If you constructed the circuit properly and made the measurements right you will have a "C" grade (exact grade depends on quality) ← GRADING

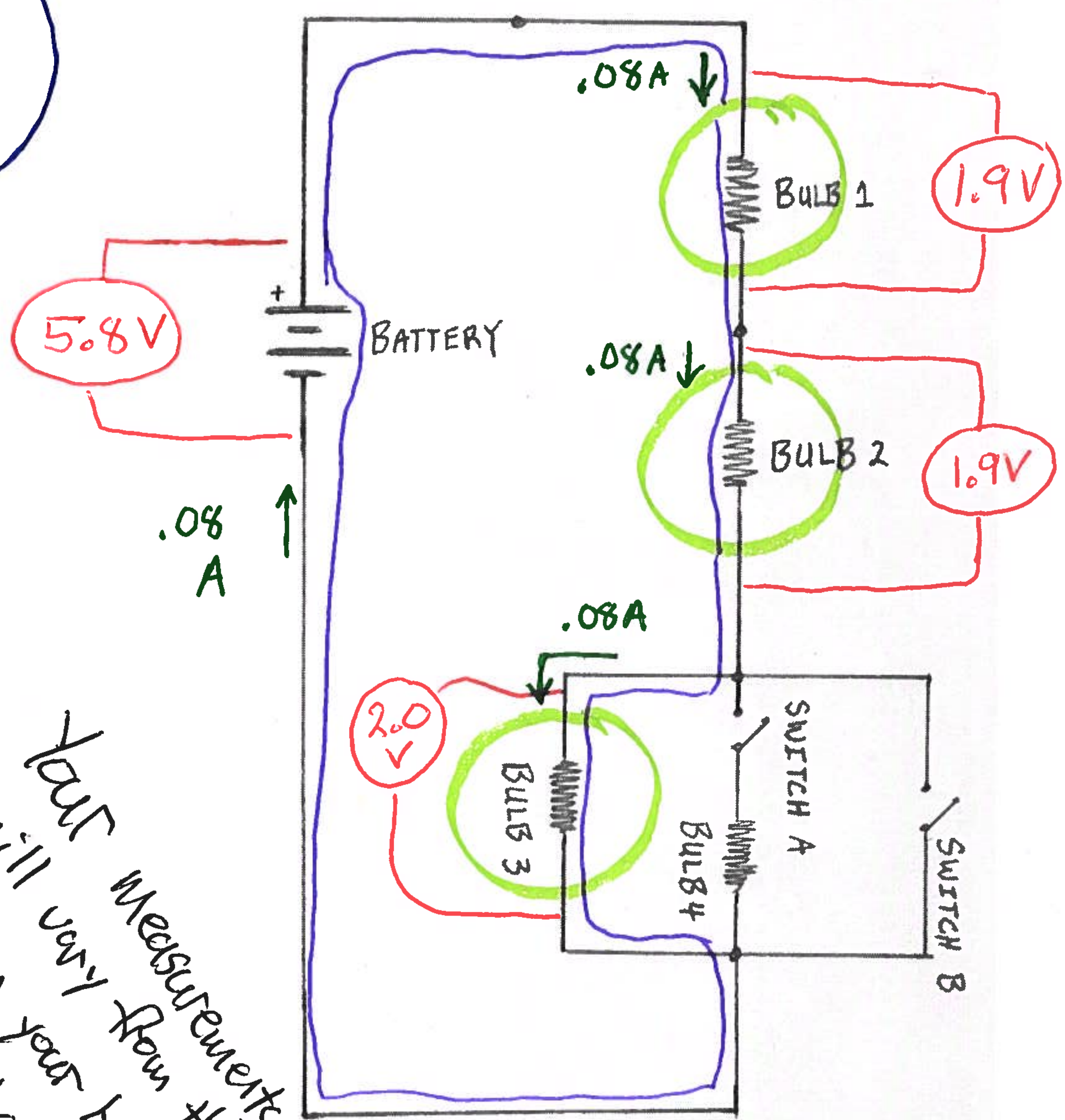
If you also did the calculations right you will have an A grade (exact grade depends on quality)

FINAL CIRCUITS PROJECT (DOUBLE CREDIT)

This is our last project for ELT 110. In it you will put to use many of the skills that you learned in this class: both the hands-on skills and the calculation skills. **This project counts "double"—worth two project grades.** You will need your multimeter for this project, plus materials left over from previous projects.

