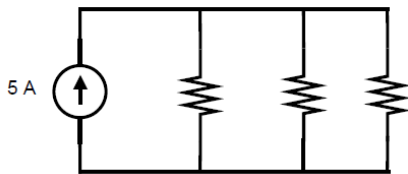


ESC201A Assignment 1

Instructor: Abhishek Gupta

2023-2024 I Semester

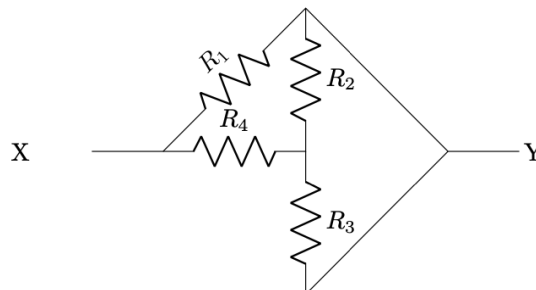
Que 1. The digital multimeter (DMM) is a device commonly used to measure voltages. It is equipped with two leads (usually red for the positive reference and black for the negative reference) and an LCD display lead at the top node and the negative lead on the bottom node. Using KCL, explain why would we ideally want a DMM used in this way to have an infinite resistance as opposed to zero resistance.



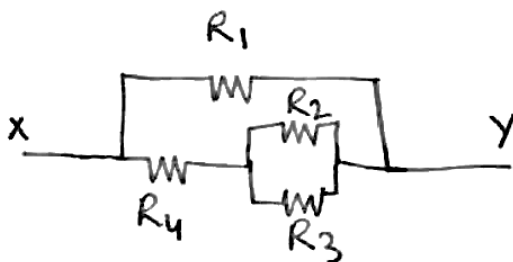
The DMM is connected in parallel with the 3 load resistors, across which develops the voltage we wish to measure. If the DMM appears as a short, then all 5 A flows through the DMM, and none through the resistors, resulting in a (false) reading of 0 V for the circuit undergoing testing. If, instead, the DMM has an infinite internal resistance, then no current is shunted away from the load resistors of the circuit, and a true voltage reading results.

Que 2.

Find the equivalent resistance between X and Y in the circuit shown where $R_1 = 8\Omega$, $R_2 = R_3 = 2\Omega$, $R_4 = 7\Omega$.



The given circuit can be redrawn as

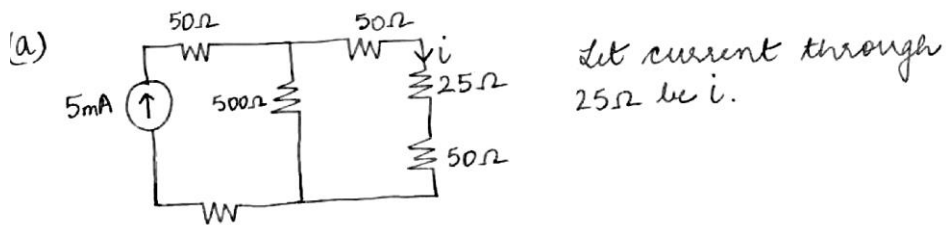
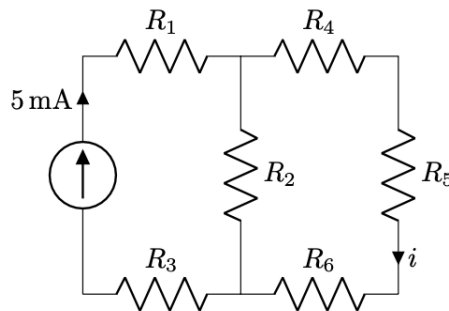


$$\begin{aligned} R_{eq} &= R_1 \parallel [R_4 + (R_2 \parallel R_3)] \\ \Rightarrow R_{eq} &= 8 \parallel [7 + (2 \parallel 2)] \Omega \\ \Rightarrow R_{eq} &= 8 \parallel [7 + 1] \Omega \\ \Rightarrow R_{eq} &= 8 \parallel 8 \Omega \\ \Rightarrow R_{eq} &= 4 \Omega \end{aligned}$$

Que 3.

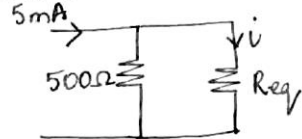
For the circuits below, $R_1 = 50\Omega$, $R_2 = 500\Omega$, $R_3 = 100\Omega$, $R_4 = 50\Omega$, $R_5 = 25\Omega$ and $R_6 = 50\Omega$.

(a) Use current division to find current i through R_5 .



