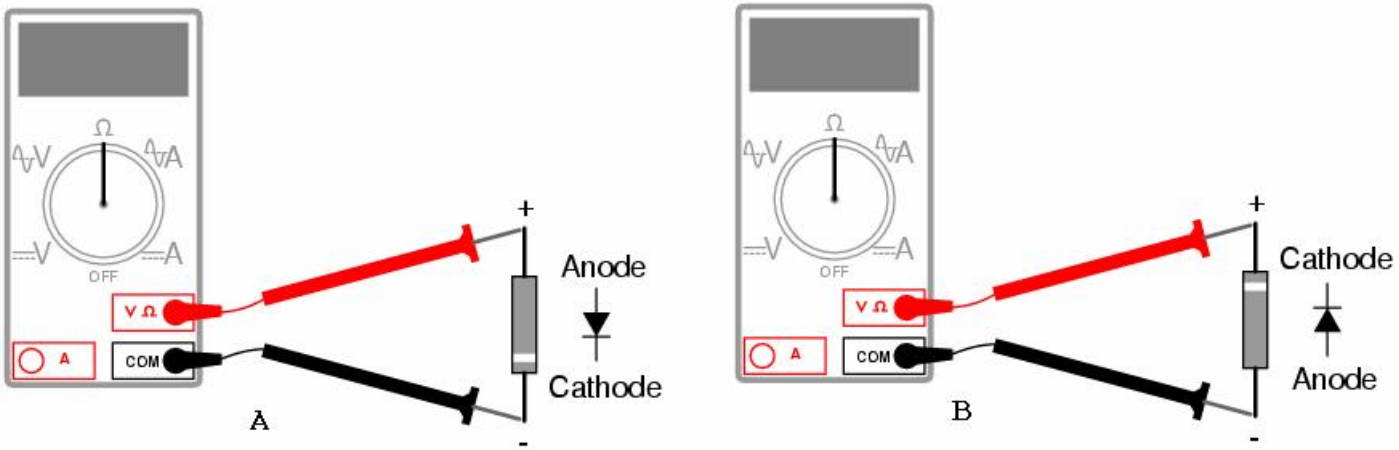
SOUTHEASTERN PA REGIONAL SCIENCE OLYMPIAD 2008

CIRCUIT LAB C DIVISION

MARCH 4, 2007



SCHOOL NAME_____ **SCHOOL CODE**_____

INSTRUCTIONS

1. Turn in all exam materials at the end of this event. *Missing exam materials will result in immediate disqualification of the team in question*. There is an exam packet and a blank answer sheet.

2. You may separate the exam pages. Re-staple them as you submit your materials to the supervisor. Keep the answer sheet separate.

3. *Only* the answers provided on the answer page will be considered. Do not write outside the designated spaces for each answer. Write LEGIBLY. Answers that can't be read can't be correct. Include units where applicable.

4. Write your school name and school code in the appropriate locations on the answer sheet as well as on the title page. Indicate the names of the participants at the bottom of the answer sheet. Write LEGIBLY.

5. Point values for each question are in parentheses. Tiebreaker questions are identified with a (T#) where the number indicates the sequence of consultation. In the event of a tie, the supervisor will first look at T1, then T2, etc. until the tie is broken. *Tiebreaker questions count toward the overall grade, and are only used as tiebreakers in the event of a tie.*

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

7. One of the two digital multimeters on the cover page would show infinite resistance. Which one is it, and what would the display actually show? Put the answers of the back of the answer sheet for two bonus points.

