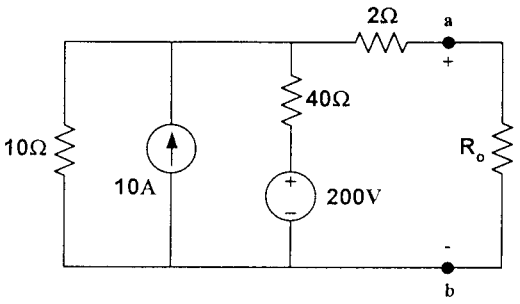
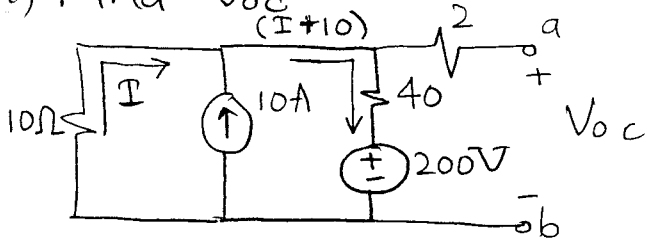
Q1. Find voltage V_{ab} when $R_o = 0,2,10,20,30,40,50\Omega$. **(8 marks)**



Since R_o is variable, the best way is to change the circuit to thevenin eq.

i) Find V_{oc}



Apply KVL in the big loop

$$10I + (I+10)40 + 200 = 0$$

$$\Rightarrow 50I + 400 + 200 = 0$$

$$\Rightarrow I = -12\,A$$

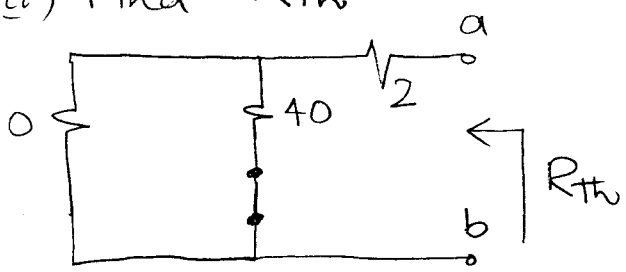
$$V_{oc} = V_{40\Omega} + 200$$

$$= (10+I)40 + 200$$

$$= (10-12)40 + 200$$

$$\Rightarrow \boxed{V_{oc} = 120\,V}$$

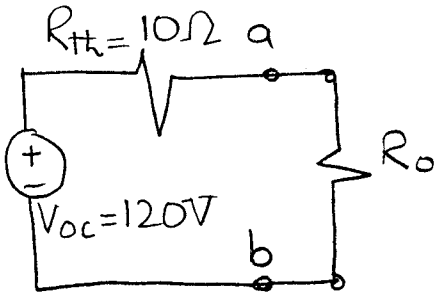
ii) Find R_{th}



$$R_{th} = [10 // 40] + 2$$

$$= \frac{10 \times 40}{10+40} + 2 =$$

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



$$\therefore V_{ab} = \frac{R_o}{R_{th}+R_o} \times V_{oc}$$

When $R_o = 0\Omega$

$$V_{ab} = \frac{0}{10+0} \times 120 = 0\ V$$

When $R_o = 2\Omega$

$$V_{ab} = \frac{2}{10+2} \times 120 = 20\ V$$

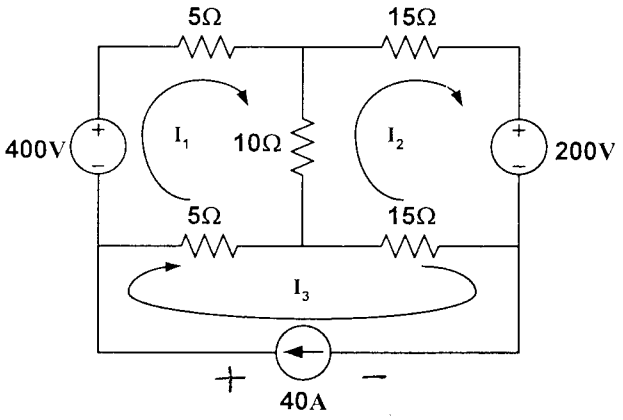
and so on.

Q2. For the following circuit,

(a) Write mesh equations using mesh analysis. **(4 marks)**

(b) Solve the equations to find mesh currents. **(1 marks)**

(c) Find total power delivered to the circuit. **(3 marks)**



a)

$I_3 = 40A$

I_1

$-400 + 5I_1 + 10(I_1 - I_2) + 5(I_1 - I_3) = 0$

$\Rightarrow -400 + 5I_1 + 10I_1 - 10I_2 + 5I_1 - 200 = 0$

$\Rightarrow 20I_1 - 10I_2 = 600$ ——— (1)

I_2

$200 + 15(I_2 - I_3) + 10(I_2 - I_1) + 15I_2 = 0$

$\Rightarrow 200 + 15I_2 - 600 + 10I_2 - 10I_1 + 15I_2 = 0$

$\Rightarrow -10I_1 + 40I_2 = 400$ ——— (2)

b) (1)×1 $\Rightarrow 20I_1 - 10I_2 = 600$

(2)×2 $\Rightarrow -20I_1 + 80I_2 = 800$

$70I_2 = 1400$

$\Rightarrow \boxed{I_2 = 20A}$

$\therefore$ (1) $\Rightarrow I_1 = \dfrac{600 + 10(20)}{20}$

$\Rightarrow \boxed{I_1 = 40A}$

c) Since we need power delivered and resistors absorb power $\therefore$ we need to calculate power of sources only.

