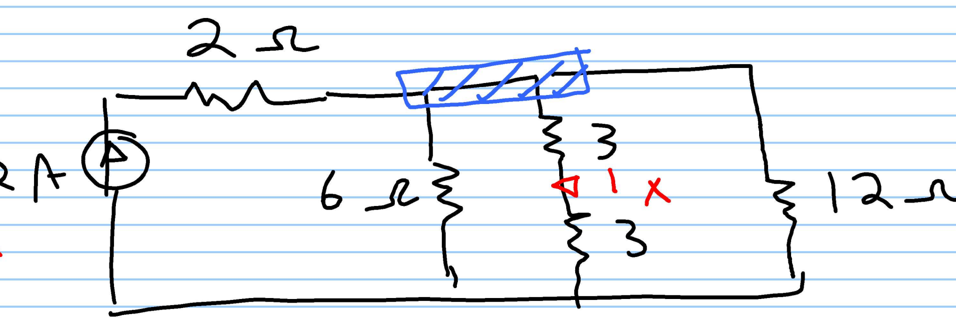
$i_x = \dfrac{12}{12 + (4+6)} * (1.34) = 0.73\ A$

$\therefore\ V_o = (6\Omega)(0.73A)$

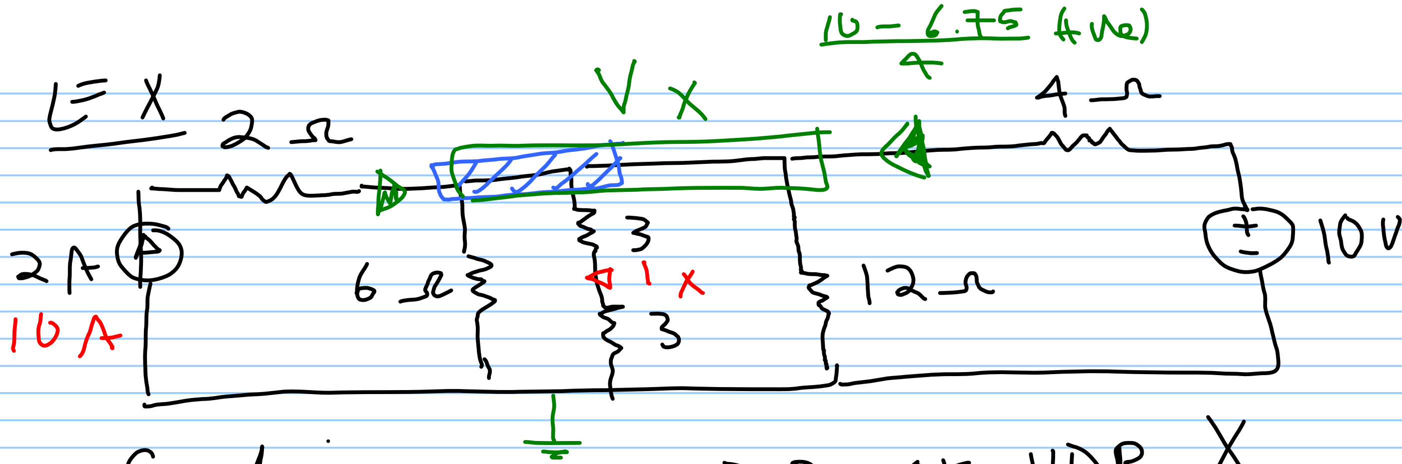
$= 4.38$ Volt.

