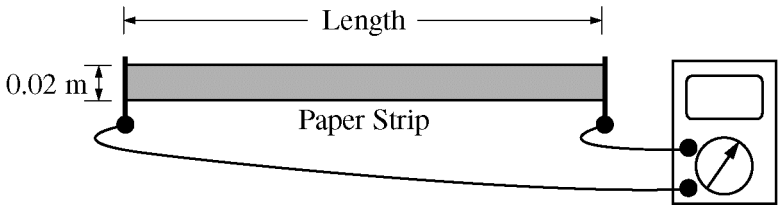


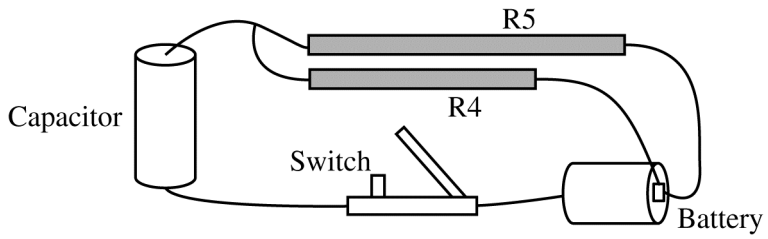
E&M. 2.

A physics student wishes to measure the resistivity of slightly conductive paper that has a thickness of 1.0×10^{-4} m. The student cuts a sheet of the conductive paper into strips of width 0.02 m and varying lengths, making five resistors labeled R1 to R5. Using an ohmmeter, the student measures the resistance of each strip, as shown above. The data are recorded below.

Resistor	R1	R2	R3	R4	R5
Length (m)	0.020	0.040	0.060	0.080	0.100
Resistance (Ω)	80,000	180,000	260,000	370,000	440,000

(a) Use the grid below to plot a linear graph of the data points from which the resistivity of the paper can be determined. Include labels and scales for both axes. Draw the straight line that best represents the data.

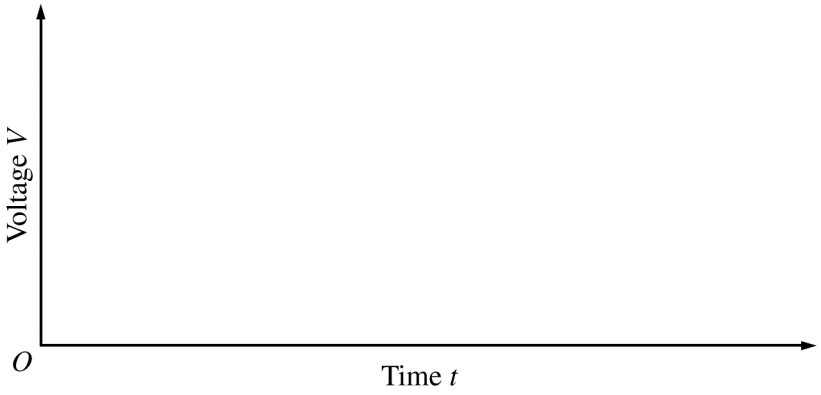
(b) Using the graph, calculate the resistivity of the paper.

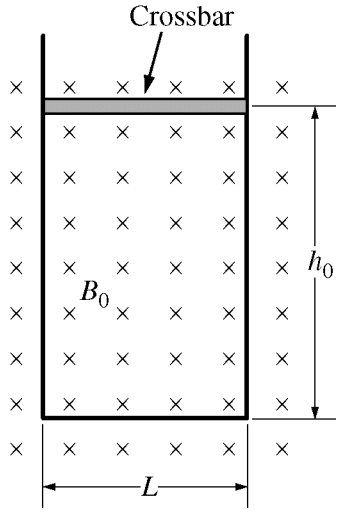


The student uses resistors R4 and R5 to build a circuit using wire, a 1.5 V battery, an uncharged 10 μF capacitor, and an open switch, as shown above.

(c) Calculate the time constant of the circuit.

(d) At time t = 0, the student closes the switch. On the axes below, sketch the magnitude of the voltage V_c across the capacitor and the magnitudes of the voltages V_{R4} and V_{R5} across each resistor as functions of time t. Clearly label each curve according to the circuit element it represents. On the axes, explicitly label any intercepts, asymptotes, maxima, or minima with values or expressions, as appropriate.





E&M. 3.

A closed loop is made of a U-shaped metal wire of negligible resistance and a movable metal crossbar of resistance R. The crossbar has mass m and length L. It is initially located a distance h_0 from the other end of the loop. The loop is placed vertically in a uniform horizontal magnetic field of magnitude B_0 in the direction shown in the figure above. Express all algebraic answers to the questions below in terms of B_0, L, m, h_0, R, and fundamental constants, as appropriate.

