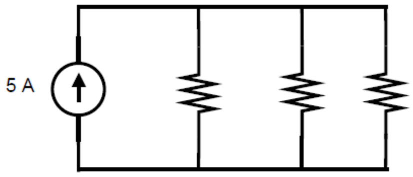
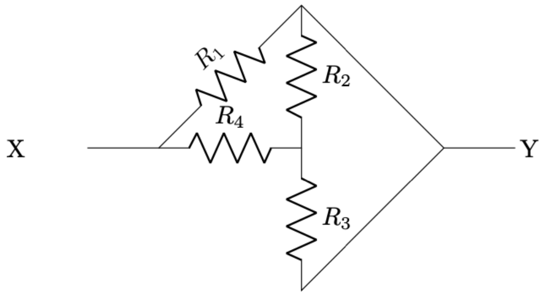
Que 1. The digital multimeter (DMM) is a device commonly used to measure voltages. It is equipped with two leads (usually red for the positive reference and black for the negative reference) and an LCD display lead at the top node and the negative lead on the bottom node. Using KCL, explain why would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



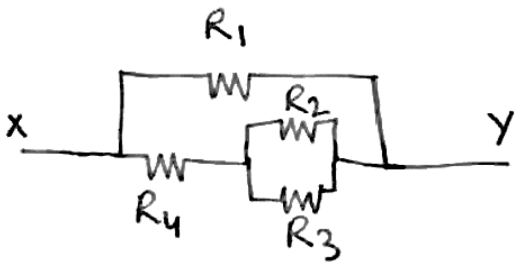
The DMM is connected in parallel with the 3 load resistors, across which develops the voltage we wish to measure. If the DMM appears as a short, then all $5\,A$ flows through the DMM, and none through the resistors, resulting in a (false) reading of $0\,V$ for the circuit undergoing testing. If, instead, 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



$$R_{eq} = R_1 \| \left[R_4 + (R_2 \| R_3) \right]$$

$$\Rightarrow R_{eq} = 8 \| \left[7 + (2 \| 2) \right]\ \Omega$$

$$\Rightarrow R_{eq} = 8 \| \left[7 + 1 \right]\ \Omega$$

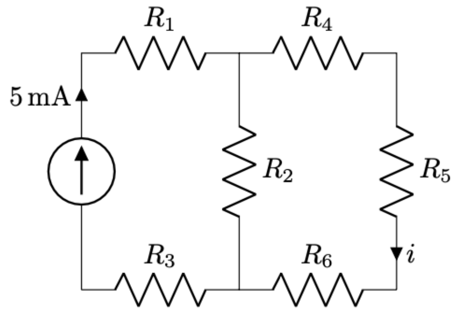
$$\Rightarrow R_{eq} = 8 \| 8\ \Omega$$

$$\Rightarrow R_{eq} = 4\Omega$$

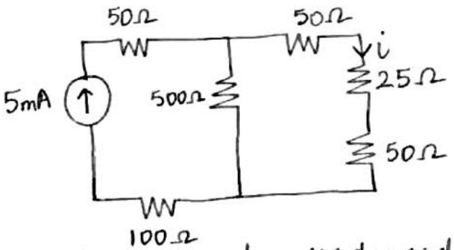
Que 3.

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.

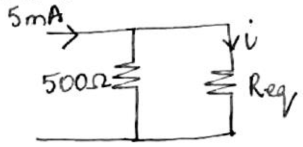


(a)



Let current through 25Ω be i.

circuit can be reduced as:

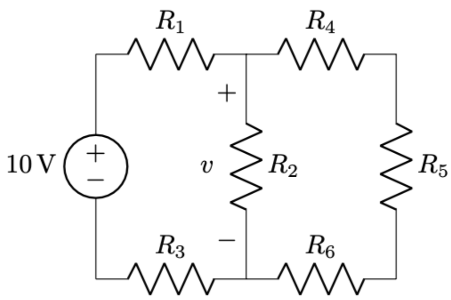


$R_{eq} = 50\Omega + 25\Omega + 50\Omega$
$= 125\Omega$

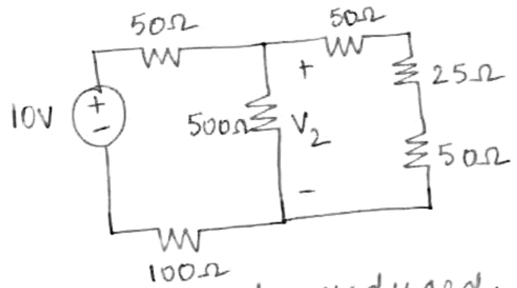
∴ By current division,

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

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

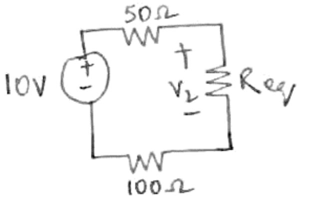


(b)



Let voltage across R_2 be V_2.

