DLS/Stevenson East Side Science Olympiad Invitational

Saturday, January 26, 2013

Circuit Lab – Practical

Team Number: _____ Team Name: _____

Team Members: _____

1. Please record your answers in the space provided. If you fail to record an answer, you will not get any credit for that question.
2. You may separate the pages but they ALL must be re-stapled in the correct order at end of the test.
3. You have 8 minutes at each station. Use your time wisely.
4. **Failing return the complete exam (all four pages) will disqualify you from the event.**
5. Voltage or current sources are as labeled. If they are not labeled you need to measure these.
6. Read all the instructions before you begin at any station.
7. You will be experimenting with fragile circuits. Be careful when you take measurements. **Damaging the circuits will disqualify you from the event.**

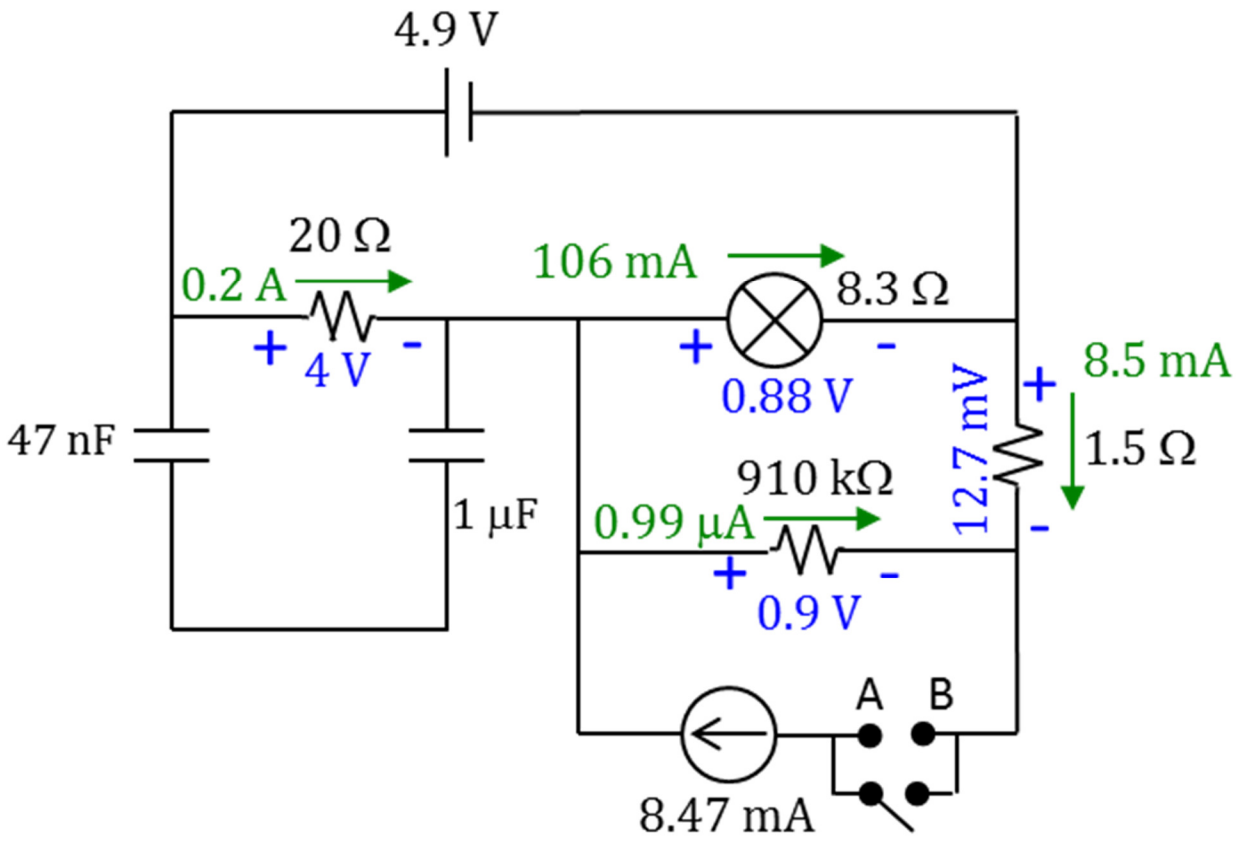
DO NOT TURN THE PAGE UNTIL YOU ARE TOLD TO!

Score: _____ Rank: _____

Station 1

1. Observe the circuit at the station.
2. It has a voltage source, three resistors, a light bulb, two capacitors, and a current source, and a switch.
3. Draw the circuit diagram and label all circuit elements with numerical value.
4. Measure the voltage source.
5. Read the resistors and capacitors.
6. Make sure the switch is in off position.
7. An identical bulb is provided. Use it to measure the resistance of the bulb.
8. Measure the current source using the open terminals A & B.
9. Turn the switch to on position.
10. Measure the voltage across all resistors and the bulb.
11. Turn the switch off.
12. Label the voltage drops across all resistors and the bulb as well as the current through these.