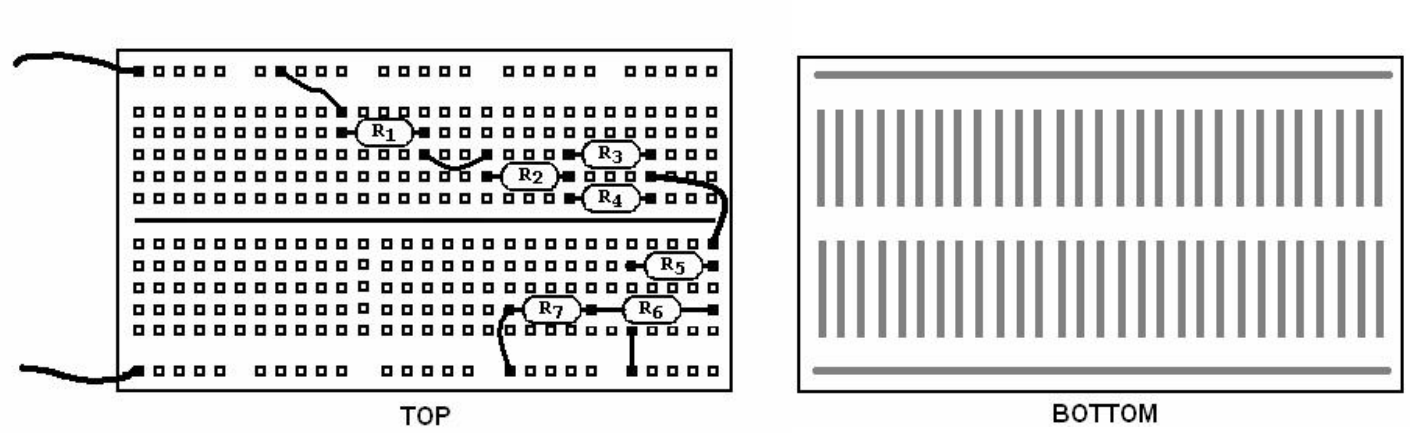
8. NON-PROGRAMMABLE CALCULATORS ONLY. DON'T ASK, THE ANSWER IS NO.

9. Use this table for the resistance of color-coded resistors.

COLOR	1st stripe 1st digit	2nd stripe 2nd digit	3rd stripe multiplier
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	
Grey	8	8	
White	9	9	

SECTION 1

The image below shows a circuit consisting of 6 color-coded resistors on a solderless breadboard. You may ignore the tolerance values (that is, the three stripes indicate the *actual* resistance). The 1st three colored stripes on each resistor are listed in the table below the image. The leads will be connected to a 60.0 volt DC power source. Point values for each question are in parentheses.



R_1	green green black
R_2	brown grey black
R_3	brown black black
R_4	violet green black
R_5	brown black brown
R_6	brown green black
R_7	red red black

(7) 1. Draw a schematic diagram of the circuit in the box provided. Use standard symbols.

(21) 2. List the resistance of each resistor and solve for the theoretical current and voltage drop for each resistor in the circuit. Assume the voltage source is ideal.

The current through R_1 is *experimentally* determined to be 503 mA.

(14) 3. Solve for the experimental current and voltage drop for each resistor in the circuit (use the same R values as in #1).

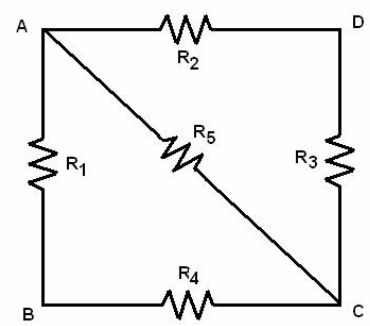
(3) 4. Using the data from #3, what is the terminal voltage of the battery?

(3) 5. (T6) Using the data from #3, what is the internal resistance of the battery?

(3) 6. Using the data from #3, what is the power dissipated by R_5?

SECTION 2

The bridge circuit shown below left consists of 5 ideal resistors, with resistances as shown in the table below right. Use this diagram for numbers 1-6.



Resistor	Resistance, kΩ
R_1	5.00
R_2	15.0
R_3	20.0
R_4	10.0
R_5	25.0

(3) 1. What is the resistance across terminals A and B?

(3) 2. What is the resistance across terminals B and C?

