**Quiz I** **ECSE 1010** **Fall 2019**

Name SOLUTIONS

1. _____ (10 pts)
2. _____ (6 pts)
3. _____ (12 pts)
4. _____ (14 pts)
5. _____ (8 pts)

Total _____

For partial credit on some questions, you may want to re-draw circuit diagrams as you simplify the circuits.

Show all of your work. Use the backs of pages if there is not enough room on the front.

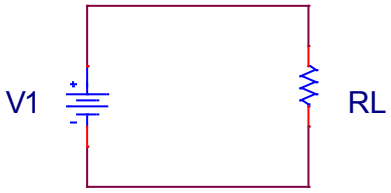
Many problems can be solved using more than one method. Check your answers by using a second method.

At least skim through the entire quiz before you begin and then start with the problems you know best.

The proctor will only answer clarification questions where wording is unclear or where there may be errors/typos. No other questions will be responded to.

**Problem 1 (12 Points) – Ohm's Law**

A simple voltage source-resistor circuit is shown to the right.




a. Determine the current through **RL** (in mAmps) when V1=10V and RL=2kΩ. (4 pts)

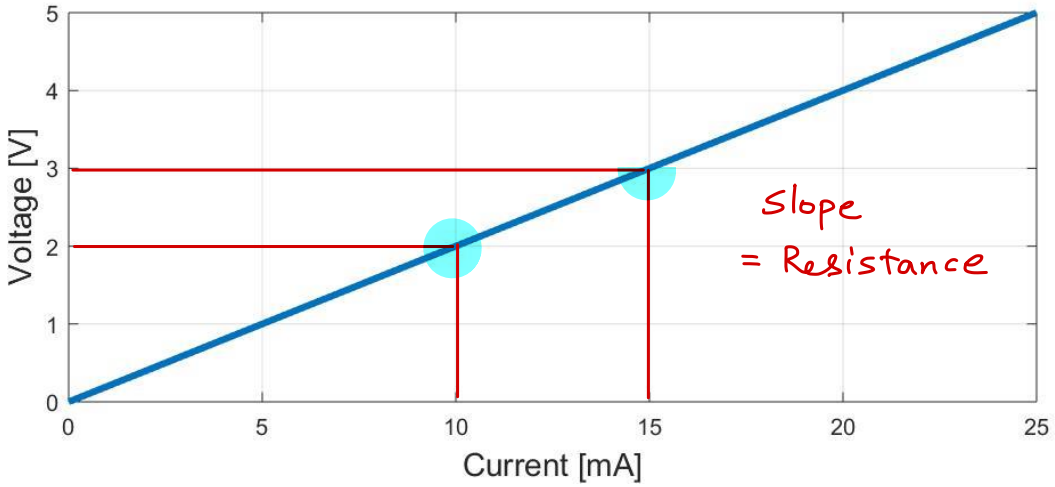
$$I_{RL} = \frac{V1}{RL} = \frac{10\,V}{2k\Omega} = 5\,mA$$

b. For the same circuit, if the voltage increases while the resistance stays constant, the current will (circle one) (1 pt)

Increase Decrease

c. For the same circuit, if the resistance increases while the voltage source stays constant, the current will (circle one) (1 pt)