Construct the circuit shown here using light bulbs (incandescent strongly recommended), switches, and a battery. All bulbs should be of the same type. You should have these materials from previous projects. Spread your circuit out—use connecting wires between the switches, bulbs, and batteries, and tape or staple the circuit down—it will make your measurements much easier. Remember that resistance changes with temperature, so bulb resistances may change if they are brighter or dimmer.

A



Your measurements will vary from these based on your battery & bulbs

A) Set the circuit so both Switch A and Switch B are open ("off").

i. Take a photo of the circuit (connected and "bulbs lit").
ii. Measure the current (in Amps) through each bulb and the battery.
iii. Measure the voltage (in Volts) across each bulb and the battery.
iv. Use the current and voltage measurements for each bulb to calculate the resistance of each bulb (in Ohms) and the power used by each bulb (in Watts).
v. Use the current and voltage measurements for the battery to calculate the total resistance of the entire circuit (in Ohms) and the power output of the battery (in Watts).
vi. Calculate the total resistance of the entire circuit by adding up the resistances of the individual bulbs in series/parallel.
vii. Answer this question: Is the power rule working in this circuit? In other words, is the total power used by the bulbs equal to the power output of the battery? Explain your answer briefly.
viii. Answer this question: Is Kirchoff's Voltage Law working in this circuit? In other words, do the voltage drops around any loop in the circuit add up to the battery voltage? Explain your answer briefly.
ix. Answer this question: Is Kirchoff's Current Law working in this circuit? Does the "current in" equal the "current out" at all junctions/nodes in the circuit? Explain your answer briefly.
x. Answer this question: Do the resistances add up in series/parallel like they should? In other words, in *step vi* did you get the same answer for the total resistance of the circuit as you got in *step v*? Explain your answer briefly.

B) Set the circuit so Switch A is closed ("on") and Switch B is open.

Repeat steps *i-x*.

C) Set the circuit so Switch A is open and Switch B is closed.

Repeat steps *i-x*.

D) Discuss in a typed paragraph what problems and successes you experienced in this project.

E) Discuss in a typed paragraph whether bulb resistance seemed to change with temperature.

F) Discuss in a typed paragraph what you learned in this project.

Turn in all your material in a single WORD or PDF document. You should have three photos, and answers to A-F.

(A)

i - PHOTO

B_1 = Bulb 1

B_2 = Bulb 2

B_3 = Bulb 3

ii - $B_1 = B_2 = B_3 = B_{ATT} = .08\,A$

iii - $B_{ATT} = 5.8V$

$B_1 = 1.9V \quad B_2 = 1.9V \quad B_3 = 2V$

iv - 

$R = \frac{V}{I} = \frac{1.9V}{.08A} = 23.75\,\Omega$ Bulb 1

$\frac{1.9}{.08} A = 23.75\,\Omega$ Bulb 2

$\frac{2V}{.08} A = 25\,\Omega$ Bulb 3

$P = IV = .08A(1.9V) = 0.152\,W$ Bulb 1

$.08A(1.9V) = 0.152\,W$ Bulb 2

$.08A(2V) = 0.160\,W$ Bulb 3

v - $R = \frac{V}{I} = \frac{5.8V}{.08A} = 72.5\,\Omega$

$P = IV = .08A(5.8V) = .464\,W$

vi - Series (add R's)

$R = 23.75 + 23.75 + 25 = 72.5\,\Omega$

vii - The total bulb power is 0.152 + 0.152 + 0.160 = 0.464W

The battery power is 0.464 W

They are equal. Power is working

viii - The battery voltage is 5.8V. There is one (purple) loop in the circuit and the voltages in that loop add to 1.9 + 1.9 + 2.0 = 5.8 V. Voltage loop Law is working.