Circuit Diagram



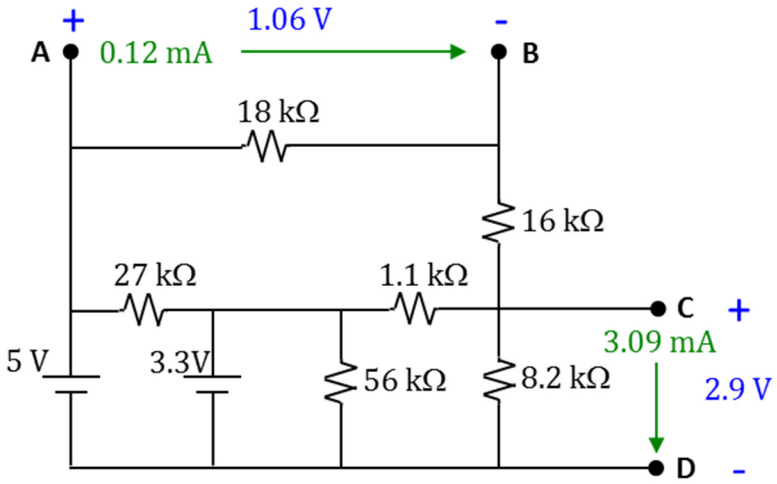
As an exercise, try KCL and KVL to see if the measurements make sense! See Station pictures! Rubric at the end.

You should get the polarities from the sign of multimeter values and placement of probes.

Station 2

1. Calculate the time constant for the circuit shown if a Capacitor with Capacitance "C" is connected across terminals A & B.
2. Show all intermediate steps and measurements.
3. Draw the Thévenin equivalent circuit with respect to terminals A & B. Label the circuit appropriately.
4. Calculate the time constant for the circuit shown if a Capacitor with Capacitance "C" is connected across terminals C & D.
5. Show all intermediate steps and measurements.
6. Draw the Norton equivalent circuit with respect to terminals C & D. Label the circuit appropriately.

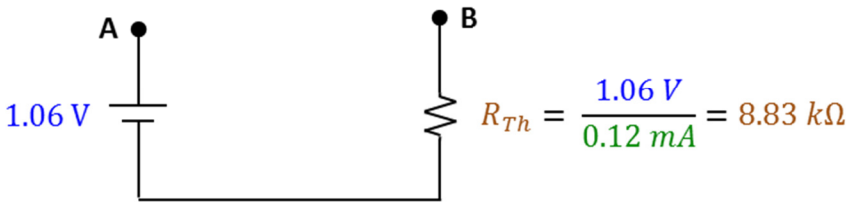
a) Circuit Diagram with measurements. Values of the resistances or voltage sources are not required. Only given for sake of completeness. Try to solve the circuit using node and mesh analysis (not part of this solution, but a suggestion for further work).



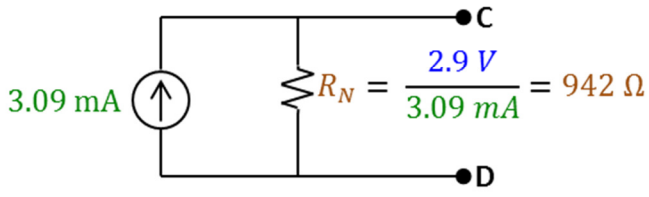
b) It is important to orient the +ve terminal of the battery to measured positive terminal A. The Thévenin equivalent resistance is in series with AB and the voltage source. The value of this resistance is calculated by dividing open circuit voltage you measured by the short circuit current you measured.

c) It is important to orient direction of current source to match the direction CD in the outer mesh. The Norton equivalent resistance is in parallel with CD and the current source. The value of this resistance is calculated by dividing open circuit voltage you measured by the short circuit current you measured.

Thévenin Equivalent Circuit



Norton Equivalent Circuit



Time Constant for AB: 8.83C kS Time Constant for CD: 942C S

Station 3

The circuit at Station 3 was recovered by the spy agency and handed over to Science. Your mission is to gain the insight on the circuit design by analyzing it. The documentation found with circuit has revealed the following clues. Use them wisely. Show your work and results!

1. The circuit is connected to a current source. What is the current when the switch is position D?

Current source: 24.6 µA - Give full credit if shown on the circuit diagram

2. The switch on the current source discharges or charges the capacitors if thrown to D or C position.
3. The voltage across the alligator clips ramps up when the switch is thrown to charge position.
4. The time it takes to reach 10 volts is of particular interest. Use the timer provided to measure the time.

Time to 10 volts: 49.2 S, 49.2 S, 48.1 S, 48.0 S, 48.2 S Mean time: 48.5 S The time will vary if the teams use different multimeter (something to think about after). Full credit for 30 to 55 sec.

