CSU11031 Electronics Assignment 1

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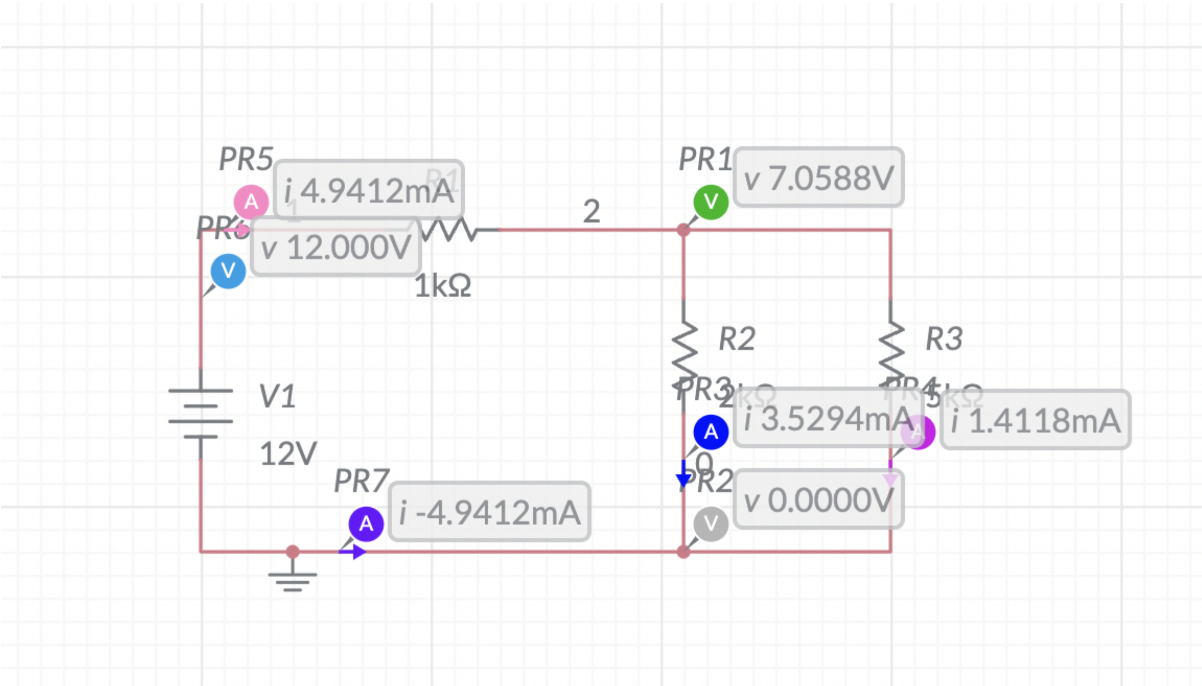
1 Problem 1



1.1 (i) Verify the voltage and current

a) Voltage

To use the Voltage Divider rule, we need to calculate the total resistance R_4 of parallel resistance R_2 and R_3. R_4 is given by

$$\frac{1}{R_4} = \frac{1}{R_2} + \frac{1}{R_3} \tag{1.1}$$

where $R_2 = 2k\Omega$, $R_3 = 5k\Omega$, then the calculation is

$$\frac{1}{R_4} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2000} + \frac{1}{5000} = \frac{7}{10000} = \frac{1}{1428.6} \tag{1.2}$$

$R_4 = 1428.6\Omega$
According to the Voltage Divider rule, the voltage in a serial circuit is given by

$$V_4 = V_{total} * \frac{R_4}{R_{total}} = \frac{R_4}{R_1 + R_4} \tag{1.3}$$

Given $V_{total} = 12V$, $R_1 = 1000\Omega$, $R_4 = 1428.6\Omega$

$$V_4 = 12V * \frac{1428.6\Omega}{2428.6\Omega} = 7.0588V \tag{1.4}$$

b) Current

According to the current rule, the total current in the circuit is given by

$$i_{total} = \frac{V_{total}}{R_{total}} = \frac{12V}{2428.6\Omega} = 4.94mA \tag{1.5}$$