ix - Current is 0.08 A in and out of everything so current in = current out everywhere.

x - Step vi total R = 72.5 Ω

Step v total R = 72.5 Ω

Yes, they added like they should

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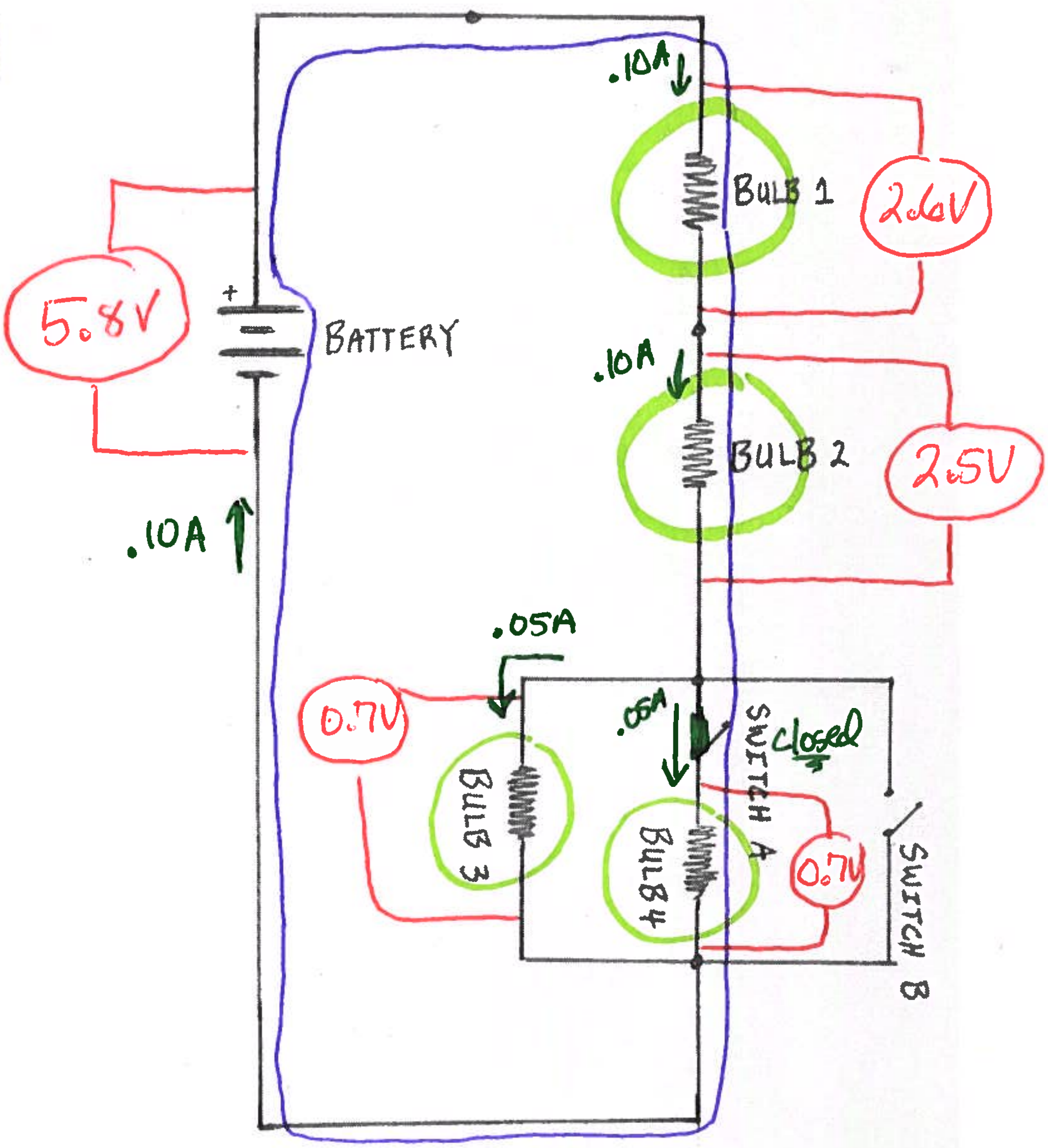
B



