ELEC1100: KCL & KVL Exercises

[Solution included]

Note:

- **This is an additional exercises document for your own practice.**
- **THIS IS NOT YOUR LAB HOMEWORK.**
- **Lab homework starts on <u>March 30 (Mon)</u>, go to your Canvas <u>lab page</u> (LA1/LA2/LA3) to download Homework Questions.**

<u>Exercise 1</u>

Use **KVL** to find the voltages at node A and node B in Figure 1.

$$\begin{cases} -12 + i_1 + 2(i_1 - i_2) + 2i_1 = 0 \\ 2i_2 + 4 + 2(i_2 - i_1) = 0 \end{cases}$$

$$\begin{cases} i_1 = \frac{5}{2}A \\ i_2 = \frac{1}{4}A \end{cases}$$

$$\begin{cases} V_A = 12 - \frac{5}{2} = \frac{19}{2}V \\ V_B = \frac{19}{2} - 2 \times \frac{1}{4} = 9V \end{cases}$$

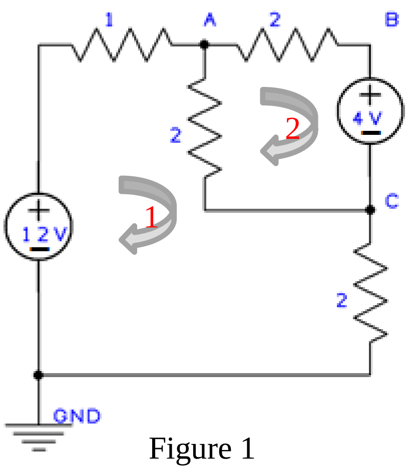


Figure 1

<u>Exercise 2</u>

Use **KCL** to find the voltages at node D and node E in Figure 2.

$$\begin{cases} \frac{5 - V_D}{10} + \frac{5 - V_D}{2 + 3} = \frac{V_D}{5} \\ \frac{5 - V_D}{2 + 3} = \frac{V_E - V_D}{2} \end{cases}$$

$$\begin{cases} V_D = 3V \\ V_E = \frac{19}{5}V \end{cases}$$

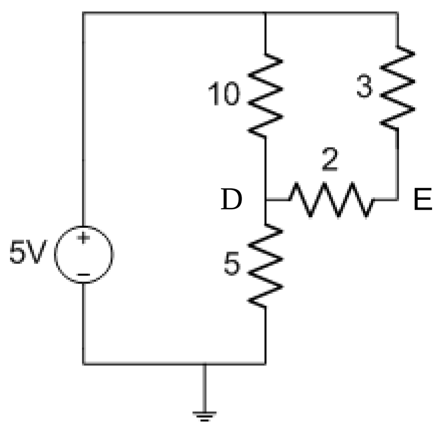


Figure 2

Exercise 3

Figure 3 shows a Zener diode circuit where the breakdown voltage of the Zener diode is 5V. It is known that when $V_{in} \geq 7V$, the Zener diode can be regarded as a small resistor $R_z = 6\ \Omega$ connected in series with a 5V voltage source as shown in the right part of Figure 3. That resistance R_s is dependent on the load R with $R_s = 0.4R$.

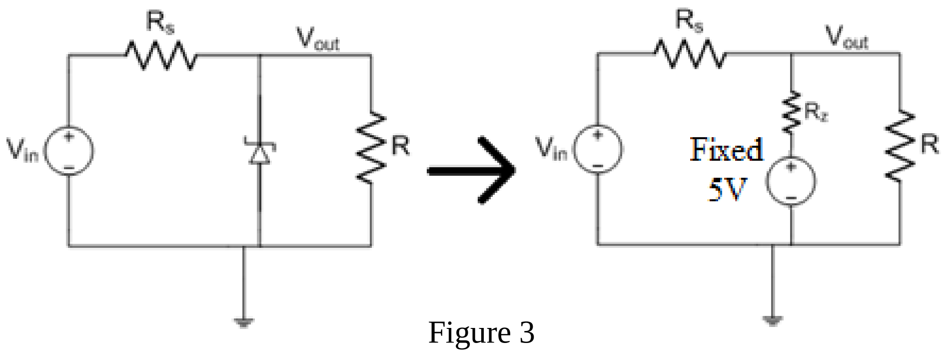


Figure 3

Show that when $V_{in} \geq 7V$, V_{out} is given by:

$$V_{out} = \frac{15V_{in} + 5R}{R + 21}$$

(Hint: You may consider using KCL)