In the parallel circuit formed by R2, R3, the current is divided by

$$i_2 = \frac{V_4}{R_2} = \frac{7.0588V}{2000\Omega} = 3.5294mA \tag{1.6}$$

$$i_3 = \frac{V_4}{R_3} = \frac{7.0588V}{5000\Omega} = 1.4117mA \tag{1.7}$$

1.2 (ii) Verify by calculation Kirchhoff's Current Law for the circuit

According to Kirchhoff's Current Law, for i_2 and i_3

$$\sum I_{node} = 0 \tag{1.8}$$

from the figure we see i_2 = 3.5294mA, i_3 = 1.4117mA, i_0 = -4.9412mA

$$i_0 + i_2 + i_3 = 3.5294mA + 1.4117mA + (-4.94mA) = 0 \tag{1.9}$$

1.3 (iii) Verify by calculation Kirchhoff's Voltage Law for the circuit

According to Kirchhoff's Voltage Law, for V_1 and V_4

$$\sum_{loop} V_{Branch} = 0 \tag{1.10}$$

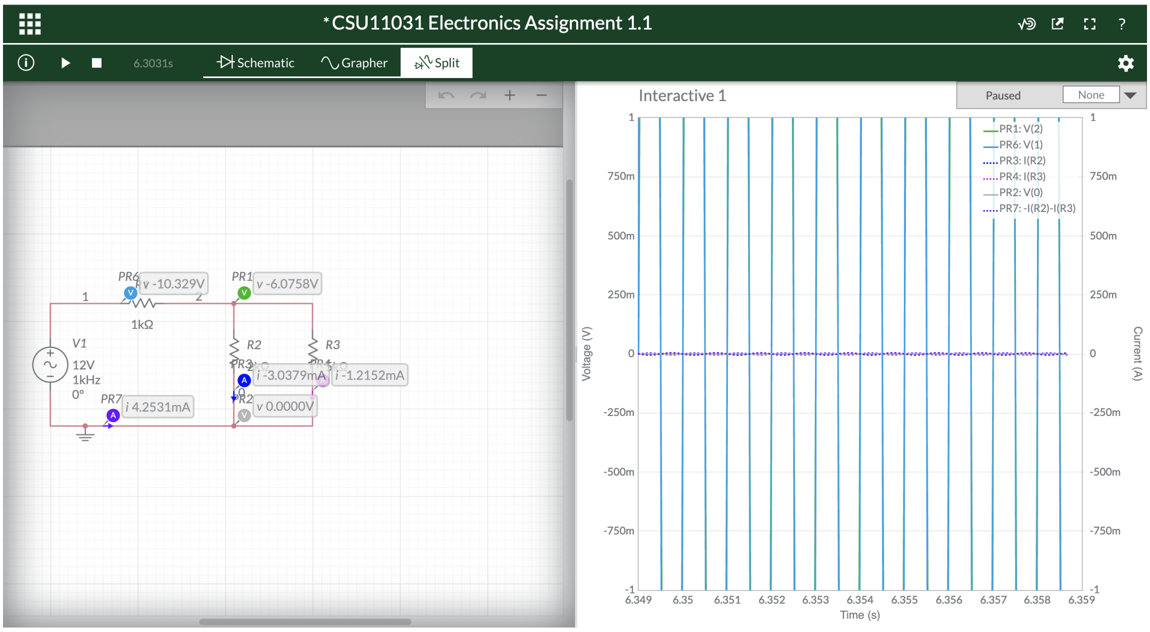
According to Voltage Division law, V_1 is given

$$V_1 = V_{total} * \frac{R1}{R_{total}} = 12V * \frac{1000\Omega}{2428.6\Omega} = 4.9411V \tag{1.11}$$

From (i) we know that R_4 as a whole = 7.0588V Therefore,

$$V_{total} = V_1 + V_2 = 4.9411V + 7.0588V = 12V \tag{1.12}$$

1.4 (iv) Replace the battery with a 12V (peak) AC source,Run the simulation, observe grapher and explain your results.



The total voltage and current goes up and down between $[-12V, 12V]$ and $[-4.94mA, 4.94mA]$ respectively.