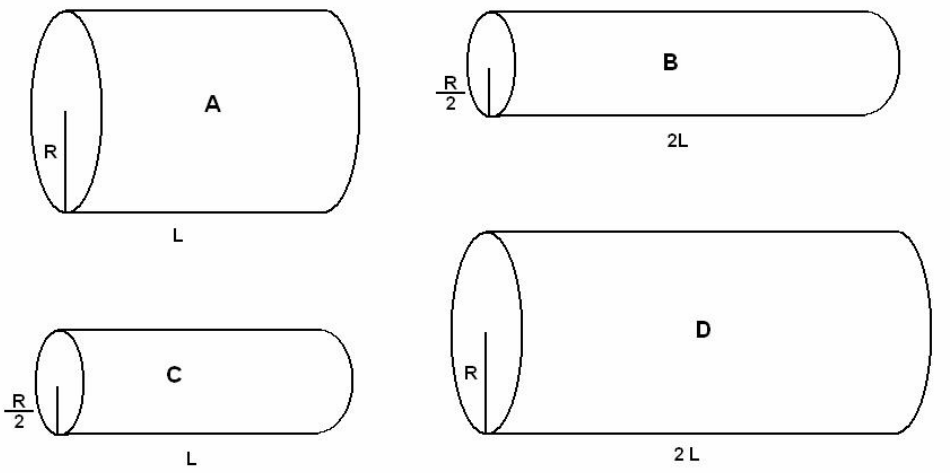
(3) 3. What is the resistance across terminals A and C?

(5) 4. (T5) What is the resistance across terminals B and D?

(3) 5. If R_2 is shorted, what is the resistance across terminals B and C?

(3) 6. If R_1 is an open resistor, what is the resistance across terminals C and D?

(4) 7. Rank the following cylindrical conductors in descending order according to the current through them when the same potential difference V is placed across their lengths.



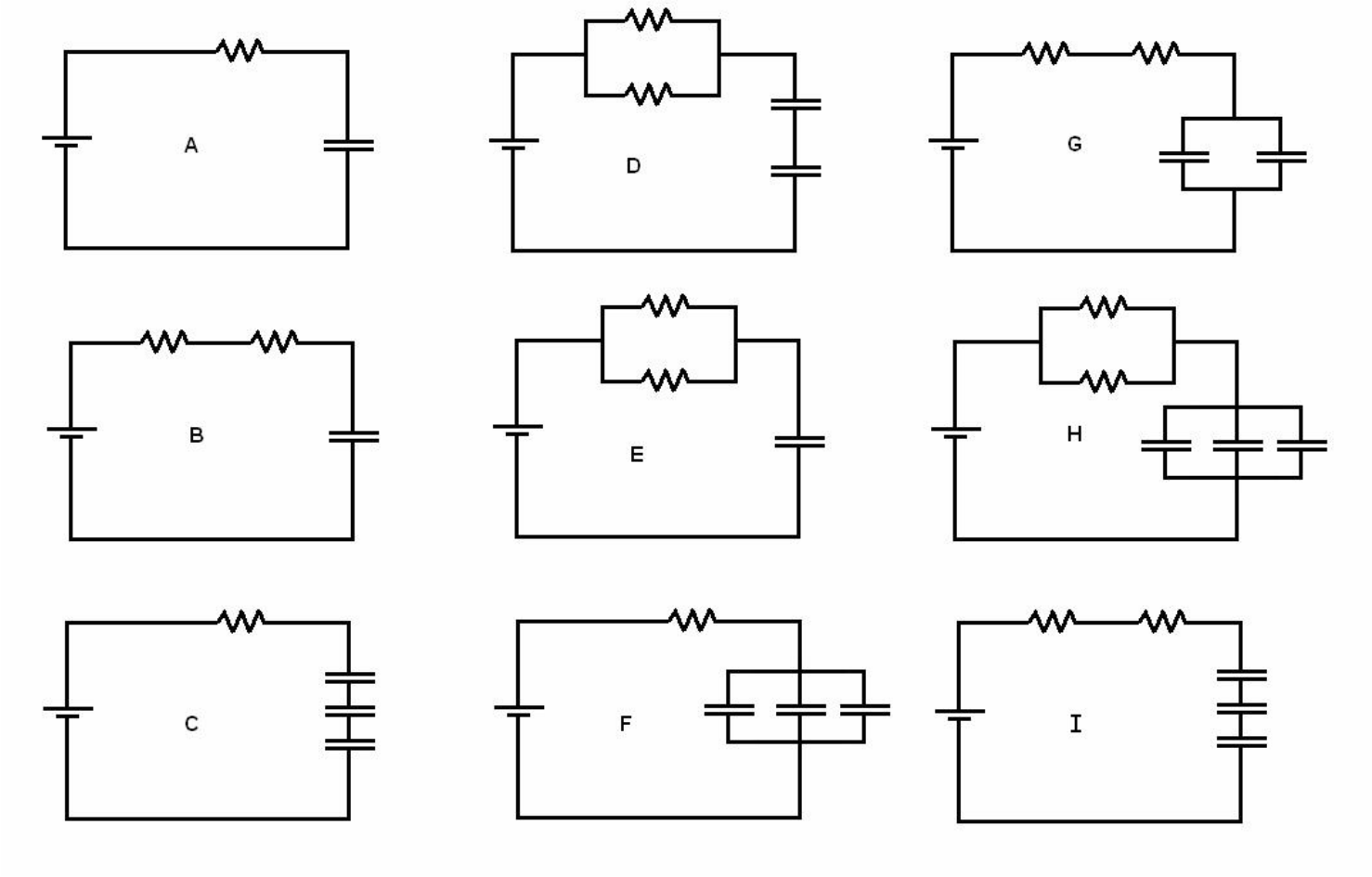
(3) 8. Conductor A in the figure above is made of aluminum ($\rho = 2.75E\text{-}8\ \Omega$ m); its radius R = 2.00 mm and its length L = 2.33 m. Calculate the resistance of conductor A.

