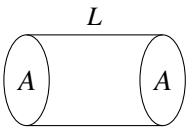
Student #: _____ Student Name: _____

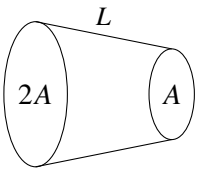
AP PHYSICS C CLASS 20: CIRCUIT ANALYSIS, PART 1

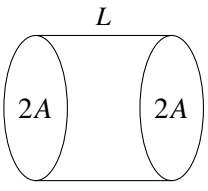
Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

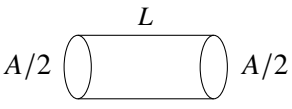
Note: To simplify calculations, you may use $g = 10\,\text{m/s}^2$ in all problems.

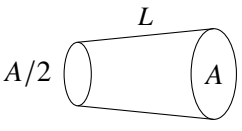
1. Five resistors are made of the same material. Which of the following has the highest resistance?

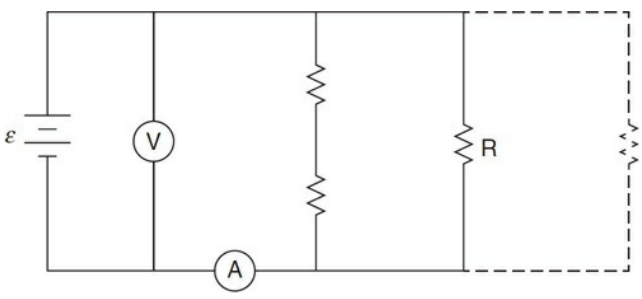
(A) 

(B) 

(C) 

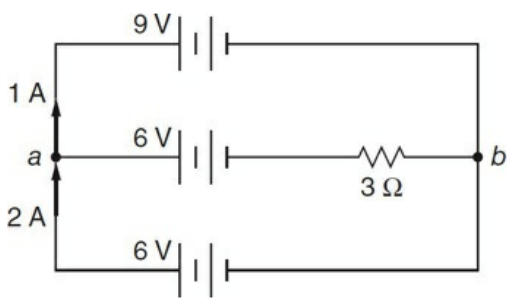
(D) 

(E) 



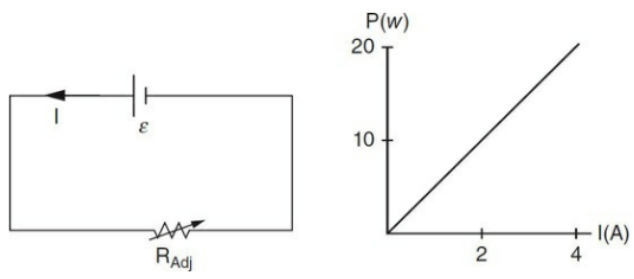
2. In the circuit shown, what effect would adding another resistor in parallel with the resistor labeled R have?
   (A) The reading on the voltmeter would increase.
   (B) The reading on the ammeter would increase.
   (C) The reading on the voltmeter would decrease.
   (D) The reading on the ammeter would decrease.
   (E) The reading on the ammeter would not change.

3. The current flowing in a wire as a function of time is given by the equation $I = 4t^3$. The charge that passes through the wire from 0 s to 2 s is
   (A) 2 C
   (B) 4 C
   (C) 8 C
   (D) 16 C
   (E) 24 C



4. There are three batteries in the circuit shown above. There may be other resistances not shown on the diagram. The potential difference between points a and b is
   (A) 3 V
   (B) 6 V
   (C) 9 V
   (D) 12 V
   (E) 18 V

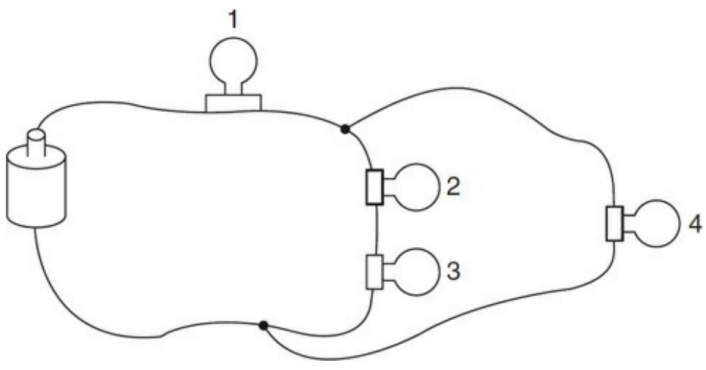
Questions 5–6 An adjustable resistor is connected to a battery of emf in a simple circuit. A graph of power vs. current in the battery is shown in the figure.



