Intro to ECSE

Quiz 1

Fall 2021

1.	/30
2.	/12
3.	/8
Total	/50

Name _____

Notes:
SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES AND UNITS. No credit will be given for numbers that appear without justification.
Use the backs of pages if there is not enough room on the front.

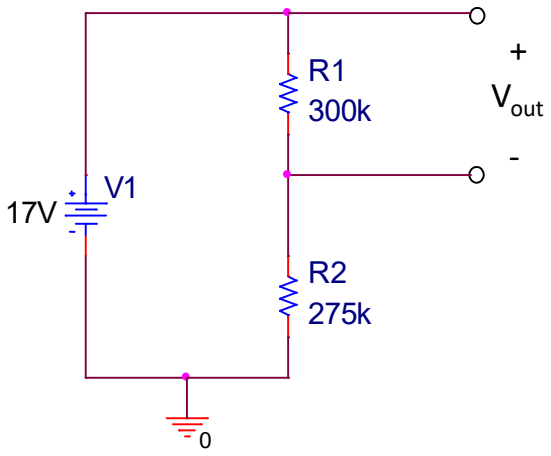
For partial credit on some questions, you may want to re-draw circuit diagrams as you simplify the circuits.

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 (30 pts) - Voltage Dividers, Series and Parallel Resistors, Ohm's law

1.1: (4 pts) Find the voltage V_{out} in the circuit below.



Schematic 1

$R_{11} := 300k\Omega \quad R_{21} := 275k\Omega$

$V_{11} := 17V$

$$V_{out11} := V_{11} \cdot \frac{R_{11}}{R_{11} + R_{21}}$$

$V_{out11} = 8.87\,V$

1.2 (3 pts) Find the current through R2 using ***Schematic 1 above***.

Approach 1:

$I_{R1} = I_{R2}$

$$I_{R1} := \frac{V_{out11}}{R_{11}} = 0.03 \cdot mA$$

$I_{R2} := I_{R1} = 2.957 \times 10^{-5} \cdot A$

Approach 2

$R_{eq11} := R_{11} + R_{21} = 5.75 \times 10^{5}\,\Omega$

$$I_{R2} := \frac{V_{11}}{R_{eq11}} = 2.957 \times 10^{-5}\,A$$

Approach 3

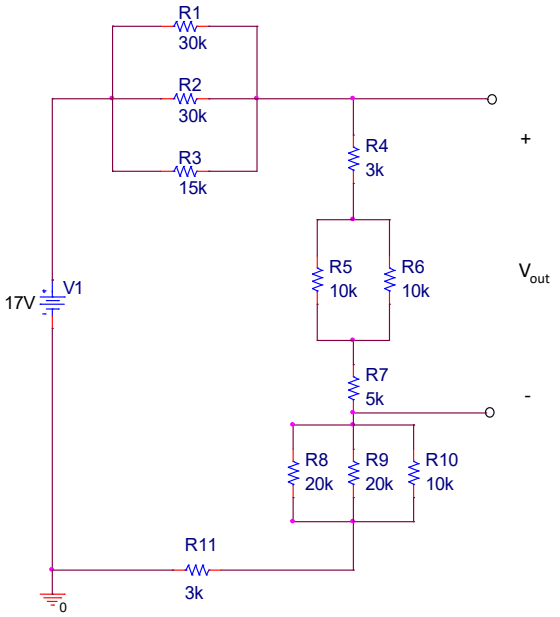
$V_{R2} := V_{11} - V_{out11} = 8.13\,V$

$$I_{R2} := \frac{V_{R2}}{R_{21}} = 2.957 \times 10^{-5}\,A$$

1.3 (4 pts) Circle all statements that are true about **Schematic 1 above**. You MUST briefly write you explanation why you did or did not circle all statements for full credit. Assume every statement is the only change made.