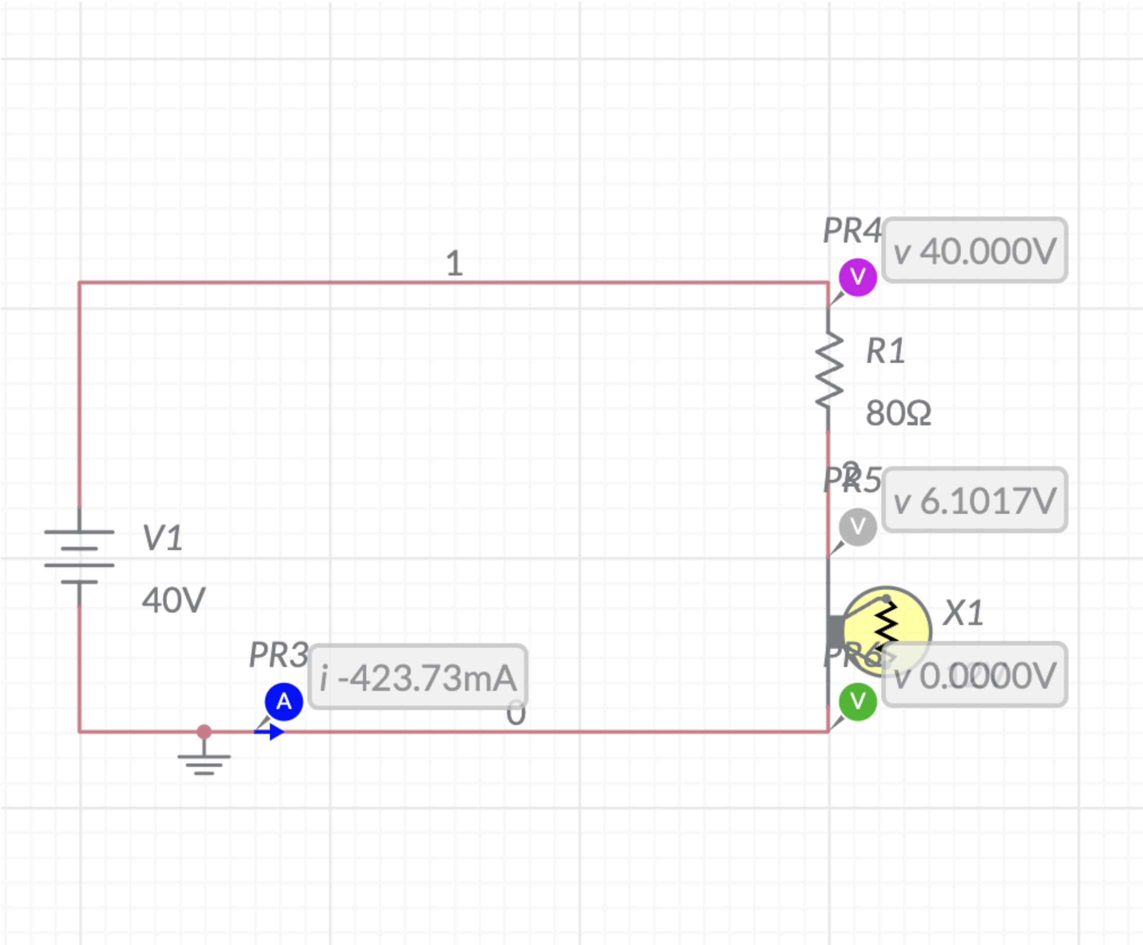
The reason why voltage and current goes is due to the way we generate them, magnetic rotates naturally generate AC which radiate energy.

The same max voltage and current value is because the AC peak voltage remain the same with the previous DC voltage, and other conditions like total resistance, circuit structure remain the same.

Under any conditions, Kirchhoff's current and voltage laws are valid.