Increase Decrease



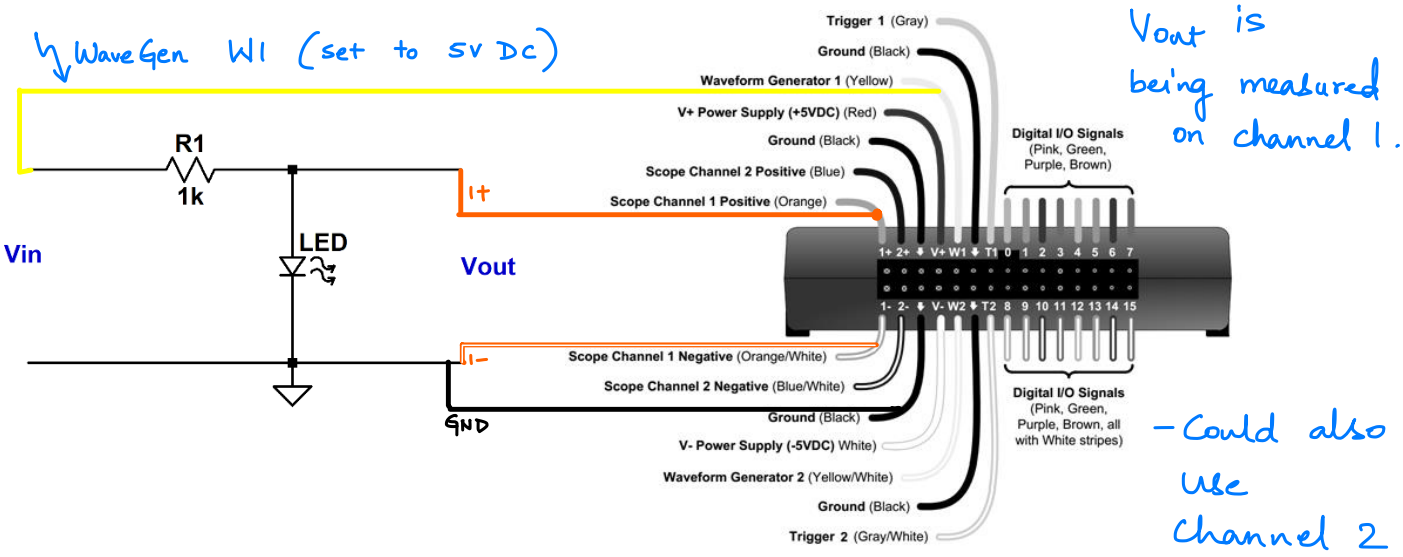

The above linear plot relates voltage and current in a resistor (similar to the circuit at the top of the page).

d. Based on the plot, determine the value of the resistance. Note, the current is given in mA ($10^{-3}$ A) (4 pts)

$$\text{Slope} = R = \frac{dV}{di} = \frac{3-2}{(15-10)m} = \frac{1}{5m}\,\Omega = 200\,\Omega$$

**Problem 2 (6 Points) – The Discovery Board**

a) In the figure below, draw lines from the Discovery Board to the circuit that represent the wires you need to connect to measure the output voltage Vout, i.e. voltage across LED. Additionally, draw lines to provide an input voltage Vin of 5V DC to the circuit using the Analog Discovery (no additional instrumentation). Remember, to generate a DC voltage with Wavegen, you need to use two connections from the Discovery Board. (4 pts)



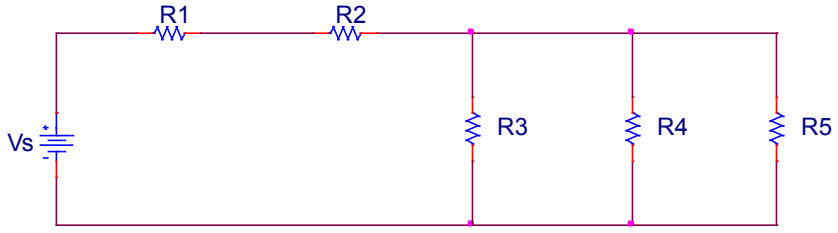

b) If your measurement for Vout is 2.0V (when Vin is 5V), find the current that flows through the resistor R1. (2 pts)

Voltage across R1 = $V_{in} - V_{out}$

= 3V

$$I_{R1} = \frac{V_{R1}}{R1} = \frac{3V}{1K} = \boxed{3\ mA}$$

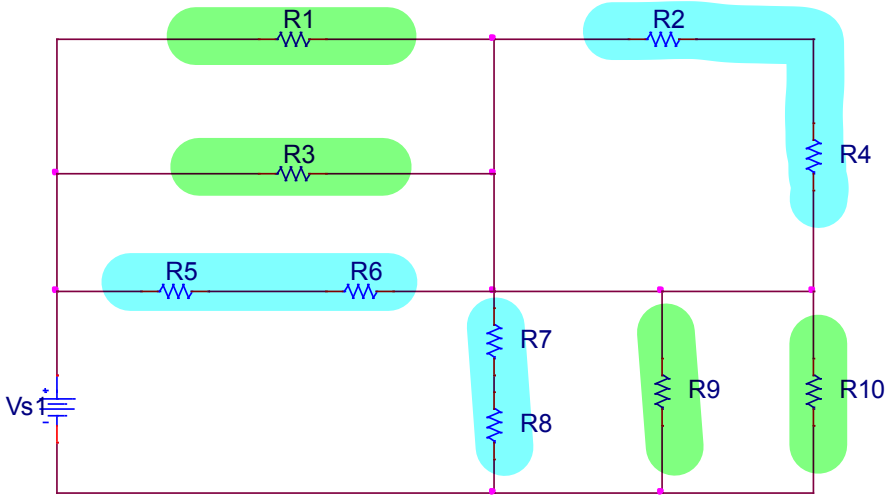
**Problem 3 (12 Points) – Resistors in parallel and series**




