Instructions

1. Turn in all exam materials at the end of this event. *Missing exam materials and/or damaged or missing electronic parts will result in the immediate disqualification of the team in question.* There is an exam packet and a blank answer sheet. There is also scrap paper for calculations, should you need it; turn in scrape paper at the end of the event.

2. You may separate the exam pages. Re-staple at end of event as you submit your materials, but keep scrap paper separate.

3. Only the answers on the provided answer sheet will be considered. Do not write outside the designated spaces for each answer.

4. Include the team name in the appropriate locations on the answer sheet and the exam title sheet. Indicate the names of the participants at the bottom of the answer sheet.

5. Point values are in parenthesis. Tie breaker questions are identified with the number indicating first, second, third, etc. They do not appear in numerical order. Tie breaker questions count toward the overall score and are used only as tie breakers in the event of a tie score.

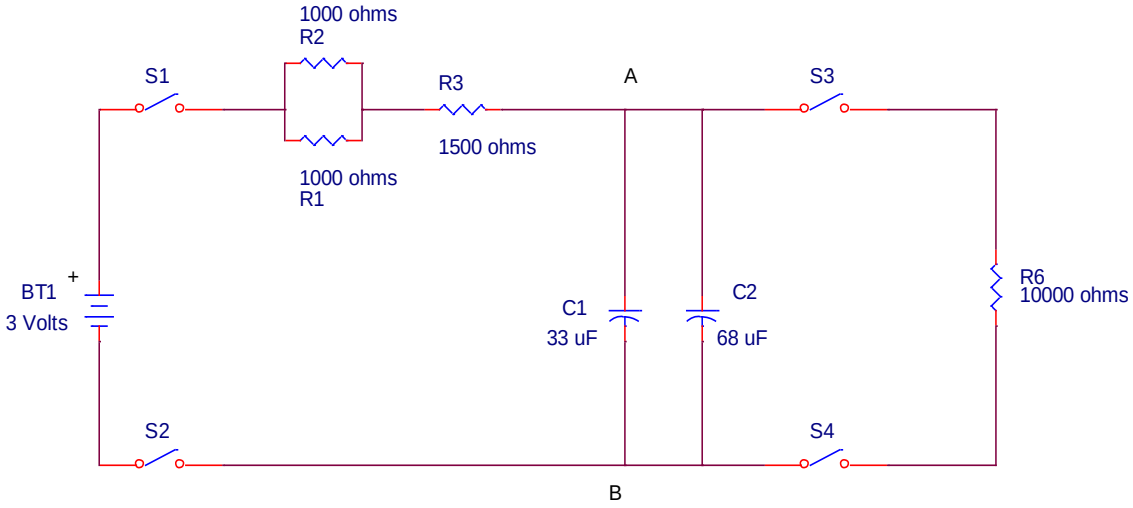
6. When time is up, the *time is up.* Continuing to write after the time has been called risks immediate disqualification.

7. NON-PROGRAMMABLE CALCULATORS ONLY.

8. Use the following table to determine the resistance value of color coded resistors.

COLOR	1st band 1st digit	2nd band 2nd digit	3rd band 3rd digit	4th band Tolerence
Black	0	0	X 1	
Brown	1	1	X 10	
Red	2	2	X 100	
Orange	3	3	X 1000	
Yellow	4	4	X 10000	
Green	5	5	X 100000	
Blue	6	6	X 1000000	
Violet	7	7		
Gray	8	8		
White	9	9		
Gold				±5%
Silver				±10%

Section 1



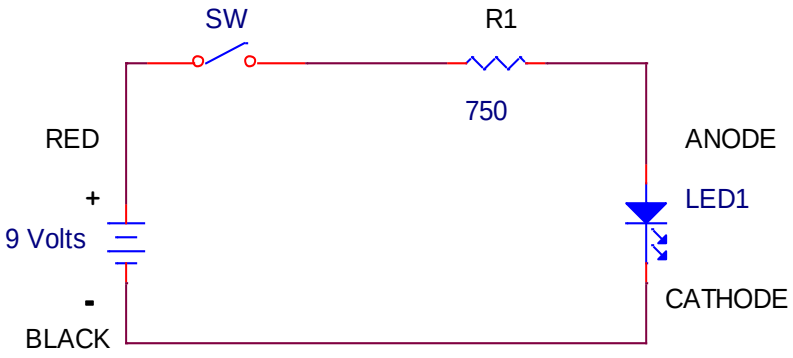
Initially, there is no charge on any capacitor. All switches are initially open.
At time t = 0, switches S1and S2 are closed.

1. What is the time constant, τ_{Charge}, associated with charging of this circuit ? **(5)**
2. What is the theoretical voltage between points **A** and **B** at t = 1τ after the switches, S1 and S2 are closed? **(2)**
3. Assume, after a time = 10τ_{Charge} , the circuit with capacitors C1 and C2 has fully charged.
    a. How much energy stored in C1? **(2) (Tiebreaker 2)**
    b. What is the SI unit of energy? **(2)**

At time t = 10 seconds after switches S1 and S2 are closed, they are opened and immediately after switches S3 and S4 are closed.