Let current through 25Ω be i .

circuit can be reduced as:

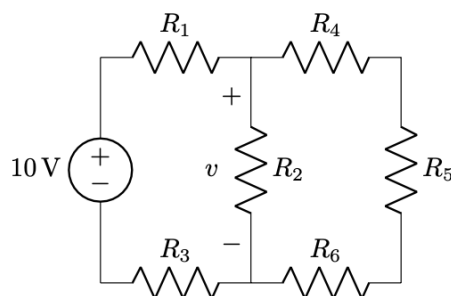


$$R_{eq} = 50\Omega + 25\Omega + 50\Omega = 125\Omega$$

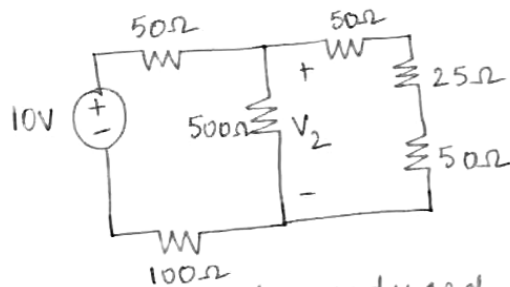
\therefore By current division,

$$i = \frac{5\text{mA} \times 500}{500 + 125} = 4\text{mA}$$

(b) Use voltage division to find voltage v across R_2 .

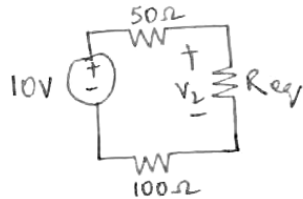


(b)



Let voltage across R_2 be V_2 .

The circuit can be reduced as:



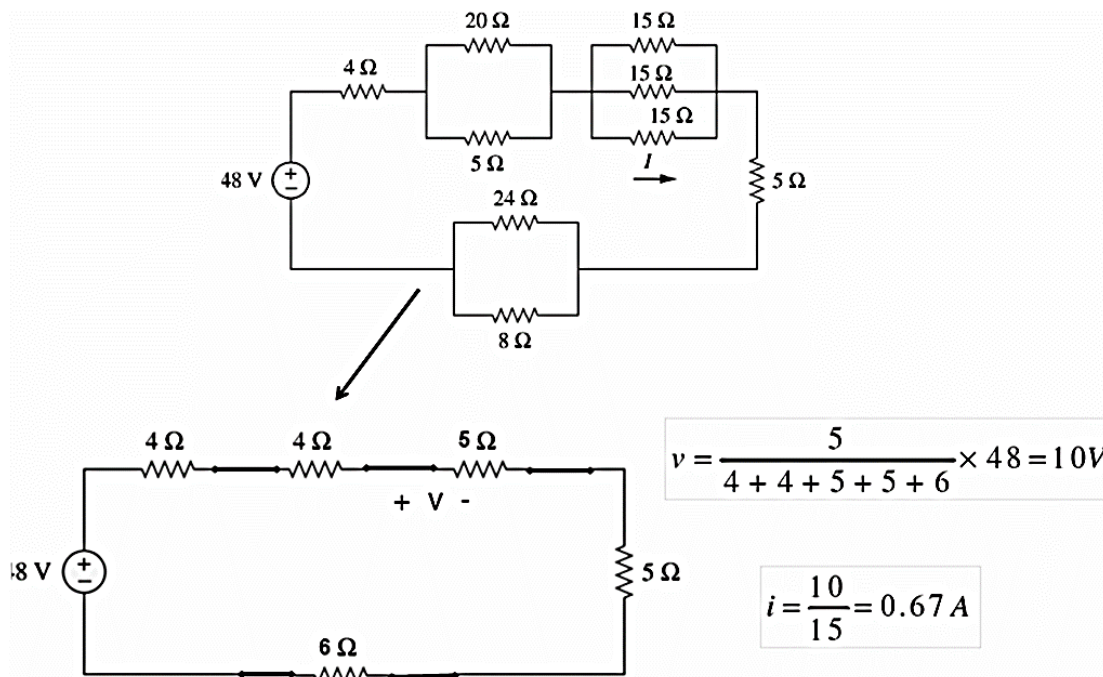
$$R_{eq} = 500 \parallel (50 + 25 + 50) \Omega$$
$$= \frac{500 \times 125}{500 + 125} \Omega = 100 \Omega$$