EX

find i_x



$i_x = \dfrac{[6 // 12]}{[6//12] + [3+3]} * 2\ \ A$



find i_x CDR or VDR X

use KVL & KCL

Ch 4

$$-2 + \frac{V_x}{6} + \frac{V_x}{3+3} + \frac{V_x}{12} + \frac{V_x - 10}{4} = 0$$

$$V_x = \_\_\_ \text{ Volt}$$

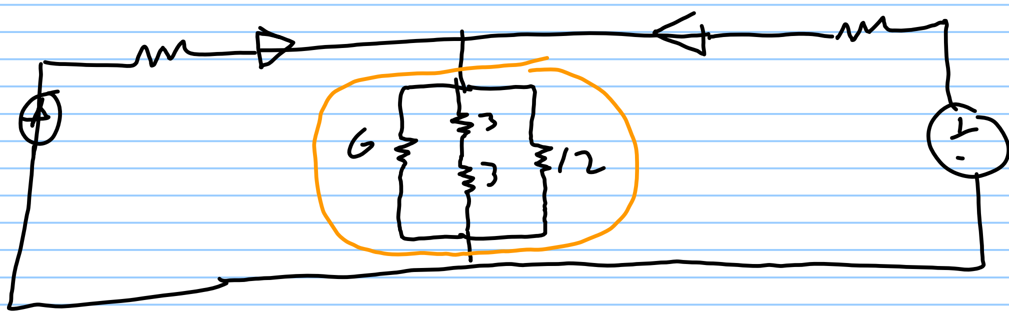
$$\therefore \; i_x = \frac{V_x}{3+3} \text{ A}$$

$$V_x\left(\frac{1}{6} + \frac{1}{6} + \frac{1}{12} + \frac{1}{4}\right) = 2 + \frac{10}{4}$$

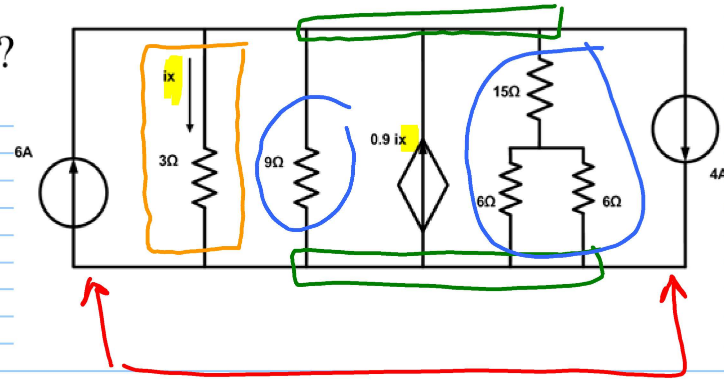
$$V_x\left(\frac{2}{3}\right) = 4.5$$

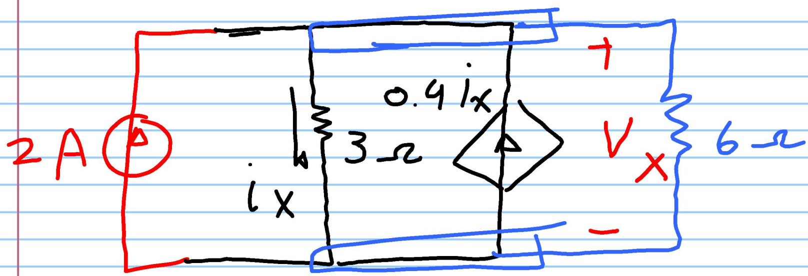
$$V_x = 6.75 \text{ Volt}$$

when using (10 A) $V_x = 18.75$



Find the power supplied by the 0.9 ix source?