When $V_{in} > 7V$, use KCL

$$\frac{V_{in} - V_{out}}{R_s} = \frac{V_{out} - 5}{R_z} + \frac{V_{out}}{R} \quad \rightarrow \quad \frac{V_{in} - V_{out}}{0.4R} = \frac{V_{out} - 5}{6} + \frac{V_{out}}{R}$$

After rearranging terms,

$$V_{out} = \frac{15V_{in} + 5R}{R + 21}$$

Exercise 4

a) Use KCL to find the current I_1 in Fig. 4.1.
b) If the resistor network in Fig. 4.1 is to be replaced by a single equivalent resistor, as in Fig. 4.2, what is the resistance required?
c) Use KVL to find the current I_2 in Fig. 4.3.
d) Based on the result in c), and by following the same procedure as that for b), find the equivalent resistance between A and B in Fig. 4.3.

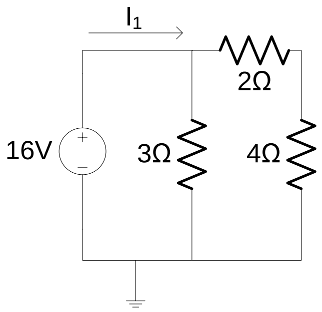


Fig. 4.1

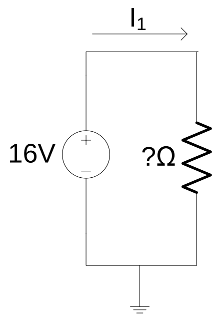


Fig. 4.2

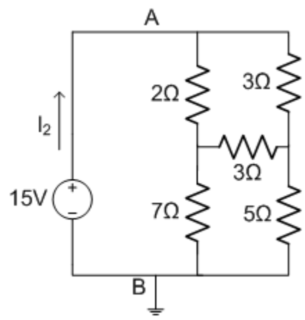


Fig. 4.3

a) Using KCL, $I_1 = \frac{16}{3} + \frac{16}{2+4} = 8A$

b) Equivalent resistance: $R = \frac{16}{8} = 2\Omega$

c) Using KVL,

Loop1: $15 - 2(I_2 - I_1) - 7(I_2 - I_3) = 0 \rightarrow 2I_1 - 9I_2 + 7I_3 = -15$ (1)
Loop2: $2(I_2 - I_1) - 3(I_1) - 3(I_1 - I_3) = 0 \rightarrow 8I_1 - 2I_2 - 3I_3 = 0$ (2)
Loop3: $7(I_2 - I_3) - 3(I_3 - I_1) - 5(I_3) = 0 \rightarrow 3I_1 + 7I_2 - 15I_3 = 0$ (3)

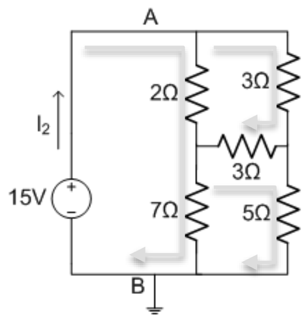
$5 \times (2) - (3)$, $37I_1 - 17I_2 = 0$ (4)

$3 \times (1) + 7 \times (2)$, $62I_1 - 41I_2 = -45$ (5)

$62 \times (4) - 37 \times (5)$, $463I_2 = 1665$,

$I_2 \approx 3.6$

Hence $I_2 = 3.6A$.



d) $R_{AB} = 15/I_2 = 4.17\Omega$.