$P_{400V} = -(400)(I_1)$

$= -16000W$ (delivered)

$P_{200V} = +(200)(I_2)$

$= +4000W$ (absorbed)

To calculate power of 40A we need voltage across it. Apply KVL in outer loop.

$-V_{40A} - 400 + 5I_1 + 15I_2 + 200 = 0$

$\Rightarrow V_{40A} = 300V$

$\therefore P_{40A} = -(300)(I_3)$

$= -12000W$ (delivered)

$\therefore$ total power delivered to the circuit is

$P_{delivered} = 16000 + 12000$

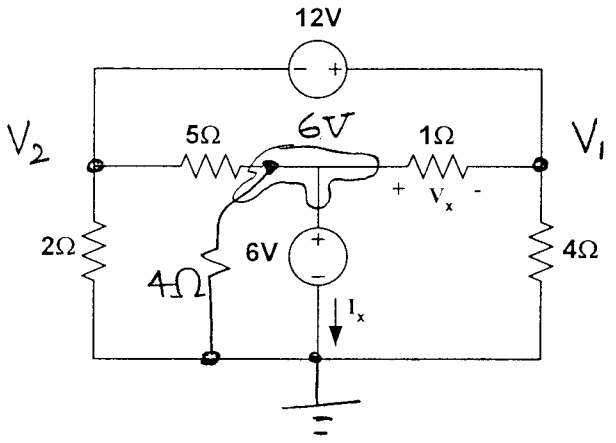
$= 28000W$

Q3. For the following circuit

(a) Write nodal equations using nodal analysis. **(5 marks)**

(b) Solve the equations to find node voltages **(1 marks)**

(c) Find current I_x and voltage V_x. **(3 marks)**



(a) Apply supernode at V_1, V_2

$$\frac{V_2}{2} + \frac{V_2-6}{5} + \frac{V_1}{4} + \frac{V_1-6}{1} = 0$$

$$\Rightarrow 10V_2 + 4V_2 - 24 + 5V_1 + 20V_1 - 120 = 0$$

$$\Rightarrow 25V_1 + 14V_2 = 144 \quad \text{—— (1)}$$

Also $V_1 - V_2 = 12$ —— (2)

(b)

(1) $\times 1 \Rightarrow 25V_1 + 14V_2 = 144$

(2) $\times 25 \Rightarrow 25V_1 - 25V_2 = 300$

$$39V_2 = -156$$

$$\Rightarrow \boxed{V_2 = -4.0\,V}$$

(2) $\Rightarrow V_1 = 12 + V_2$

$$\Rightarrow \boxed{V_1 = +8.0\,V}$$

(c) $V_x = 6 - V_1$

$$\Rightarrow \boxed{V_x = -2.0\,V}$$

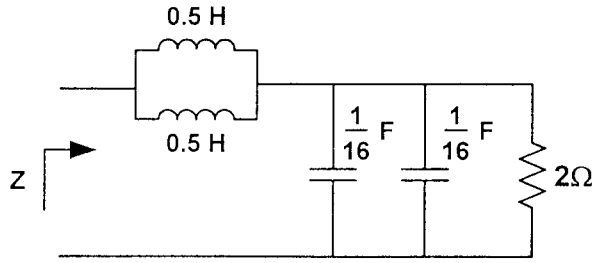
To find I_x apply KCL at 6V node:

$$\frac{6-V_2}{5} + \frac{6}{4} + I_x + \frac{6-V_1}{1} = 0$$

$$\Rightarrow 2.0 + 1.5 + I_x + (-2.0) = 0$$

$$\Rightarrow \boxed{I_x = -1.5\,A}$$

Q4. For the following RLC circuit, find total impedance Z when $\omega = 4$ rad/sec. **(5 marks)**

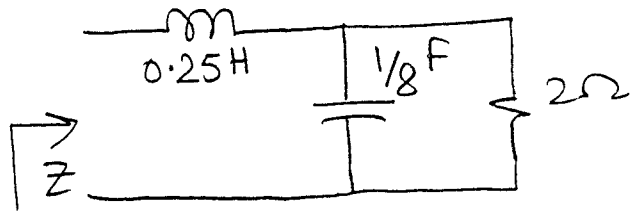


Combine inductors in parallel

$$L_{eq} = \frac{0.5 \times 0.5}{0.5 + 0.5} = 0.25\,H$$

Combine capacitors in parallel

$$C_{eq} = \frac{1}{16} + \frac{1}{16} = \frac{1}{8} f$$

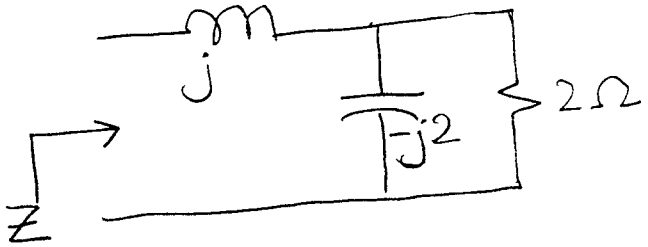


Change to Impedance

$$Z_L = j\omega L = j\,\Omega$$

$$Z_C = \frac{-j}{\omega C} = -j2\,\Omega$$

$$Z_R = R = 2\,\Omega$$



$$Z = \frac{(2)(-j2)}{(2)+(-j2)} + j$$

$$Z = \frac{-4j}{2-j2} + j$$

$$\Rightarrow Z = \frac{4\angle -90^\circ}{2.83\angle -45^\circ} + j = 1.413\angle -45^\circ + j$$

$$= 1 - j + j = 1\,\Omega$$