To increase the current through R2 I can:	Please write why below
Put another resistor, R3, in parallel with R1	yes circle, parallel with R1 reduces resistance, more current I=V/R
Increase the resistance of R2.	No circle, I=V/R R goes up, I goes down
Put another resistor, R3, in parallel with R2.	No circle, current will split between R2 and R3
Increase the source voltage.	Yes circle, more voltage means more voltage drop across R2, means more current through R2

1.4: (6 pts) **Reduce the circuit to 3 resistors (in a way to make it easy to find Vout)**. Redraw the circuit and label the circuit with the appropriate component values. ***Include the label for Vout.***



Schematic 2

$R_{12} := 30k\Omega \quad R_{22} := 30k\Omega$

$R_{32} := 15k\Omega \quad R_{42} := 3k\Omega$

$R_{52} := 10k\Omega \quad R_{62} := 10k\Omega$

$R_{72} := 5k\Omega \quad R_{82} := 20k\Omega$

$R_{92} := 20k\Omega \quad R_{102} := 10k\Omega$

$R_{112} := 3k\Omega \quad V_{12} := 17V$

Your redrawn circuit schematic below:

$$R_{123} := \left(\frac{1}{R_{12}} + \frac{1}{R_{22}} + \frac{1}{R_{32}}\right)^{-1}$$

$R_{123} = 7.5 \times 10^{3}\,\Omega$

$$R_{4567} := R_{42} + \left(\frac{1}{R_{52}} + \frac{1}{R_{62}}\right)^{-1} + R_{72}$$

$R_{4567} = 1.3 \times 10^{4}\,\Omega$

$$R_{891011} := R_{112} + \left(\frac{1}{R_{82}} + \frac{1}{R_{92}} + \frac{1}{R_{102}}\right)^{-1}$$

$R_{891011} = 8 \times 10^{3}\,\Omega$

1.5: (3 pts) Find the value of Vout in your redrawn schematic:

$$V_{outp12} := V_{12} \cdot \frac{R_{4567}}{R_{123} + R_{4567} + R_{891011}}$$

$V_{outp12} = 7.754\,V$ V_{out} **=** 7.75

1.6: (4 pts) Using your **redrawn schematic from Schematic 2**, find the total current from the 17V source (total source current).

$$R_{eq3} := R_{123} + R_{4567} + R_{891011}$$

$$R_{eq3} = 2.85 \times 10^{4}\,\Omega$$

$$I_{V12} := \frac{V_{12}}{R_{eq3}} = 5.965 \times 10^{-4}\,A \qquad I_{V12} = 5.97 \cdot 10^{-4}\,A$$

1.7: (2 pts) Using your **redrawn schematic from Schematic 2**, find the current through R4.

It must be the same as the source current.

$$I_{R4} := I_{V12} = 5.965 \times 10^{-4}\,A \qquad I_{R4} = 5.97 \cdot 10^{-4}\,A$$

1.8: (4 pts) Using your **redrawn schematic from Schematic 2**, find the current through R5.

You could find the voltage across V56 using voltage divider from vout then use ohm's law

$$V_{outp12} = 7.754\,V \qquad R_{56} := \frac{R_{52} \cdot R_{62}}{R_{52} + R_{62}} = 5 \times 10^{3}\,\Omega$$

$$V_{56} := V_{outp12} \cdot \frac{R_{56}}{R_{42} + R_{56} + R_{72}} = 2.982\,V$$

$$I_{R5} := \frac{V_{56}}{R_{52}} = 2.982 \times 10^{-4}\,A$$

Problem 2 (12 pts) - Experimental Setup and the M1K Board

2.1: (4 pts) 4-band Resistor values

What are the colors of the bands for the following resistor values:

350 ohm ± 5%

_____ _____ _____ _____

Orange Green Brown Gold

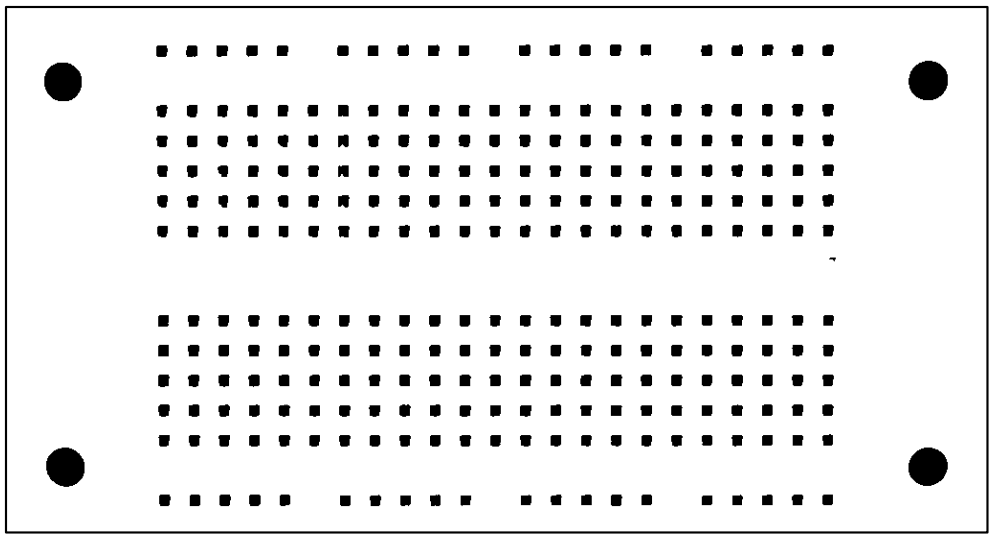
74 kohm ± 10%

_____ _____ _____ _____

Violet Yellow Orange Silver

Color	Value	Multiplier	Tolerance
Black	0	$x10^0$	±20%
Brown	1	$x10^1$	±1%
Red	2	$x10^2$	±2%
Orange	3	$x10^3$	±3%
Yellow	4	$x10^4$	-0%, +100%
Green	5	$x10^5$	±0.5%
Blue	6	$x10^6$	±0.25%
Violet	7	$x10^7$	±0.10%
Gray	8	$x10^8$	±0.05%
White	9	$x10^9$	±10%
Gold	-	$x10^{-1}$	±5%
Silver	-	$x10^{-2}$	±10%

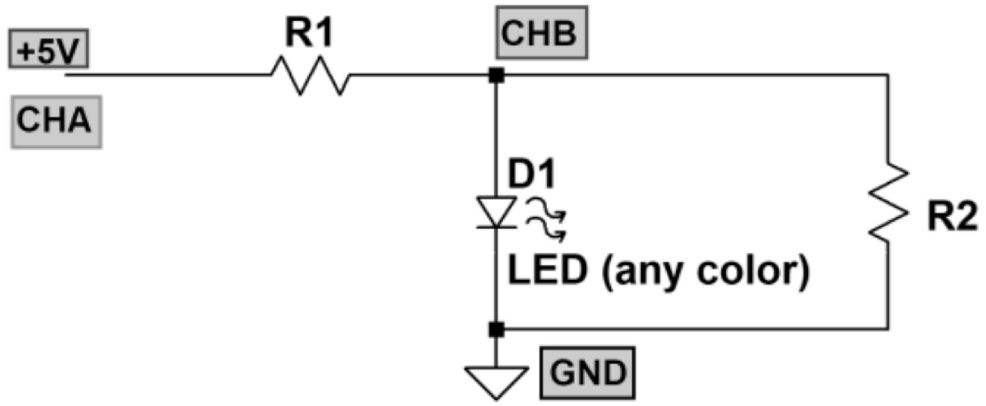
2.2: (2 pts) Breadboards



Draw a two lines above that demonstrate how the breadboard is connected. Be sure to ***draw your line through all holes that are connected in your choices.***

Five holes above or below DIP support should have a line (vertical in this picture)
All the holes at very bottom or very top should have a line (horizontal in this picture)

2.3: (4 pts) M1K DC Measurement



In this circuit above, what M1K pinouts are you using?
(The colors on the M1K are inverted for easier reading)