(a) Determine the magnitude of the magnetic flux through the loop when the crossbar is in the position shown.

The crossbar is released from rest and slides with negligible friction down the U-shaped wire without losing electrical contact.

(b) On the figure below, indicate the direction of the current in the crossbar as it falls.

Justify your answer.

(c) Calculate the magnitude of the current in the crossbar as it falls as a function of the crossbar's speed v.

(d) Derive, but do NOT solve, the differential equation that could be used to determine the speed v of the crossbar as a function of time t.

(e) Determine the terminal speed v_T of the crossbar.

(f) If the resistance R of the crossbar is increased, does the terminal speed increase, decrease, or remain the same?

____ Increases ____ Decreases ____ Remains the same

Give a physical justification for your answer in terms of the forces on the crossbar.

STOP

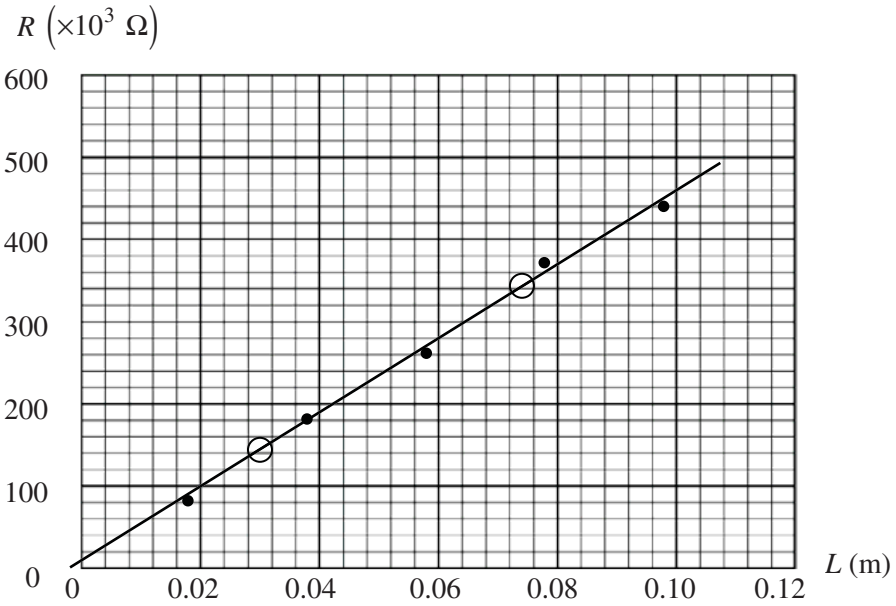
END OF EXAM

AP® PHYSICS C: ELECTRICITY AND MAGNETISM
2012 SCORING GUIDELINES

Question 2

15 points total **Distribution of points**

(a) 4 points



For a correct label on each axis (one including resistance, one including length), that leads to a linear graph — 1 point

For two linear scales, one for each axis, corresponding to the labels and occupying at least three-quarters of each axis — 1 point

For reasonably correctly plotted points according to the scale — 1 point

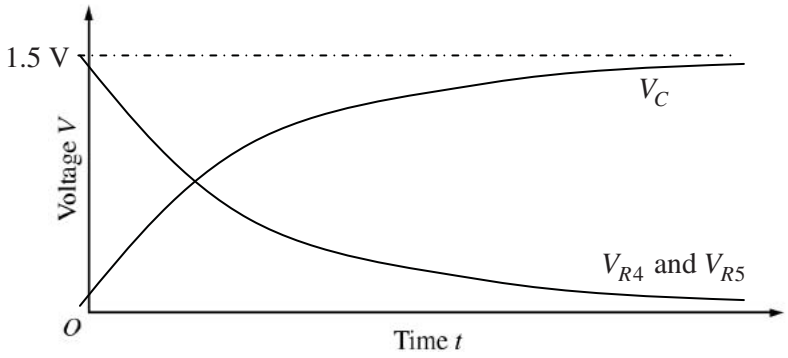
For a reasonable best-fit straight line — 1 point

Note: Circles on the graph are to indicate points chosen to calculate slope in part (b). They are not necessary to receive credit.

Question 2 (continued)

Distribution of points

(d) 4 points



For correctly indicating the battery voltage as an asymptote for the V_C curve (or in the absence of a correct V_C curve, as the maximum of the resistor curves) — 1 point

For a capacitor voltage curve starting at the origin, increasing, concave down, and appropriately labeled — 1 point

For a resistor voltage curve starting at the intersection of the asymptotic voltage with the voltage axis, decreasing and concave up (asymptotic with the time axis), and appropriately labeled — 1 point

For any indication that $V_{R4} = V_{R5}$ — 1 point