a) For the above circuit, indicate which resistors are in series and which resistors are in parallel.

Series: R1 , R2

Parallel: R3, R4, R5




b) For the above circuit, indicate which **pairs** of resistors are in series and which resistors are in parallel. Each line is for a specific pair. There may be more lines than needed. (8 pts)

Series: R5 , R6

Series: R7, R8

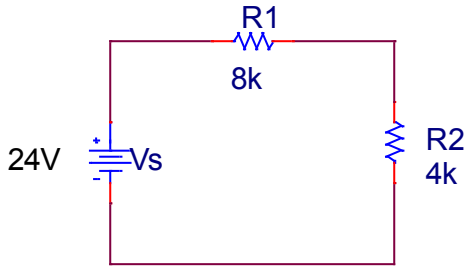
Series: R2, R4

Parallel: R1, R3

Parallel: R9, R10

Parallel:

**Problem 4 (14 Points) – Voltage Dividers – Part 1**




a) For the above circuit, determine the voltages across R1 and R2. (4 pts)

R1:

$$V_{R1} = V_s \left( \frac{R1}{R1+R2} \right) = 24 \left( \frac{8K}{12K} \right)$$

$$= \boxed{16\ V}$$

R2:

$$V_{R2} = V_s \left( \frac{R_2}{R1+R2} \right) = 24 \left( \frac{4K}{12K} \right)$$

$$= \boxed{8\ V}$$

b) If R2 becomes very large (goes to infinity) and R1 stays the same, what is the maximum voltage across R2? (1 pt)

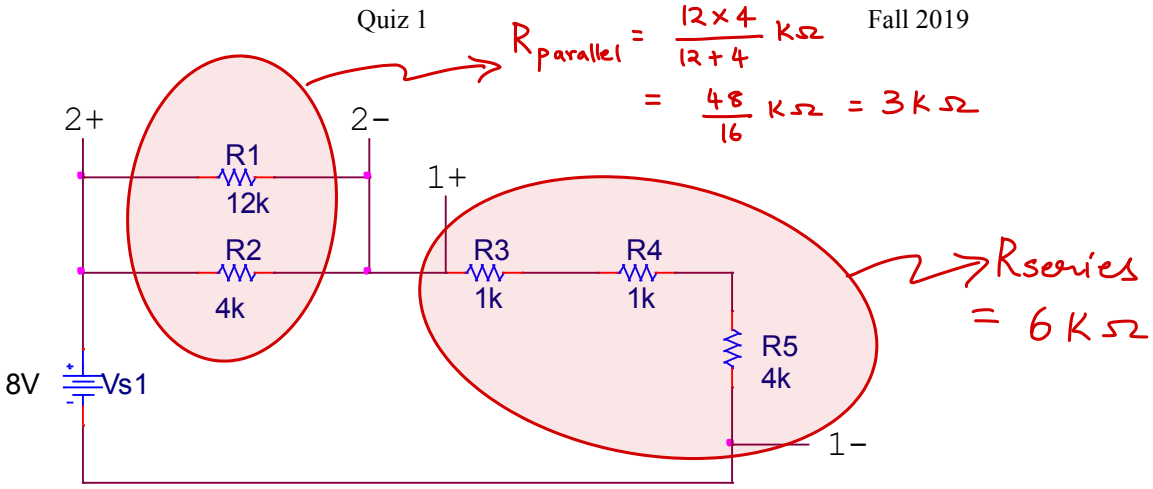
$V_{R2} \propto R2 \Rightarrow$ As $R2 \to \infty$, $V_{R2} \to V_s$