The circuit can be reduced as:



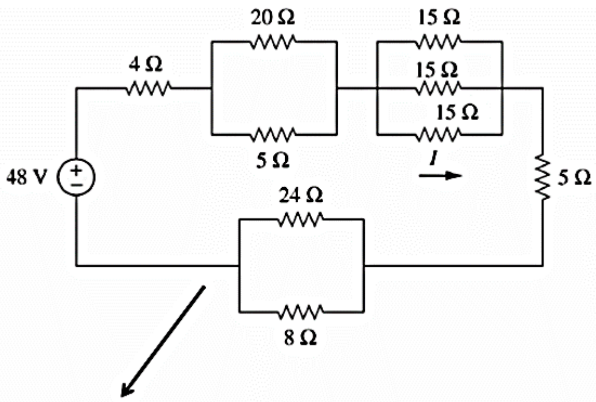
$$R_{eq} = 500 \parallel (50+25+50)\ \Omega$$
$$= \frac{500 \times 125}{500+125}\ \Omega = 100\ \Omega$$

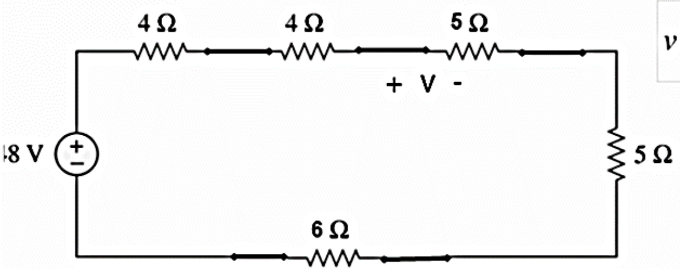
∴ By voltage division,

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

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

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

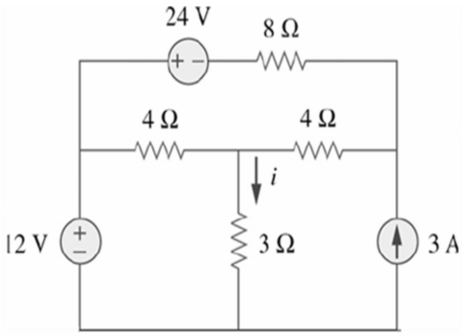




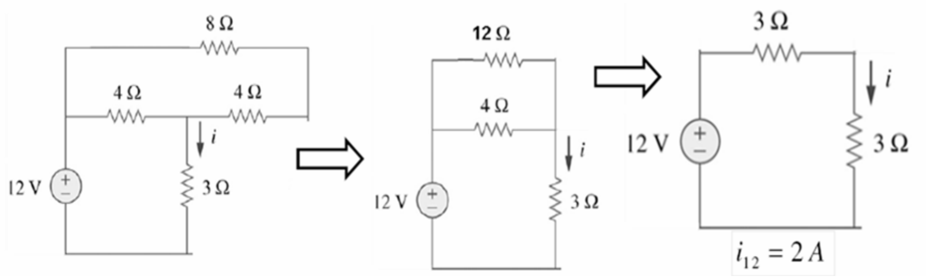
$$v = \frac{5}{4+4+5+5+6} \times 48 = 10V$$

$$i = \frac{10}{15} = 0.67A$$

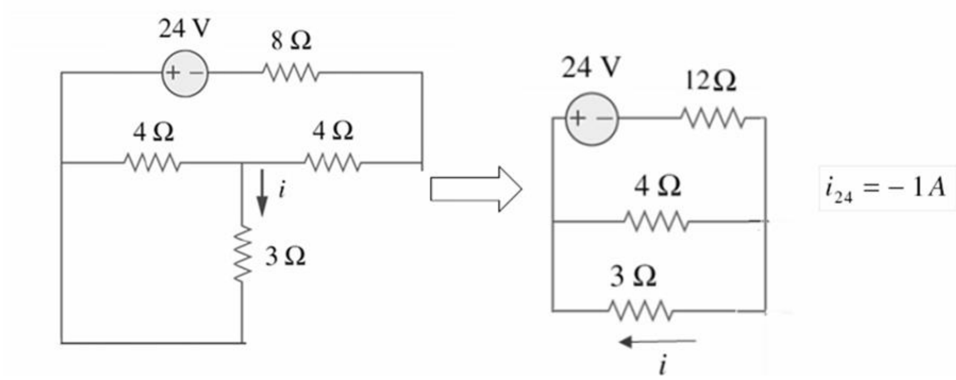
Que 5. Use superposition theorem to solve for current i in the circuit shown below