(5) 9. (T1) Two resistors, R_1 and R_2, may be connected either in series or in parallel across an ideal voltage source V. The power dissipation when wired in parallel is five times the power dissipation when wired in series. IF R_1 is 100 Ω, what is the resistance of R_2? (there are two possible answers – provide both).

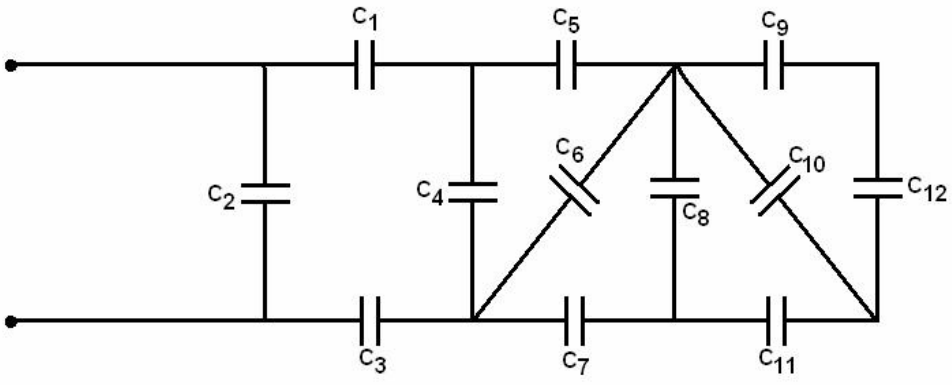
(1) 10. What happens to the resistance of a semiconductor when the temperature increases?

SECTION 3

(9) 1. (T7) In each of the following circuits, resistors have the value R and capacitors have the value C. Rank the circuits by letter in descending order (greatest first) in terms of their time constants.