$$\Rightarrow \boxed{V_{R2(max)} = 24\ V}$$

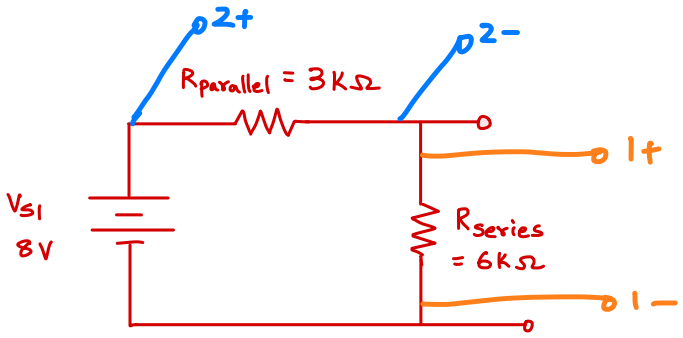
c) If R1 becomes very large (goes to infinity) and R2 stays the same, what is the minimum voltage across R2? (1 pt)

As $R1 \to \infty \Rightarrow V_{R1} \to V_s$

$$\Rightarrow \boxed{V_{R2(min)} = 0V}$$




d) Apply series and parallel relationships to obtain a simplified two resistor (Rseries and Rparallel) circuit. Sketch the new circuit. (4 pts)



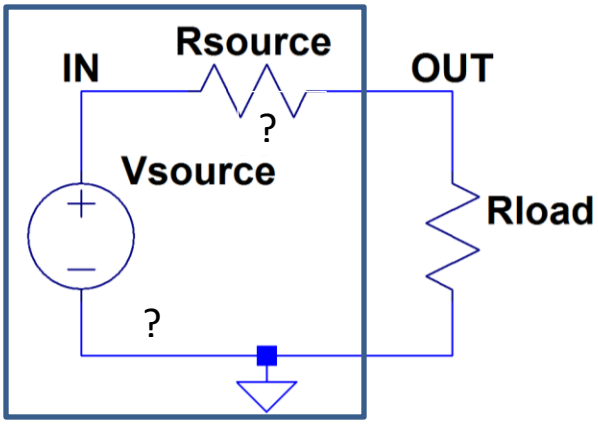

e) Use your simplified circuit to determine the voltages across the equivalent resistors, Rseries and Rparallel, as indicated by the Channel 1 and 2 connections in the original circuit. (4 pts)

$$V_{ch1} = V_{R_{series}} = V_{S1}\left(\frac{6K}{9K}\right) = \boxed{5.33\ V}$$

$$V_{ch2} = V_{R_{parallel}} = V_{S1}\left(\frac{3K}{9K}\right) = \boxed{2.67\ V}$$

**Problem 5 (8 Points) – Source Characterization Using a Voltage Divider**

Batteries and other voltage sources can generally be modeled by combining an ideal voltage source and a resistor. The circuit at the right is set up to study some kind of a black box DC voltage source. Different load resistors are connected and the voltage V(OUT) is measured. The results of the trials are listed in the table below. *Note that there is more information than you need to find the source voltage and resistance.*




| Trial | Rload | V(OUT) |
|---|---|---|
| 1 | 1Ω | 0.692V |
| 2 | 2Ω | 1.245V |
| 3 | 10Ω | 4.276V |
| 4 | 20Ω | 6.316V |
| 5 | 100Ω | 10.15V |
| 6 | 200Ω | 11.01V |
| 7 | 1kΩ | 11.787V |
| 8 | 2kΩ | 11.892V |
| 9 | 10kΩ | 11.978V |
| 10 | 20kΩ | 11.989V |

a. (4 pts) Determine the source voltage **Vsource** (in Volts)

As Rload increases, V(OUT) → 12V

⇒ $V_{source} = 12\ V$

b. (4 pts) Determine the source resistance **Rsource** (in Ohms)

Guess for $R_{source}$ = 20 – 40 Ω

$$V_{(OUT)} = V_{source}\left(\frac{R_{load}}{R_{load} + R_{source}}\right)$$

$$\Rightarrow \quad 6.316 = 12\left(\frac{20}{20 + R_{source}}\right) \Rightarrow \quad R_{source} = 18\ \Omega$$