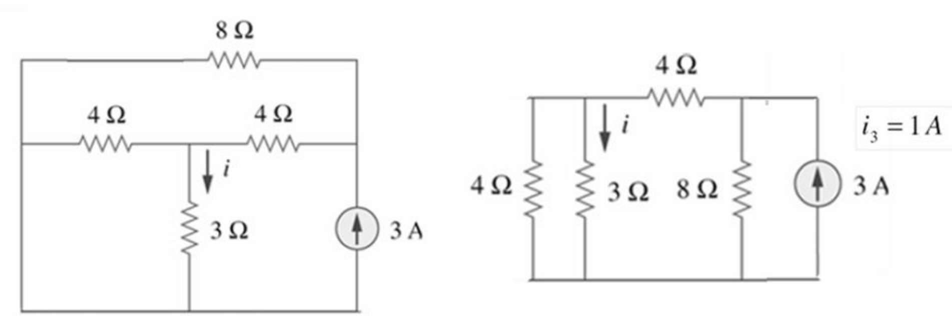
Find current due to 12V source only



Find current due to 24V source only



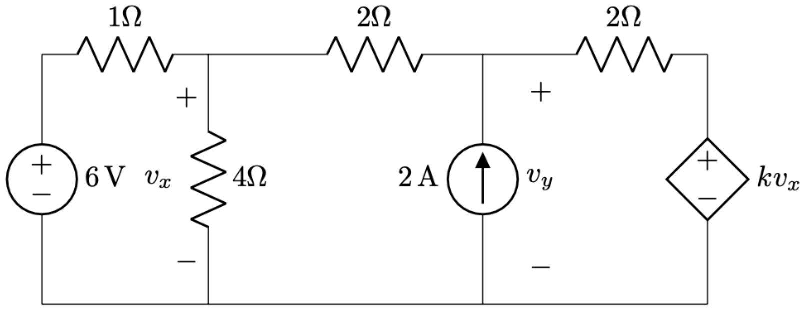
Find current due to 3A source only



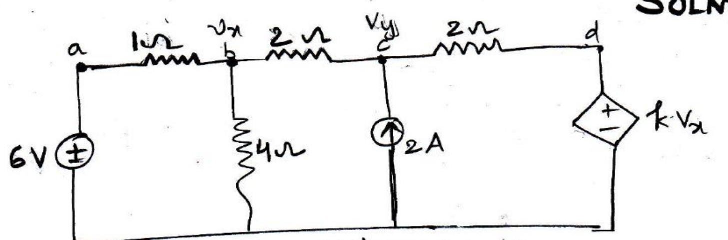
Net current = $i_{12} + i_{24} + i_3 = 2\,A$

Que 6.

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



SOLN. 1.



reference node

At nodes 'a' and 'd', we have

$$V_a = 6\,V \; ; \; V_d = k v_x$$

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

$$\frac{v_x - 6}{1} + \frac{v_x - v_y}{2} + \frac{v_x}{4} = 0. \qquad (1)$$

$$\frac{v_y - v_x}{2} + \frac{v_y - k v_x}{2} = 2 \qquad (2)$$

Put $v_y = 0$ for finding 'k'

From (1),

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

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

$$\Rightarrow \quad v_x = \frac{24}{7}\,V.$$

From ②,

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

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

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

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

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

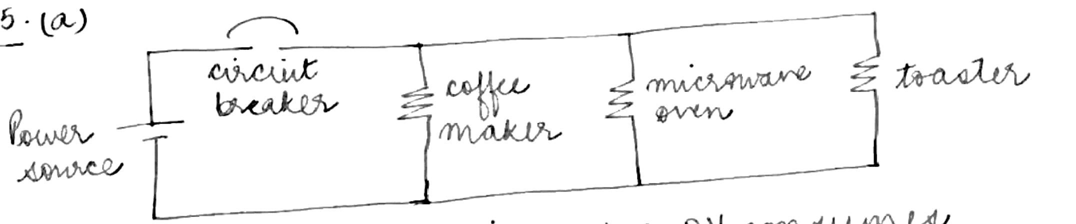
Que 7.

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 X 120W = 1800 W total power

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

i) Coffee maker + microwave oven = 850W + 1200W = 2050W > 1800W

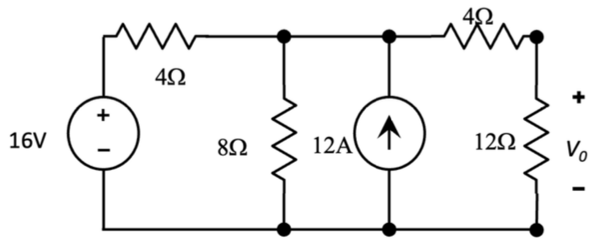
ii) Microwave oven + toaster = 1200W + 900W = 2100W > 1800W

iii) Toaster + coffee maker = 900W + 850W = 1750W < 1800W

∴ On this circuit, only coffee maker and toaster can be operated simultaneously. All other combin-ations 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),

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

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