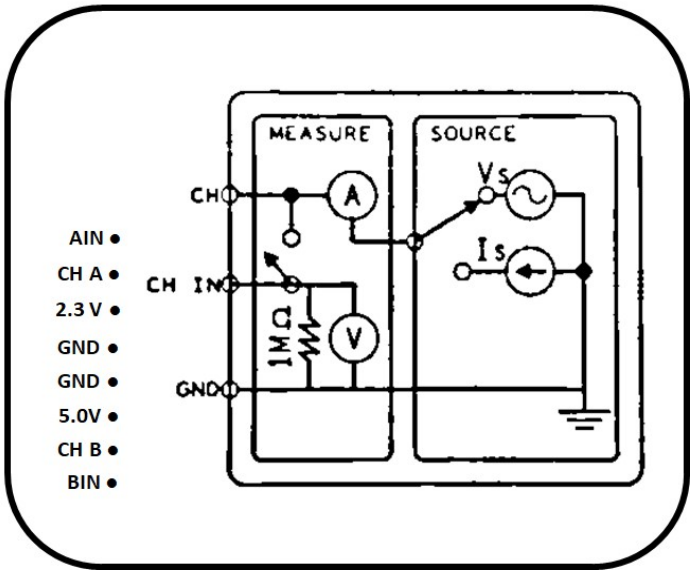
You may point to the pinout and label with notation shown in green in the schematic.

AIN (OR CHA) – CHA

BIN (OR CHB) – CHB

GND – GND

5.0V - +5V



2.4: (2 pts) How would you change the switches to source current instead of voltage but keep a voltmeter measurement?

Depending on configuration in 2.3:
If chose AIN for CHA in 2.3 to measure voltage, use CHA to source current, click split I/0 there, CHA on, then CHA I.

If chose CHA for CHA in 2.3 to measure voltage, change to AIN to measure voltage CHA, use CHA to source current, click split I/0 there, CHA on, then CHA I.

Problem 3 (8 pts) - Source Characterization

3.1: (2 pts) What equation will help determine the internal resistance of a batter (value of Rbat)?

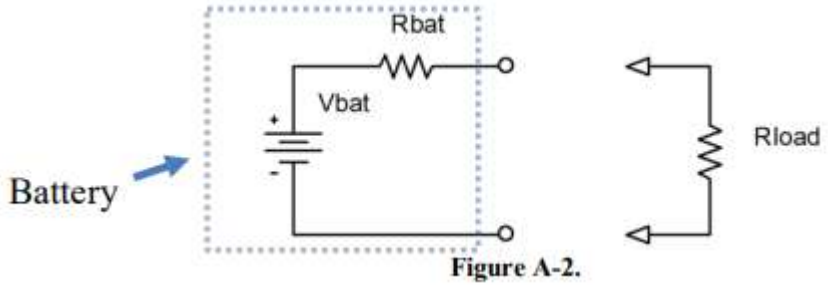


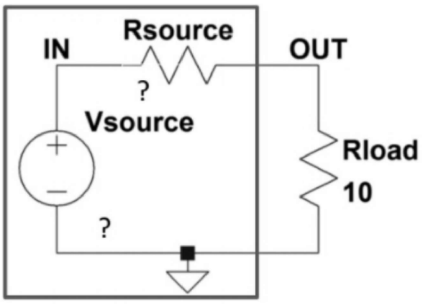
Figure A-2.

the voltage divider equation

$$V_{out} = V_{bat} \cdot \frac{R_{Load}}{R_{bat} + R_{Load}}$$

3.2: (3 pts) Batteries can be modeled by cominbing an ideal voltage source and a resistor. The trials below are experimental values after connecting different loads to the battery.

Find the source voltage Vsource (in Volts) using the chart below. Circle what helped you determine this in the chart.



RLoad gets bigger and voltage starts to saturate at 4.5V

Trial	Rload (ohms)	V(out)
1	68Ω	1.588V
2	100Ω	1.682V
3	150Ω	1.712V
4	200Ω	1.753V
5	250Ω	1.819V
6	500Ω	2.232V
7	750Ω	2.721V
8	1KΩ	3.878V
9	2KΩ	4.417V
10	10KΩ	4.476V
11	20KΩ	4.495V

3.3: (3 pts) Find the source resistance (Rsource).

Look for when Vout is half of the saturation volage with a high load resistance.

$$\text{Vouthalf} := \frac{4.5}{2} = 2.25$$

This is close to 500 ohms value 2.232V

$$2.232 = 4.5 \cdot \frac{500}{R_{source} + 500}$$

$$R_{source} := 4.5\text{V} \cdot \frac{500\Omega}{2.232\text{V}} - 500\Omega = 508.065\Omega$$