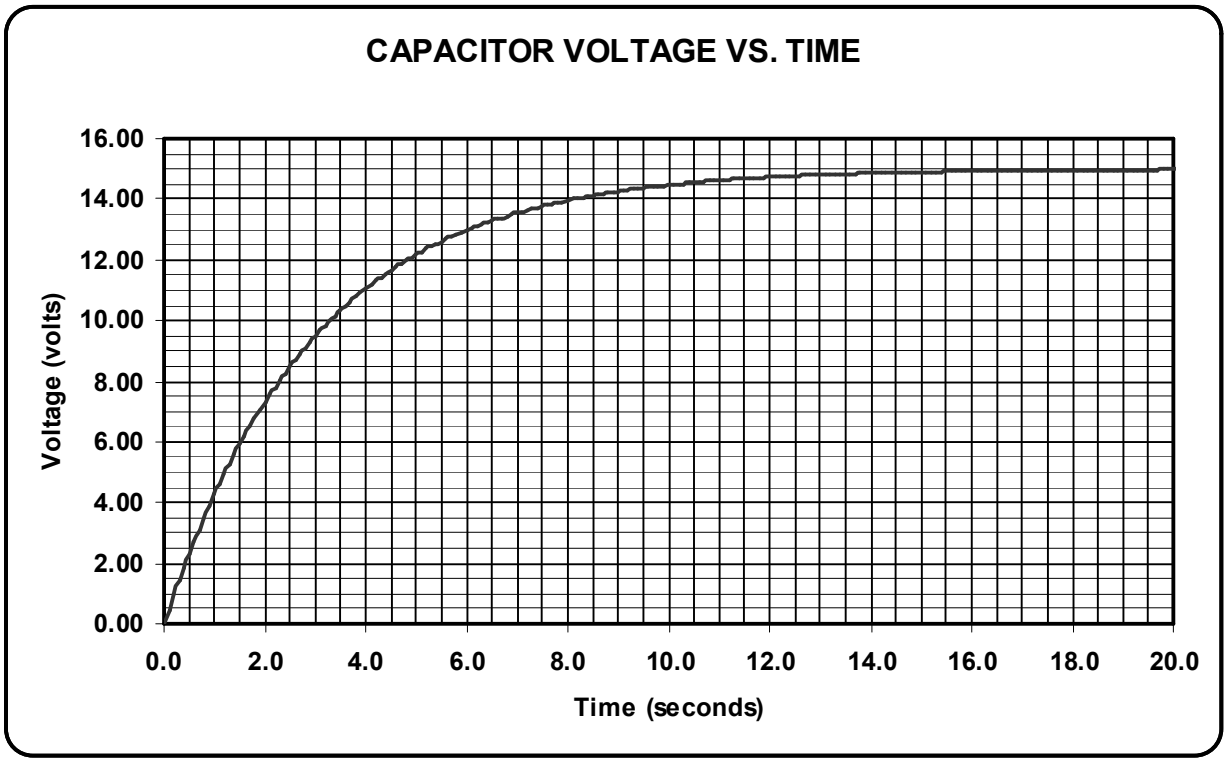
(5) 2. (T4) Solve for the total capacitance of the ladder network shown below. Capacitance values are in the table below right.



Capacitor	μF
C_1	25.0
C_2	30.0
C_3	10.0
C_4	50.0
C_5	35.0
C_6	15.0
C_7	40.0
C_8	45.0
C_9	10.0
C_{10}	15.0
C_{11}	25.0
C_{12}	20.0

SECTION 3 CONTINUED

The circuit shown schematically below contains an ideal battery, an ideal resistor, and an ideal capacitor. The switch is closed at time t = 0, and the voltage across the capacitor is recorded as a function of time, producing the graph shown below. When the capacitor is fully charged, it is seen that it contains 90.0 μC of charge.



(2) 3. What is the voltage of the battery?

(3) 4. What is the time constant for this circuit?

(3) 5. (T3) What is the capacitance C of the capacitor?

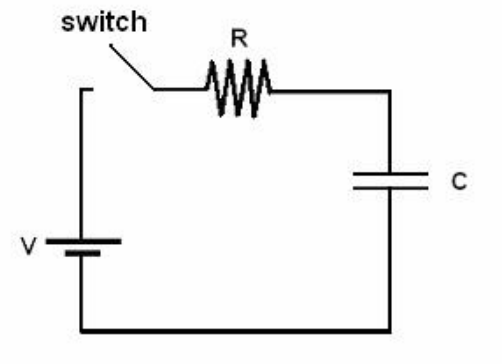
(3) 6. What is the resistance R of the resistor?

(2) 7. What is the voltage across the *resistor* at t = 6.0 seconds?

(3) 8. What is the current in the circuit at t = 0?

(3) 9. What is the current in the circuit at t = 8.0 seconds?

(3) 10. What is the charge on the capacitor at t = 8.0 seconds?



SECTION 4

A

B

C

(1) 1. Which of these multimeters is being used as an ohmmeter?

(1) 2. Which of these multimeters is being used as an ammeter?

(1) 3. Which of these multimeters is being used as a voltmeter?

(3) 4. What is the reading (including units) shown by multimeter A?

(3) 5. What is the reading (including units) shown by multimeter B?

