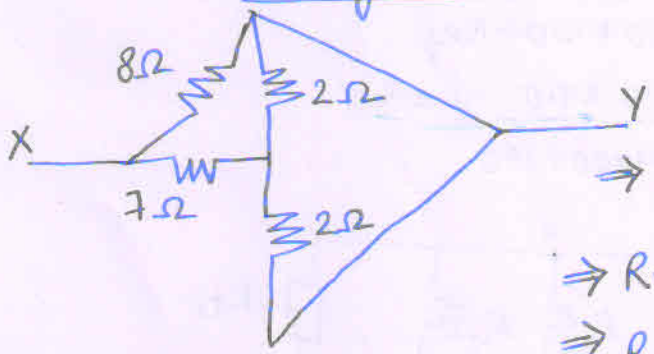
ESC201
Assignment 1 Solutions

Ans 1.



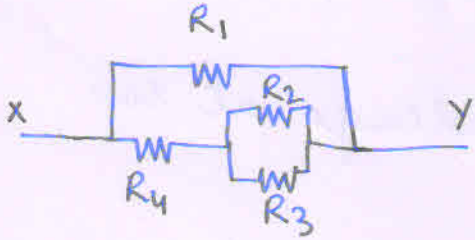
$$R_{eq} = R_1 \| [R_4 + (R_2 \| R_3)]$$

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

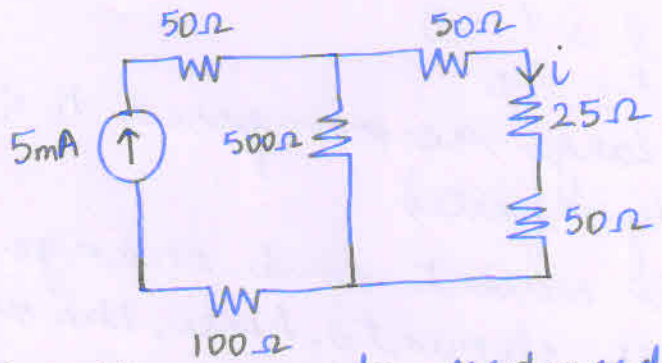
$$\Rightarrow R_{eq} = 8 \| [7+1]\ \Omega$$

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

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

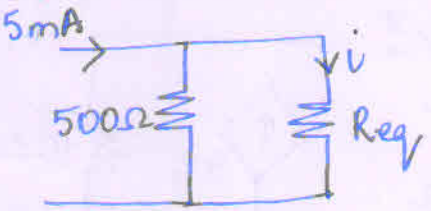


Ans 2. (a)



Let current through 25Ω be i.

The circuit can be reduced as:

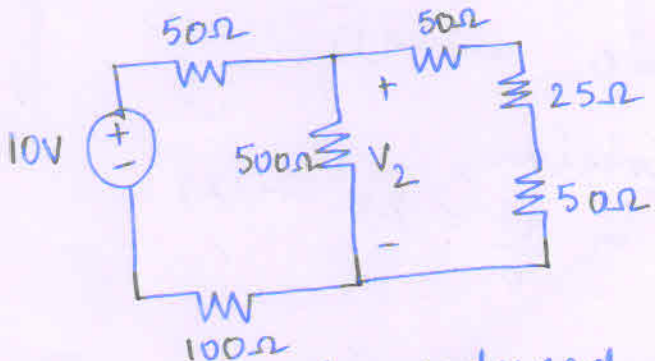


$$R_{eq} = 50\Omega + 25\Omega + 50\Omega = 125\Omega$$

∴ By current division,

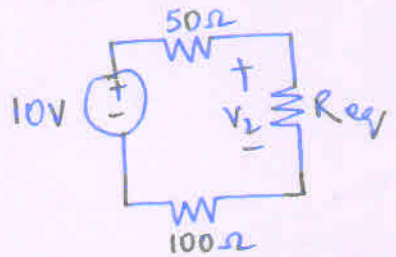
$$i = \frac{5\text{mA} \times 500}{500+125} = 4\text{mA}$$

(b)



Let voltage across R2 be V_2.