5. What did the voltage stabilize to?

Maximum Voltage: 21 ±2 V

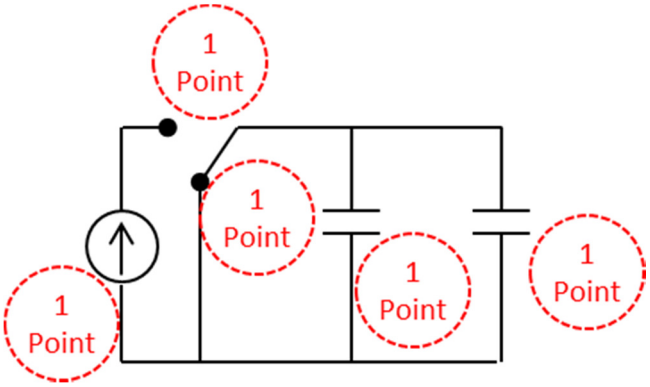
6. How do you relate the current measured to the rate of voltage ramp up?

$Q = C\,V \;\Rightarrow \frac{Q}{t} = C\,\frac{V}{t}$ or $I = C\,\frac{V}{t}$

7. What will be the equivalent capacitance of the capacitors used?

Equivalent capacitance $C = I * t/10V = 24.6\ \mu A * 48.5\ S / 10\ V = 119\ \mu F$

8. Are these capacitors in series or parallel? Parallel
9. Since commercial capacitors are used, can you identify the capacitance for each using the table of commercially available capacitance at the Station? 22 & 100 µF, but any two that add up to Q7 answer.
10. Draw the circuit diagram. Show the switch in the discharge position.



11. Does polarity matter on how the capacitors are connected? Why or Why not?

For non-polar capacitors (like ceramic or parallel plate or foil) the polarity does not matter. This is because they are identical (symmetrical) in how these are constructed.
For polar capacitors (like electrolytic or tantalum capacitors) the polarity matters. This is because of how these capacitors are constructed. For Electrolytic capacitors there is a metal tube filled with electrolytic fluid separated by an insulator. Tantalum capacitors are also constructed similar but outer tantalum tube and inner tantalum cylinder.

Circuit Lab – Practical: Grading Rubric

Station 1

Component	Symbol	Circuit placement	Value	Units	Voltage Across	Voltage Polarity	Current Through	Current Direction
Resistor 1	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points
Resistor 2	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points
Resistor 3	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points
Bulb	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points	2 Points
Capacitor 1	2 Points	2 Points	2 Points	2 Points	• Light bulb and resistors may have different symbols than shown. • Polarity of Voltage Source must be correct to get credit for symbol. • Direction of current source arrow must be correct to get credit for symbol			
Capacitor 2	2 Points	2 Points	2 Points	2 Points				
Current Source	2 Points	2 Points	2 Points	2 Points				
Voltage Source	2 Points	2 Points	2 Points	2 Points				
Switch	2 Points	2 Points	**Total: 100 points**					

Station 2

Measure Voltage across AB	5 Points	Measure Voltage across CD	5 Points
Measure Current across AB	5 Points	Measure Current across CD	5 Points
Determine Equivalent Resistance across AB	5 Points	Determine Equivalent Resistance across CD	5 Points
Determine Time constant Across AB	5 Points	Determine Time constant Across CD	5 Points
Thévenin Equivalent Circuit with respect to AB		Norton Equivalent Circuit with respect to CD	
Correct circuit diagram		Correct circuit diagram	
voltage source shown	1 Point	current source shown	1 Point
resistance shown	1 Point	resistance shown	1 Point
Nodes AB shown	1 Point	Nodes CD shown	1 Point
correct polarity of voltage source	2 Points	correct direction of current source	2 Points
correct value of voltage source	2 Points	correct value of current source	2 Points
correct unit of voltage source	2 Points	correct unit of current source	2 Points
correct placement of resistance	2 Points	correct placement of resistance	2 Points
correct value of resistance	2 Points	correct value of resistance	2 Points
correct units of resistance	2 Points	correct units of resistance	2 Points
Subtotal	35 Points	Subtotal	35 Points
Total	70 Points		

Station 3

Measure current	5 Points	Draw the circuit Diagram in Discharge Position	5 Points
Mean time to 10 volts	10 Points	Is the polarity on the capacitors important? Why or Why not?	
Measure maximum voltage	10 Points	If they say yes	1 Points
Relationship with current and voltage	10 Points	If they give correct reason	1 Points
Compute equivalent capacitance	10 Points	If they say no	1 Points
Figure out the capacitors are in parallel	5 Points	If they give correct reason	1 Points
Figure out capacitor combination		If they say both and give reason	1 Points
Capacitor 1	10 Points		
Capacitor 2	10 Points		
Total	80 Points		