(3) 6. What is the reading (including units) shown by multimeter C?

(3) 7. (T8) What is the precision of the reading on the 100 V setting?

The galvanometer in these multimeters shows a full-scale deflection with a current of 2.00 mA and has a resistance of 165 Ω.

(5) 8. On the 300 mA setting, what is the resistance of the shunt resistor?

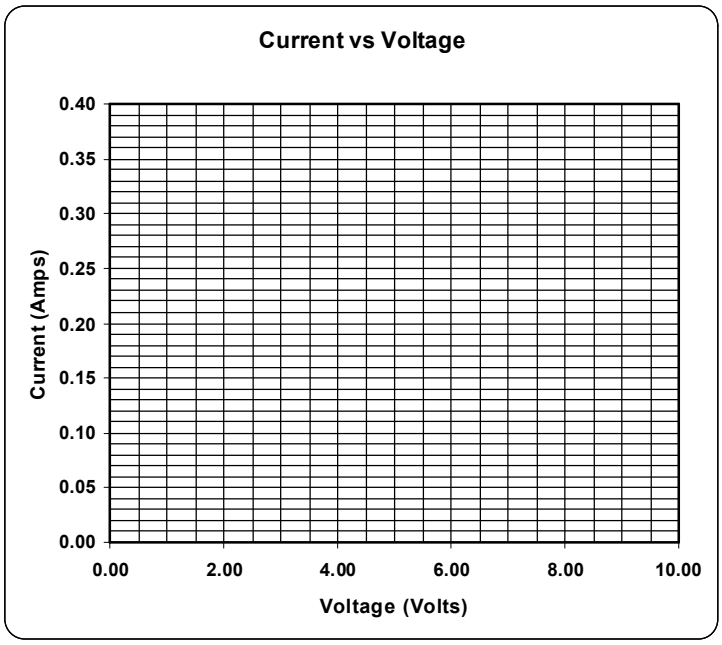
(5) 9. (T2) On the 300 V setting, what is the limiting resistance to the nearest kΩ?

(1) 10. Should multimeter C (at right) be connected in series or in parallel to measure the quantity indicated on the selector switch?

SECTION 5

Current is measured through three different resistors for various potential differences. The results of the experiment are shown in the table below. The current through resistor R_n is listed as I_n.

V volts	I_1 amps	I_2 amps	I_3 amps
1.00	0.018	0.004	0.151
2.00	0.036	0.018	0.149
3.00	0.054	0.040	0.154
4.00	0.071	0.071	0.152
5.00	0.089	0.112	0.201
6.00	0.107	0.161	0.211
7.00	0.125	0.219	0.221
8.00	0.143	0.286	0.231
9.00	0.161	0.362	0.241

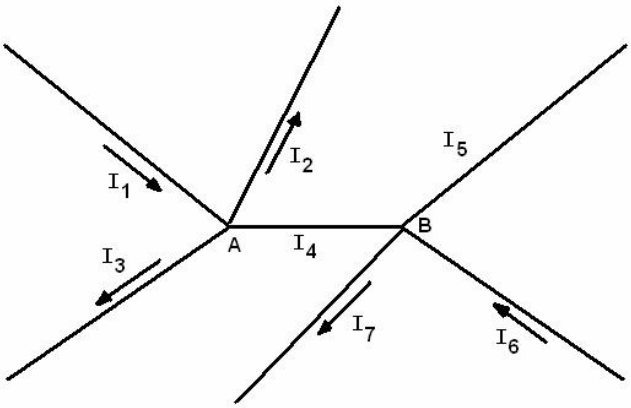


(2) 1. Which of the resistors is an ohmic resistor?

(3) 2. What is the resistance of the ohmic resistor?

(3) 3. What is the magnitude and direction (R or L) of current I_4 in the diagram shown at right?

(3) 4. What is the magnitude and direction (into or out of node B) of current I_5 in the diagram shown at right?



current in mA	
I_1	12
I_2	3
I_3	4
I_4	
I_5	
I_6	8
I_7	2

(3) 5. Transform the 200 milliamp current source shown below into a voltage source. The value of the resistor R is 2.20 kΩ. What is the voltage v_s?