5. The emf $\mathcal{E}$ of the battery is most nearly
   (A) 5 V
   (B) 10 V
   (C) 20 V
   (D) 40 V
   (E) 60 V

6. What is the resistance of the adjustable resistor when the power in the circuit is 10 watts?
   (A) 1.25 Ω
   (B) 1.5 Ω
   (C) 2.5 Ω
   (D) 5.0 Ω
   (E) 0 Ω

Questions 7–8 Four identical light bulbs are connected to a battery as shown.

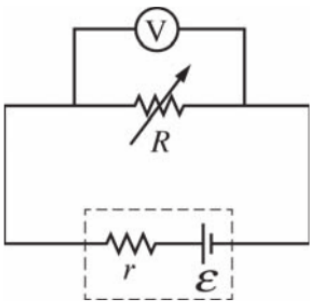


7. Which bulb will burn the brightest?
   (A) 1
   (B) 2
   (C) 3
   (D) 4
   (E) All will emit the same brightness.

8. If bulb 4 is removed, how will the brightness of each of the bulbs change, if at all?
   (A) Bulb 2 will be less bright.
   (B) Bulb 2 will be brighter.
   (C) Bulb 3 will not change its brightness.
   (D) Bulb 1 will not give off light.
   (E) None of the bulbs will change their brightness.

AP PHYSICS C CLASS C: ELECTRIC CIRCUITS
SECTION II
5 Questions

Directions: Answer all questions. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for.



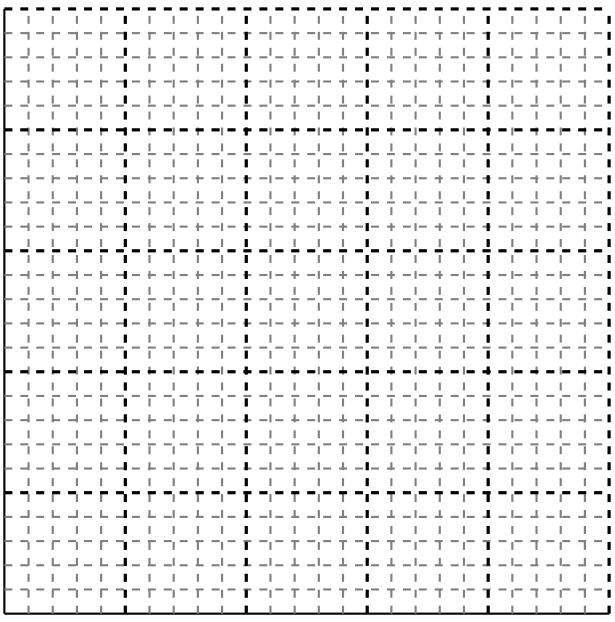
1. A student performs an experiment to determine the emf $\mathcal{E}$ and internal resistance r of a given battery. The student connects the battery in series to a variable resistance R, with a voltmeter across the variable resistor, as shown in the figure above, and measures the voltmeter reading V as a function of the resistance R. The data are shown in the table below.

Trial #	Resistance (Ω)	Voltage (V)	$1/R$ $(1/\Omega)$	$1/V$ $(1/\text{V})$
1	0.50	5.6	2.00	0.179
2	1.0	7.4	1.00	0.135
3	2.0	9.4	0.50	0.106
4	3.0	10.6	0.33	0.094
5	5.0	10.9	0.20	0.092
6	10	11.4	0.10	0.088

(a) i. Derive an expression for the measured voltage V. Express your answer in terms of R, $\mathcal{E}$, r, and physical constants, as appropriate.

ii. Rewrite your expression from part (a)-i to express $1/V$ as a function of $1/R$.

(b) On the grid below, plot data points for the graph of $1/V$ as a function of $1/R$. Clearly scale and label all axes, including units as appropriate. Draw a straight line that best represents the data.