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B

i - Photo

ii - $B_1 = B_2 = 0.10\,A$ = BATT

$B_3 = B_4 = 0.05\,A$

iii - BATT = 5.8V

$B_1 = 2.6V$ $\quad$ $B_3 = 0.7V$

$B_2 = 2.5V$ $\quad$ $B_4 = 0.7V$

iv - V / IR $\quad$ $R = \frac{V}{I} = \frac{2.6\,V}{.10\,A} = 26\,\Omega$ Bulb 1

$R = \frac{V}{I} = \frac{2.5V}{.10A} = 25\,\Omega$ Bulb 2

$\frac{0.7V}{.05A} = 14\,\Omega$ Bulb 3 + Bulb 4

v - P / IV $\quad$ $P = IV$ $\quad$ $P = .10A(2.6V) = 0.260\,W$ Bulb 1

$.10A(2.5V) = 0.250\,W$ Bulb 2

$.05A(0.7V) = 0.035W$ Bulb 3 + Bulb 4

$\frac{5.8V}{.10A} = 58\,\Omega$ whole circuit

$5.8V(.10A) = 0.58\,W$

vi Add B3 + B4 in parallel

$G_3 = \frac{1}{14} = 0.07143$

$G_4 = + \frac{1}{14} = 0.07143$

0.14286

$R_{\text{BOTH BULBS}} = \frac{1}{0.14286} = 7\,\Omega$

So the bulb 3-4 parallel combination is 7Ω

Now add the 3/4 combo to Bulbs 1+2 in series:

$$26\,\Omega + 25\,\Omega + 7\,\Omega = 58\,\Omega$$

vii. TOTAL BULB POWER = 0.260 W + 0.250 W + 0.035 W + 0.035 W
= 0.580 W

BATTERY POWER = 0.58 W   It works!

viii. Battery voltage is 5.8 V.

Going around Purple loop, bulbs add up to

$$2.6\,V + 2.5\,V + 0.7\,V = 5.8\,V$$

For loop you can't include both Bulb 3 and Bulb 4.

ix. Current is 0.10 A in and out of each series element and at the parallel pair the currents are