\therefore By voltage division,

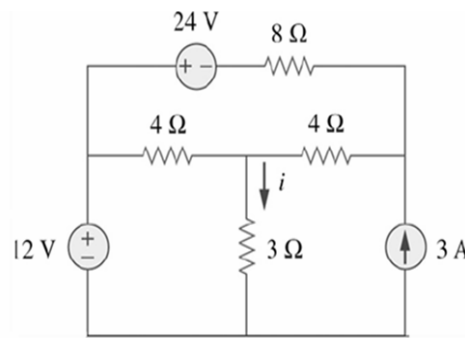
$$V_2 = \frac{10 \times R_{eq}}{50 + 100 + R_{eq}} V$$

$$\Rightarrow V_2 = \frac{10 \times 100}{50 + 100 + 100} V = 4V$$

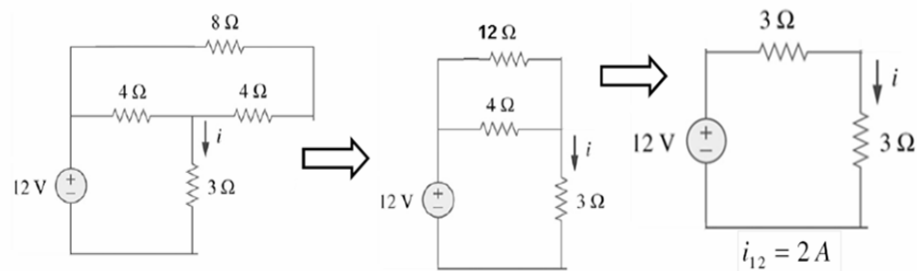
Que 4. Use the concept of series/parallel resistances and voltage and current division to determine the current in the circuit shown below



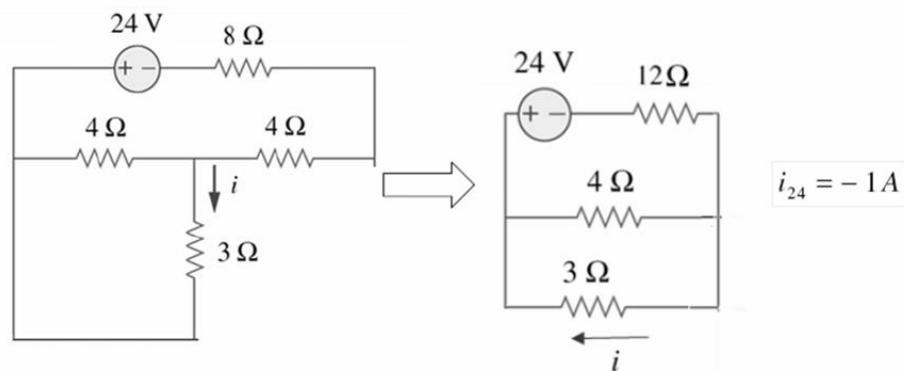
Que 5. Use superposition theorem to solve for current i in the circuit shown below



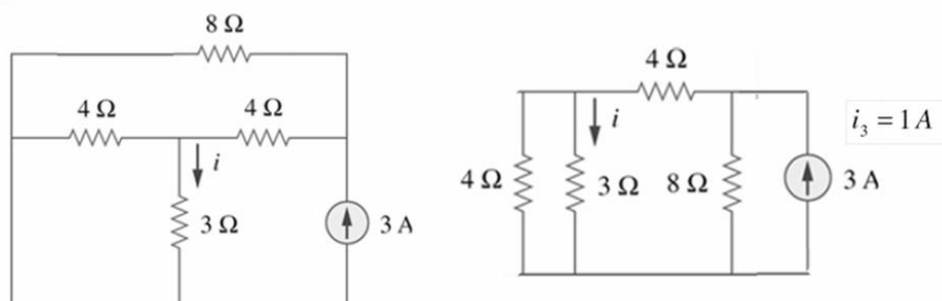
Find current due to 12V source only



Find current due to 24V source only



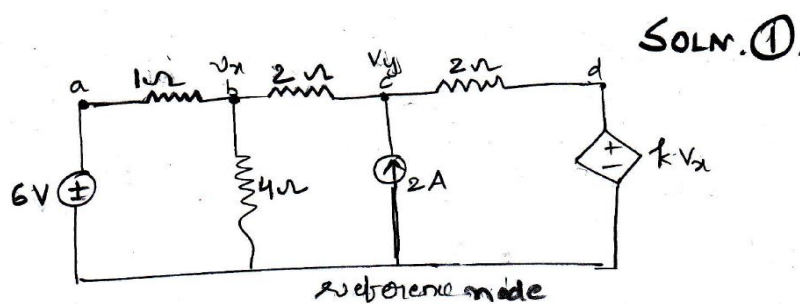
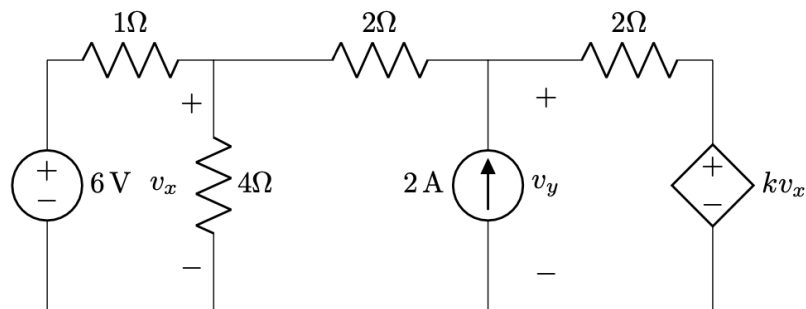
Find current due to 3A source only