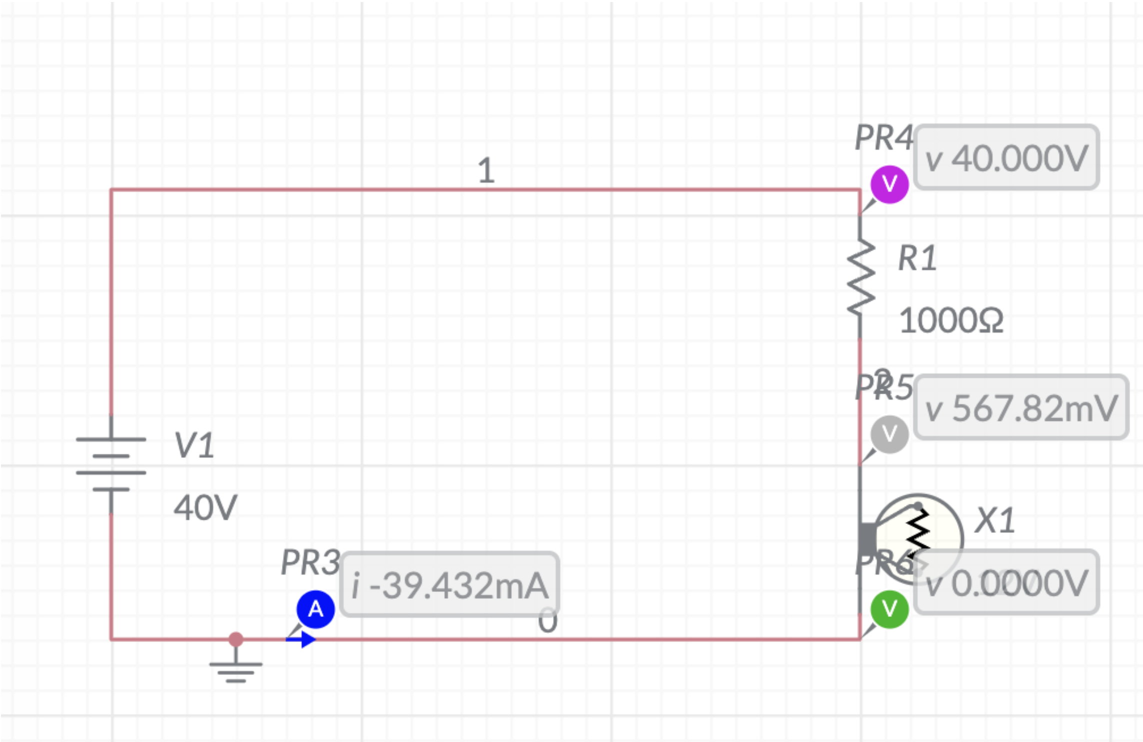
2 Problem 2

2.1 (i) Run the simulation. What do you observe?



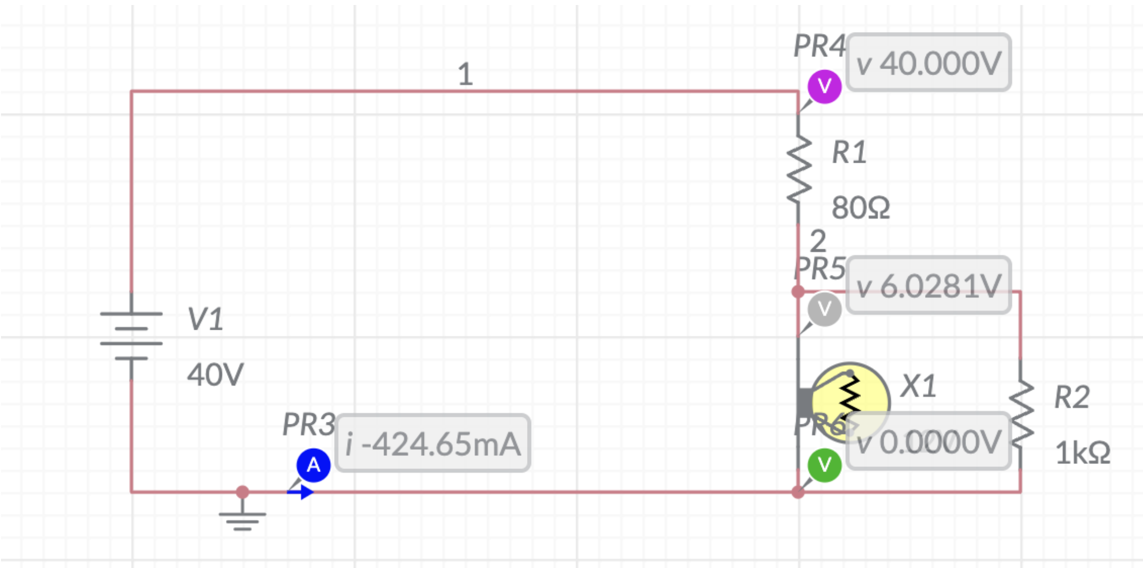
The voltage of the circuit is divided by the voltage division law, giving the 12V bulb a 6.1017V voltage. Therefore the bulb lights up.

2.2 (ii) Replace R1 with a 1K resistor.What do you observe and why?



As R1 upgrades to $1k\Omega$, the bulb with a resistance at about 10Ω can only share 0.56V voltage in a 40V serial circuit, barely lighting it up.

2.3 (iii) With R1 at 80 Ohms, place a 1K resistor in parallel with the lamp. What do you observe and why?