$$R_{eq}^{*} = 9 \,//\, [15+3]$$

$$= 9 \,//\, 18$$

$$= 6\,\Omega$$

CDR

$$i_x = \frac{6}{6+3}\left[2 + 0.9\, i_x\right]$$

$$i_x = \frac{12 + 5.4\, i_x}{9}$$

$$\{9 i_x = 12 + 5.4\, i_x\}$$

$$\therefore\ i_x = \frac{12}{9 - 5.4} = 3.33\,A$$

$$\therefore\ V_x = (3\,\Omega)(3.33)$$

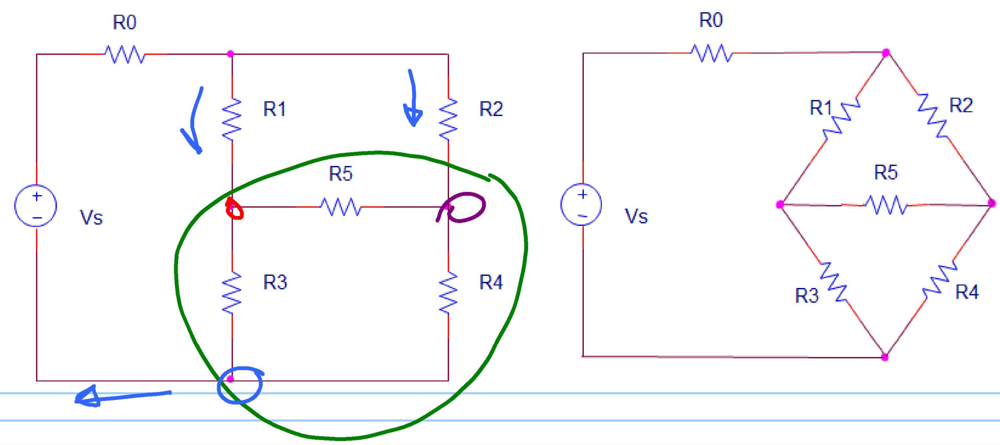
$$\simeq 10 \text{ Volt}$$

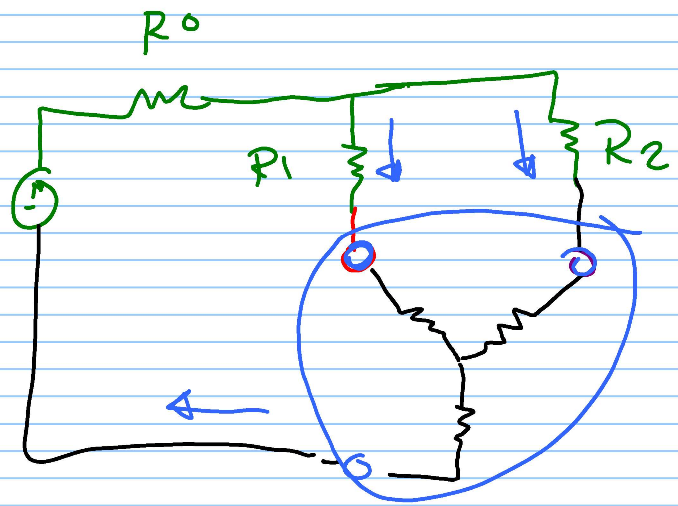
$$P_{0.9 i_x} = -(0.9\, i_x)(V_x)$$

$$= -30\,W$$

Bridge Circuits

One type of resistive circuit that cannot be simplified through series and/or parallel combinations is the "bridge circuit." A bridge circuit is shown below (drawn twice). Study the circuit to verify that there are no series resistors and no parallel resistors.