4. What is the time constant, $\tau_{Discharge}$, associated with the discharge of this circuit? **(5)**
5. Assuming switches S3 and S4 remain closed and S1 and S2 open, what is the voltage between points A and B at t = ∞ ? **(2)**
6. Assuming conventional current flow, draw on the schematic the direction of current flow thru R6. **(2)**
7. BT1 represents a common, primary (non-rechargeable) single cell battery chemistry (or type of battery) with a 3 volt nominal cell voltage. What chemistry or type could it represent? **(2) (Tiebreaker 3)**
8. Sketch V_{AB} vs time after S1 and S2 are opened and S3 and S4 are closed.

Section 2



Schematic

Build the circuit represented by the schematic above, on the prototype plug board illustrated below. Note the gray lines on the BACK side represent electrical connections.

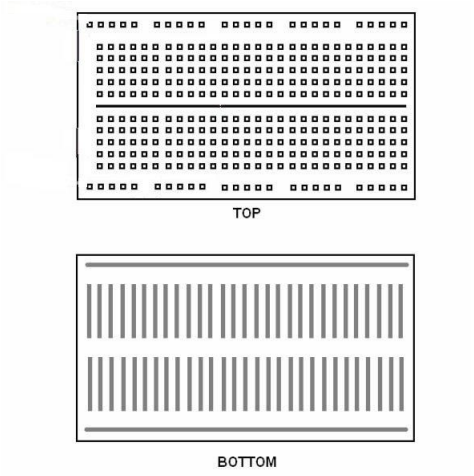


Illustration of the prototype plug board

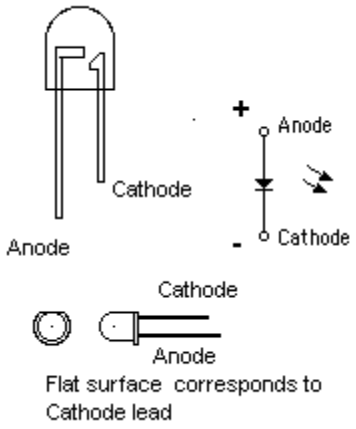


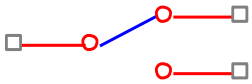
Illustration of the polarity for a LED

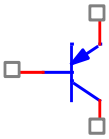
Using the Digital MultiMeter (DMM) and the prototype circuit built on the plug board, complete the following questions:

1. What is the measured voltage of the 9 Volt battery with the switch open? **(2)**
2. What is the measured voltage of the 9 Volt battery with the switch closed? **(2)**
3. What is the measured voltage across the resistor? **(2)**
4. What is the value of the resistor indicated by the colored bands on the resistor body? **(2)**
5. Using the answers from the previous two steps, calculate the current passing thru the resistor? **(2)**
6. "LED" is an acronym for what 3 words? **(3)**
7. The LED used in this experiment produces light in the visible spectrum. Another type, an IR LED, produces light in the infrared spectrum. What common device uses an IR LED for communication? **(2)**
8. Name one element that may be used to dope to make a p-type semiconductor? **(2)**
9. Name one element that may be used to dope to make a n-type semiconductor? **(2)**
10. What compound semiconductor material may be used for the red LED ? **(2) (Tiebreaker 4)**
11. Plot the open circuit battery voltage and battery voltage under load measured above on the graph provided. **(2)**
12. Estimate the internal resistance of the 9 Volt battery. **(5) (Tiebreaker 1)**
13. If the 9 Volt battery has a capacity of 550 mA-hrs, use the current determined in Question 5 to estimate the battery life. **(2)**
14. Qualitatively, if R1 is replaced with at 1000Ω resistor, what would happen to the LED? **(2)**
15. Again, if R1 is replaced with at 1000Ω resistor, what would happen to the battery life? **(2)**

Section 3

Name the devices these graphic symbols represent:

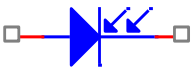
(2) 1. 

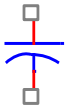
(2) 2. 

(2) 3. 

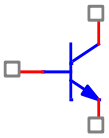
(2) 4. 

(2) 5. 

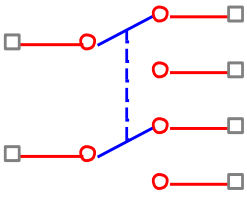
(2) 6. 

(2) 7. 

(2) 8. 

(2) 9. 

(2) 10. 

(2) 11. 

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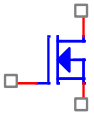
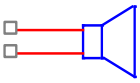
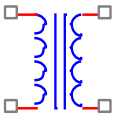
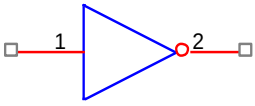
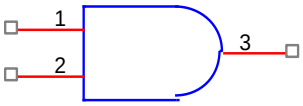
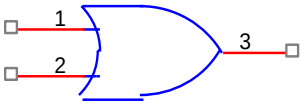
(2) 13. 

(2) 14. 

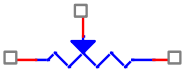
(2) 15. 

(2) 16. 

(2) 17. 

(2) 18. 

(2) 19. 

(2) 20. 

Bonus Question

(5) Who is credited with developing the electric battery in 1800?