Flipping Physics Lecture Notes:

2018 #2 Free Response Question - AP Physics 1 - Exam Solution
http://www.flippingphysics.com/ap1-2018-frq2.html

This Experimental Design Question also works as a part of the AP Physics C: Electricity & Magnetism curriculum.

A group of students prepare a large batch of conductive dough (a soft substance that can conduct electricity) and then mold the dough into several cylinders with various cross-sectional areas A and lengths ℓ. Each student applies a potential difference ΔV across the ends of a dough cylinder and determines the resistance R of the cylinder. The results of their experiments are shown in the table.

Dough Cylinder	A (m^2)	ℓ (m)	ΔV (V)	R (Ω)	*RA* ($\Omega \cdot m^2$)	
1	0.00049	0.030	1.02	23.6	*0.01156*	
2	0.00049	0.050	2.34	31.5	*0.01544*	
3	0.00053	0.080	3.58	61.2	*0.03244*	
4	0.00057	0.150	6.21	105	*0.05985*	

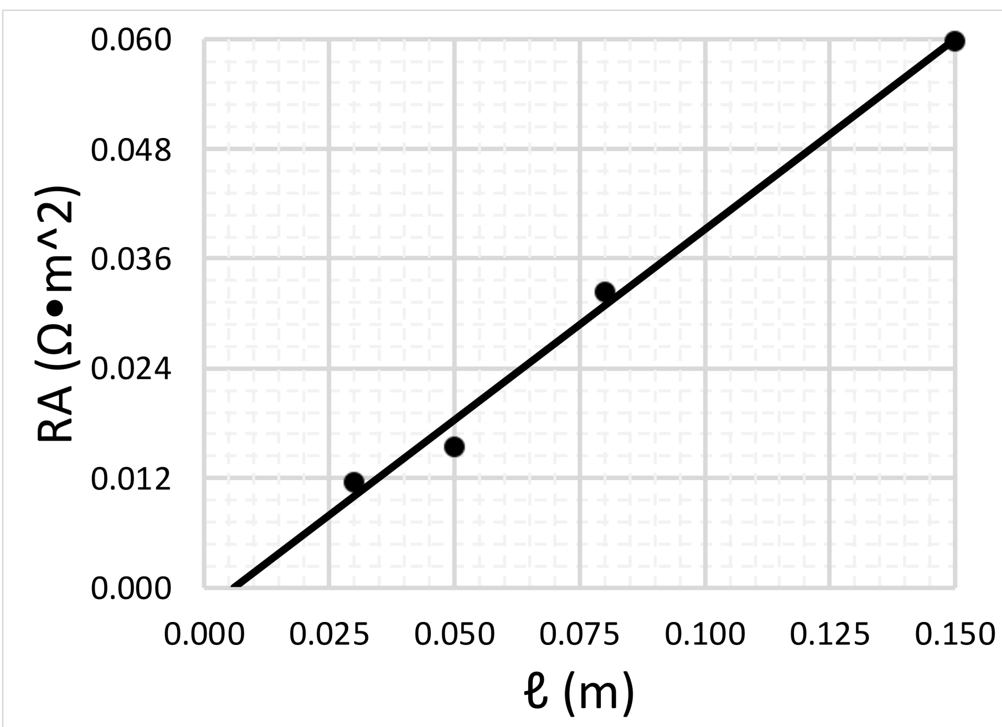
(a) The students want to determine the resistivity of the dough cylinders.

i. Indicate which quantities could be graphed to determine a value for the resistivity of the dough cylinders. You may use the remaining columns in the table above, as needed, to record any quantities (including units) that are not already in the table.

$$R = \frac{\rho \ell}{A} \Rightarrow \rho = \frac{RA}{\ell} \;\&\; slope = \frac{rise}{run} \Rightarrow Vertical\ Axis = RA \;\&\; Horizontal\ Axis = \ell$$

From the Scoring Guidelines, this question is worth 12 points. Part (a i) is worth 2 points with no explanation required. Make sure to notice when they require an explanation and also when they do not.

ii. On the grid, plot the appropriate quantities to determine the resistivity of the dough cylinders. Clearly scale and label all axes, including units as appropriate.



From the Scoring Guidelines, you gain 1 point in part (a ii):

- "For a linear scale where the plotted data uses at least half the grid"
- So, when they provide you with a grid to plot your graph, make sure you use at least half of the space provided in the grid.
- You also gain 1 point in part (a ii): "For labeling both axes, with units as appropriate"
- To me this should be obvious, because it literally tells you to do this in the problem, however, enough of my students forget to do this that I felt it necessary to point it out. Somehow y'all remember to add numbers, however, it is difficult for you to remember to label your axes and include units!

iii. Use the graph to estimate a value for the resistivity of the dough cylinders.

To solve for the units: $\rho = \frac{RA}{\ell} \Rightarrow units = \frac{\Omega \bullet m^2}{m} = \Omega \bullet m$

$$slope = \frac{rise}{run} = \frac{\Delta y}{\Delta x} = \frac{0.06 - 0}{0.15 - 0.007} = 0.41958 \approx 0.42\Omega \bullet m$$

From the Scoring Guidelines, you gain 1 point in part (a iii):
"For a correct value of the resistivity ρ = 0.42 Ω•m (± 0.03) calculated from graph or data." Notice, the slope you calculate needs to be between 0.39 and 0.45 Ω•m and has to have units. So, please, be careful plotting your data, drawing your best-fit line using your straight edge or rule, and remember units!

(b) Another group of students perform the experiment described in part (a) but shape the dough into long rectangular shapes instead of cylinders. Will this change affect the value of the resistivity determined by the second group of students?

____ Yes __X__ No Briefly justify your reasoning.

No, resistivity is a property of the material only. Material shape does not affect resistivity.

From the Scoring Guidelines, part (b) is only worth 1 point.
They mean it when they say, "***Briefly*** justify your reasoning."

(c) Describe an experimental procedure to determine whether or not the resistivity of the dough cylinders depends on the temperature of the dough. Give enough detail so that another student could replicate the experiment. As needed, include a diagram of the experimental setup. Assume equipment usually found in a school physics laboratory is available.

Using only one of the dough cylinders from part (a), apply a constant electric potential difference across the dough cylinder and measure the current through and temperature of the dough cylinder. Because the dough cylinder will be converting electric potential energy to internal energy, the temperature of the dough cylinder will increase over time. If the resistivity of the conductive dough changes with a change in temperature, the resistance of the dough cylinder will change, and therefore the measured current will change. Make sure to let the experiment run long enough to give the dough enough time to experience a significant temperature change.