Δ Y

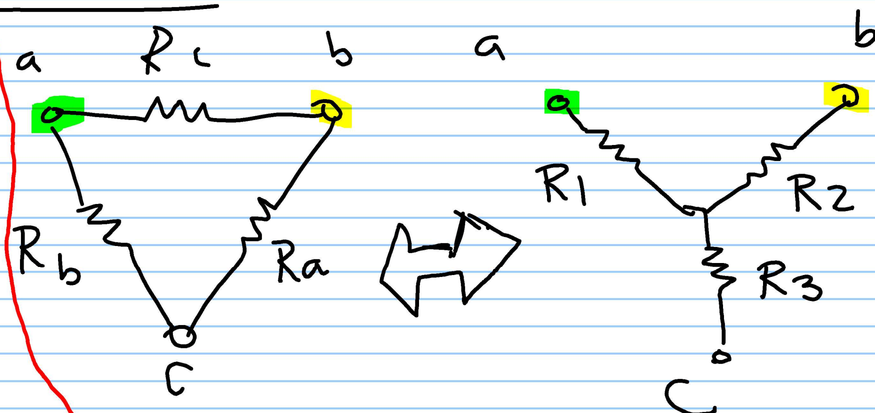
π T

Δ – Y Transformation

$$R_{ab} = \frac{R_c(R_a+R_b)}{R_a+R_b+R_c} = R_1+R_2$$

$$R_{bc} = \frac{R_a(R_b+R_c)}{R_a+R_b+R_c} = R_2+R_3$$

$$R_{ca} = \frac{R_b(R_a+R_c)}{R_a+R_b+R_c} = R_1+R_3$$



$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$

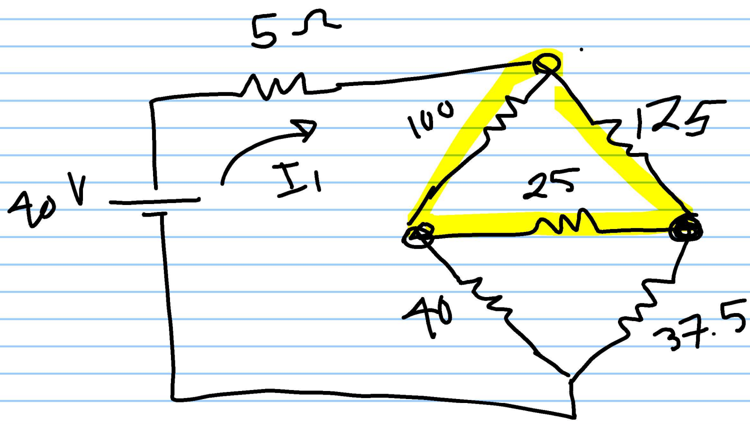
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$

$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

$$R_c = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$

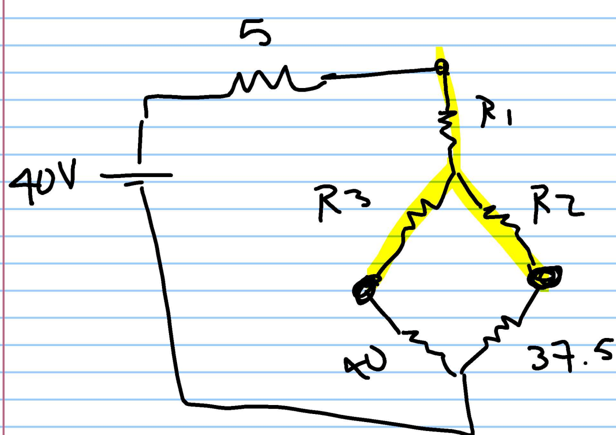
EX) find the current & the power supplied by 40V source



$$R_1 = \frac{100 \times 125}{100 + 125 + 25} = 50\,\Omega$$

$$R_2 = \frac{25 \times 125}{100 + 125 + 25} = 12.5\,\Omega$$

$$R_3 = \frac{100 \times 25}{100 + 125 + 25} = 10\,\Omega$$



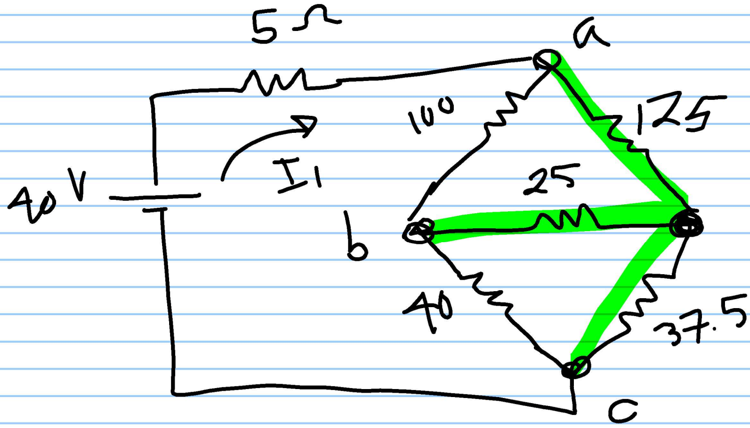
$$R_{eq} = 5 + R_1 + (R_3 + 40) // (R_2 + 37.5)$$

$$= 80\,\Omega$$

$$\therefore I = 40/80 = 0.5\,A$$

$$P_{40V} = -VI$$

$$= -40 \times 0.5 = -20\,W$$



try it