$$\text{Net current} = i_{12} + i_{24} + i_3 = 2 \text{ A}$$

Que 6.

In the given circuit, use nodal analysis to find the value of k , that will cause v_y to be zero.



At nodes 'a' and 'd', we have
 $v_a = 6\text{V}$; $v_d = kv_x$

At nodes 'b' and 'c', we can write that

$$\frac{v_x - 6}{1} + \frac{v_x - v_y}{2} + \frac{v_x}{4} = 0 \quad \text{--- ①}$$

$$\frac{v_y - v_x}{2} + \frac{v_y - kv_x}{2} = 2 \quad \text{--- ②}$$

Put $v_y = 0$ for finding 'k'

From ①,

$$\frac{v_x - 6}{1} + \frac{v_x}{2} + \frac{v_x}{4} = 0$$

$$\Rightarrow 6 = v_x \left(\frac{7}{4} \right)$$

$$\Rightarrow v_x = \frac{24}{7} \text{ V}$$

From (2),

$$\frac{v_x}{2} + \frac{K v_x}{2} = -2$$

$$\Rightarrow (1+K) \frac{v_x}{2} = -2$$

$$\Rightarrow 1+K = -\frac{4}{v_x} = -\frac{4}{(24/7)} = -\frac{28}{24}$$

$$\Rightarrow K = -1 - \frac{28}{24} = -\frac{52}{24} = -\frac{13}{6}$$

$$\therefore \boxed{K = -\frac{13}{6}}$$

Que 7.

Three appliances — an 850W coffee maker, a 1200W microwave oven, and a 900W toaster — are connected in parallel to a 120V circuit with a 15A circuit breaker.

(a) Draw a schematic diagram of this circuit.

(b) Which of these appliances can be operated simultaneously without tripping the circuit breaker?

Ans 5. (a)



(b) A 15A circuit operating at 120V consumes
 $15 \times 120 \text{ W} = 1800 \text{ W}$ total power

Total power in a parallel circuit is the sum of power consumed in individual branches.

i) coffee maker + microwave oven
 $= 850 \text{ W} + 1200 \text{ W} = 2050 \text{ W} > 1800 \text{ W}$

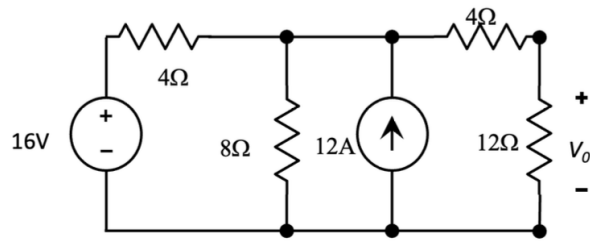
ii) Microwave oven + toaster = $1200 \text{ W} + 900 \text{ W} = 2100 \text{ W} > 1800 \text{ W}$

iii) Toaster + coffee maker = $900 \text{ W} + 850 \text{ W} = 1750 \text{ W} < 1800 \text{ W}$

\therefore On this circuit, only coffee maker and toaster can be operated simultaneously. All other combinations will trigger the circuit breaker to open.

Que 8.

Find V_0 using Nodal Analysis.



Let voltage at node a be V and let b be the reference node. Applying KCL at node a,

$$\frac{V-16}{4} + \frac{V}{8} + \frac{V-V_0}{4} - 12 = 0$$

$$\Rightarrow 5V - 2V_0 = 128 \quad \text{--- (1)}$$

Applying KCL at node c,

$$\frac{V_0 - V}{4} + \frac{V_0}{12} = 0$$

$$\Rightarrow V = \frac{4V_0}{3} \quad \text{--- (2)}$$

From (1) and (2),

$$5\left(\frac{4V_0}{3}\right) - 2V_0 = 128$$

$$\Rightarrow V_0 = \frac{128 \times 3}{14} \text{ V} = 27.42 \text{ V}$$