The bulb now shares 6.0281V voltage and lights up. The voltage is a bit lower than the case in 2.(i)

This is due to the parallel $1k\Omega$ resistor which slightly decrease the total resistance of the bulb-resistor parallel circuit.

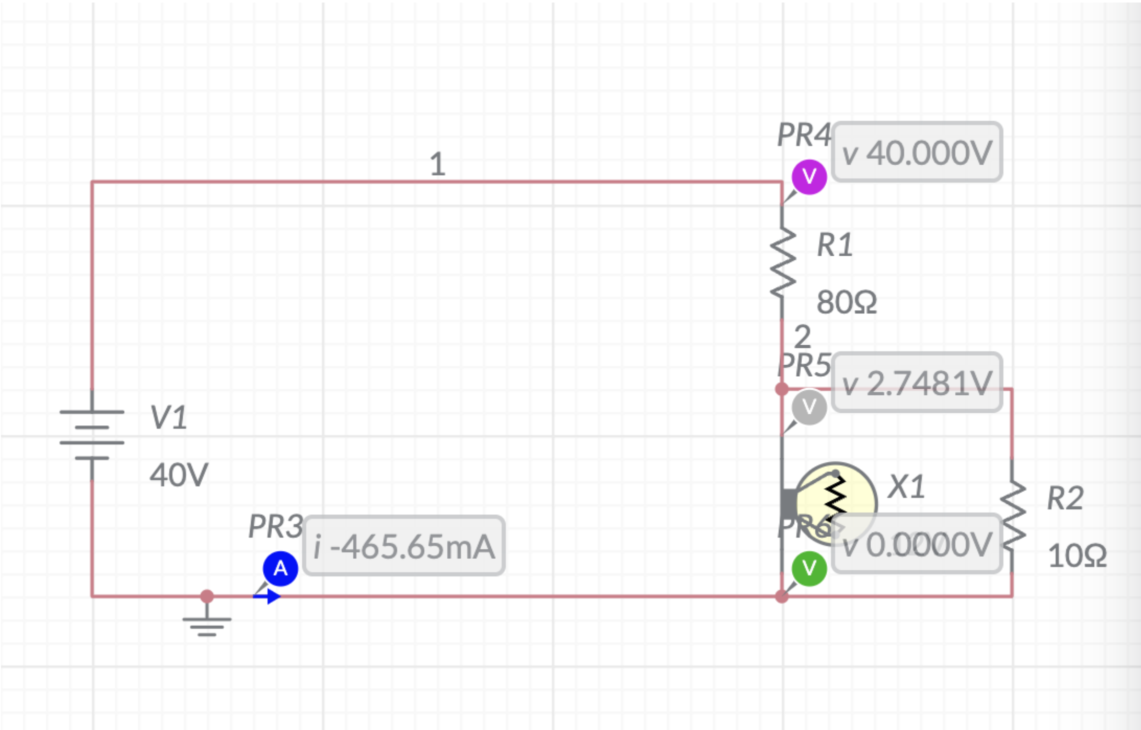
The total resistance of the parallel circuit R_3 can be calculated as:

$$\frac{1}{R_3} = \frac{1}{R_{bulb}} + \frac{1}{R_2} \tag{2.1}$$

$$\frac{1}{R_3} = \frac{1}{10} + \frac{1}{1000} = \frac{1}{9.9} \tag{2.2}$$

Therefore, $R_3 = 9.9\Omega$, 0.1Ω less than the 2.(i)case, so it shares a bit lower voltage.

2.4 (iv) Replace the parallel 1K resistor with a 10 Ohm resistor keeping R1 at 80 Ohms. What do you observe and why?



The voltage that bulb shares is decreased to 2.7481V.

This is because the R2 resistance drop leads to a resistance drop in the total resistance of the bulb-resistor parallel circuit.

The total resistance of the parallel circuit R_3 can be calculated as:

$$\frac{1}{R_3} = \frac{1}{R_{bulb}} + \frac{1}{R_2} \tag{2.3}$$

$$\frac{1}{R_3} = \frac{1}{10} + \frac{1}{10} = \frac{1}{5} \tag{2.4}$$

Therefore, $R_3 = 5\Omega$, 5Ω less than the 2.(i)case, so it shares a lower voltage.

I have also replaced R2 with higher risistance as $10,000\Omega$, and I find that the higher

R2 is, the higher the total resistance, then the voltage is. However, the total resistance of the parallel circuit cannot exceed the single resistance of X1.