The circuit can be reduced as:



$$R_{eq} = 500 \| (50+25+50)\ \Omega$$

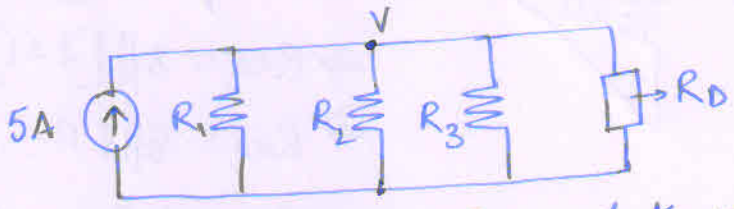
$$= \frac{500 \times 125}{500+125}\ \Omega = 100\ \Omega$$

∴ By voltage division,

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

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

Ans 3.



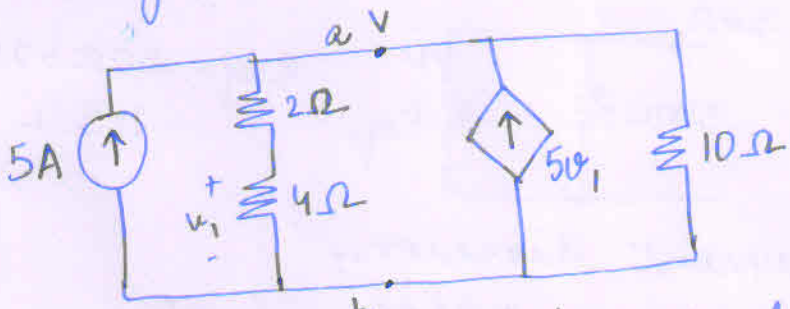
Let resistance of DMM be R_D. Let voltage at top node be V. Applying KCL,

$$-5 + \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} + \frac{V}{R_D} = 0$$

If R_D is not very large as compared to R_1, R_2, R_3, (ideally infinite)

then, it will draw current and change the current through other elements, hence, the voltage.

Ans 4.



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

$$-5 + \frac{V}{6} - 5v_1 + \frac{V}{10} = 0 \quad \text{——(1)}$$

Also, by voltage division,

$$v_1 = \frac{V \times 4}{2+4} = \frac{4V}{6} = \frac{2}{3}V \quad \text{—(2)}$$

From (1) and (2),

$$-5 + \frac{V}{6} - 5\left(\frac{2V}{3}\right) + \frac{V}{10} = 0$$

$$\Rightarrow \frac{V}{6} - \frac{10V}{3} + \frac{V}{10} = 5$$

$$\Rightarrow \frac{5V - 100V + 3V}{30} = 5$$

$$\Rightarrow -92V = 5 \times 30$$

$$\Rightarrow V = -\frac{5 \times 30}{92} V$$

$\therefore$ Power across $10\Omega = \left(\frac{5 \times 30}{92}\right)^2 \times \frac{1}{10} W$

$$= \frac{25 \times 900}{920 \times 92} W = 265.83 mW$$

Ans 5. (a)

(b) A 15A circuit operating at 120V consumes

$15 \times 120W = 1800 W$ total power

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

i) Coffee maker + microwave oven

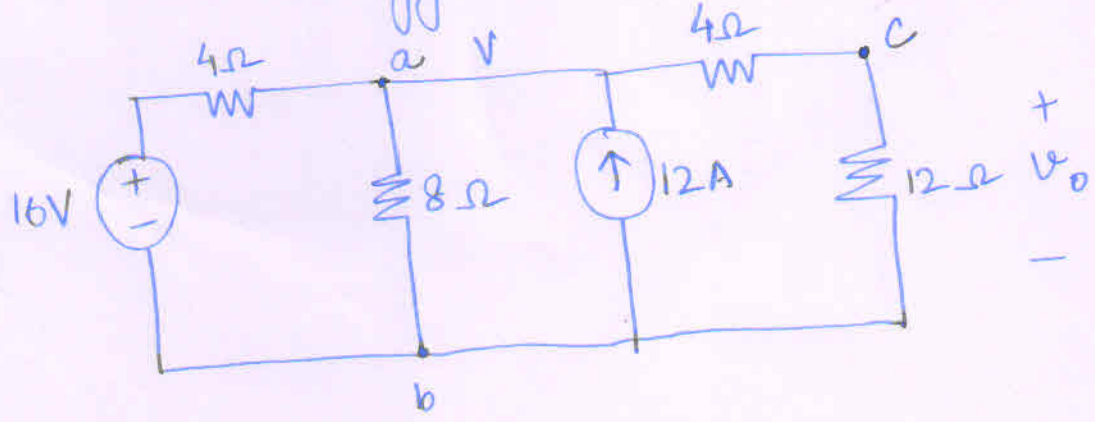
$: 850W + 1200W = 2050W > 1800W$

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

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

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

Ans 6.



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),

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

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