(c) Use the straight line from part (b) to obtain values for the following.

i. $\mathcal{E}$

ii. r

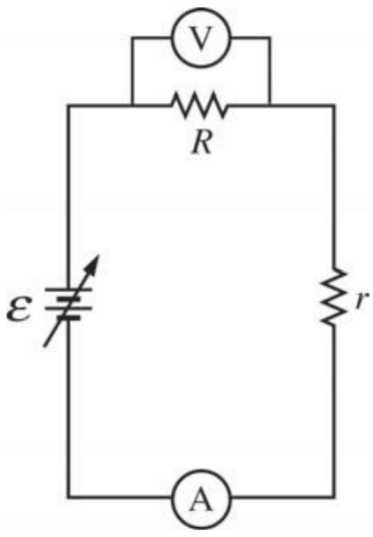
(d) Using the results of the experiment, calculate the maximum current that the battery can provide.

(e) A voltmeter is to be used to determine the emf of the battery after removing the battery from the circuit. Two voltmeters are available to take this measurement—one with low internal resistance and one with high internal resistance. Indicate which voltmeter will provide the most accurate measurement. Justify your answer.

_____ The voltmeter with low resistance will provide the most accurate measurement.

_____ The voltmeter with high resistance will provide the most accurate measurement.

_____ The two voltmeters will provide equal accuracy.



2. The circuit shown above consists of a source of variable emf $\mathcal{E}$, an ideal ammeter A, an ideal voltmeter V, a resistor of resistance R, and a sample of wire with resistance r.

   (a) How does the current through the wire sample compare with the current through the resistor R? Justify your answer.

   _____ It is greater through R.

   _____ It is greater through the sample.

   _____ It is the same through both.

   _____ It depends on the resistance of the sample.

   (b) How does the potential difference across the wire sample compare with the potential difference across the resistor R? Justify your answer.

   _____It is greater across R.

   _____It is greater across the sample.

   _____It is the same across both.

   _____It depends on the resistance of the sample.

   With the sample of wire in place, the emf of the source is set to a given value. The current through and potential difference across the resistor R are measured. This is repeated for several values of emf, and the data are recorded in the table below.

$\mathcal{E}$ (V)	V_R (V)	I_R (A)		
0.250	0.179	0.162		
0.500	0.335	0.327		
0.750	0.520	0.490		
1.000	0.670	0.687		

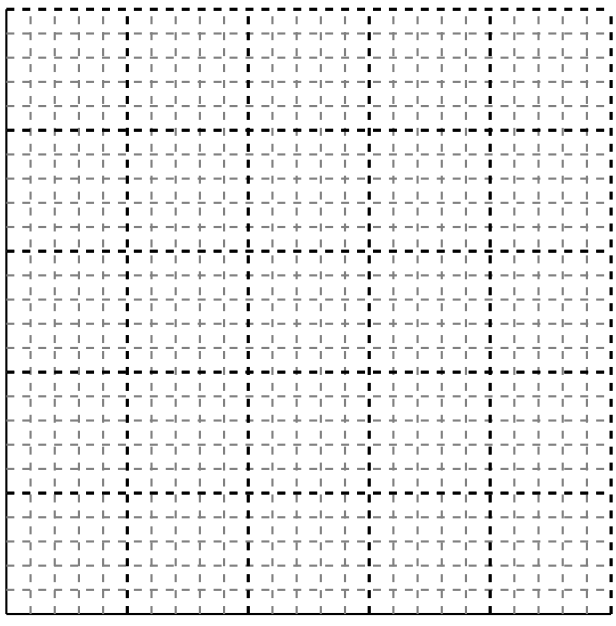
   (c) Indicate below which quantities should be graphed to yield a straight line that could be used to calculate a numerical value for the resistance of the wire sample.

   Horizontal axis: _____

   Vertical axis: _____

   You may use the remaining columns in the table above, as needed, to record any quantities that you indicated that are not given.

   (d) On the grid below, plot the straight line data points from part (c). Clearly scale and label all axes, including units if appropriate. Draw a straight line that best represents the data.



   (e) Use your straight line to calculate the value of the resistance of the wire sample.

(f) The wire sample has a length of 3.00 m and a radius of 1.00×10^{-3} m. Calculate the resistivity of the material from which the wire sample is made.

(g) i. Suppose the ammeter used to collect these data was not ideal. Would the actual value of the resistance of the wire sample be greater than, less than, or equal to that calculated in part (e)? Justify your answer.

_____ Greater than _____ Less than _____ Equal to

ii. If the ideal voltmeter is replaced by a voltmeter that is not ideal and the experiment is repeated, would the readings of the ideal ammeter be greater than, less than, or equal to those in the data chart before part (c)? Justify your answer.

_____ Greater than _____ Less than _____ Equal to