0.05 + 0.05 A = 0.10 A so current in = current out

x. Step v R = 58 Ω
Step vi R = 58 Ω

They add up like they should

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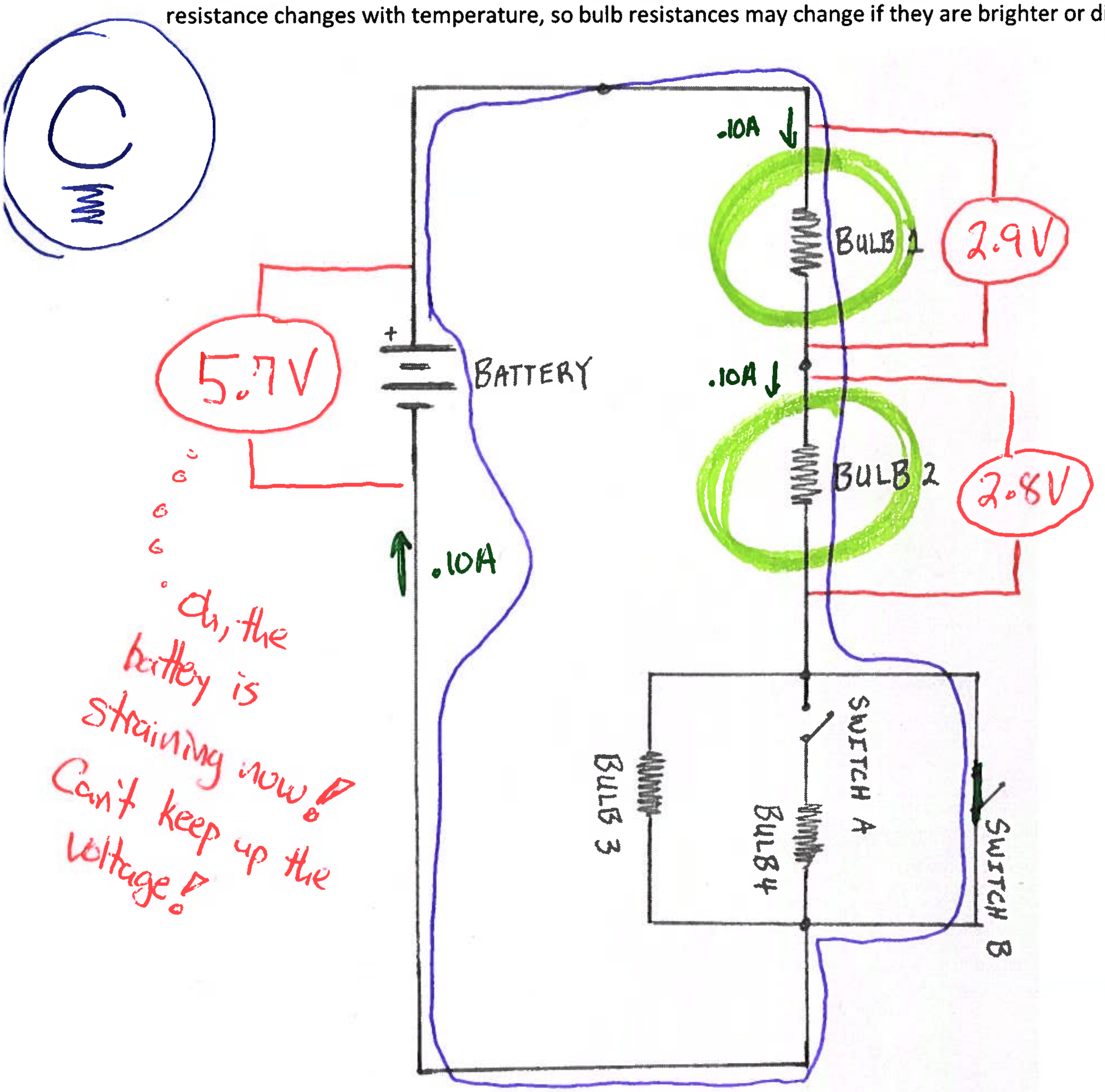

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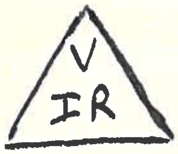
i- PHOTO

C

ii - $B_1 = B_2 = BATT = 0.10\,A$

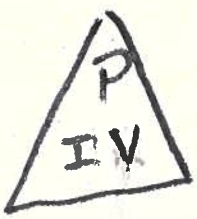
iii - $B_1 = 2.9V \quad B_2 = 2.8V \quad BATT = 5.7V$

iv -



$R = \frac{V}{I} \qquad \frac{2.9V}{.10A} = 29\,\Omega$ Bulb 1

$\frac{2.8V}{.10A} = 28\,\Omega$ Bulb 2



$P = IV \qquad .10A(2.9V) = 0.290\,W$ Bulb 1

$.10A(2.8V) = 0.280\,W$ Bulb 2

v - $R = \frac{V}{I} = \frac{5.7V}{.10A} = 57\,\Omega$ whole circuit

$P = IV = .10A(5.7V) = 0.57\,W$

vi - Series - add Resistances

$29\,\Omega + 28\,\Omega = 57\,\Omega$

vii Bulbs add to $0.29W + .28W = 0.57W$

Total is $0.57\,W$ Power works

viii → Batt = 5.7V   Bulbs = 2.9V + 2.8V = 5.7V

It works

ix → 0.10 A everywhere It works

X = Step V 57 Ω
    Step vi 57 Ω   It works

QUESTION

E: Bulb Resistance does change – the hotter the bulb is (more power) the higher its resistance:

Bulb 3/4 in Part B: 0.035 W → 14 Ω

Bulb 1 in Part A: 0.152 W → 23.75 Ω

Bulb 1 in Part B: 0.260 W → 26 Ω

Bulb 1 in Part C: 0.29 W → 29 Ω