

2018 AP[®] PHYSICS 1 FREE-RESPONSE QUESTIONS

2. (12 points, suggested time 25 minutes)

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 below.

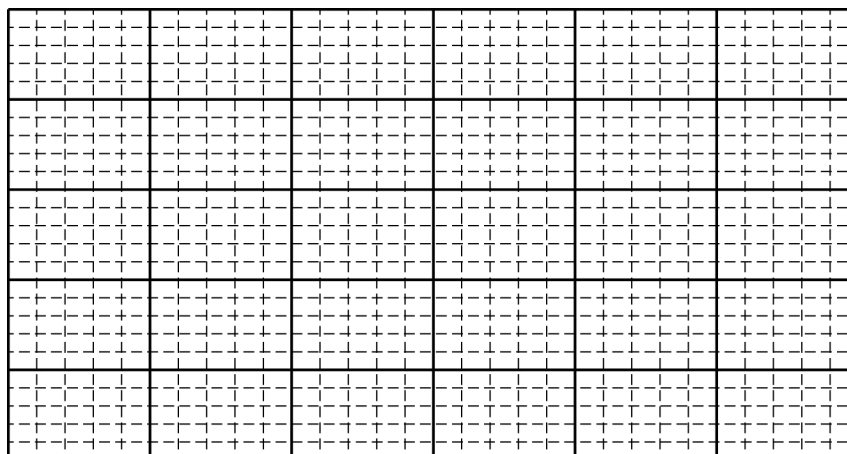
Dough Cylinder	A (m ²)	ℓ (m)	ΔV (V)	R (Ω)		
1	0.00049	0.030	1.02	23.6		
2	0.00049	0.050	2.34	31.5		
3	0.00053	0.080	3.58	61.2		
4	0.00057	0.150	6.21	105		

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

- Indicate below 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.

Vertical Axis: _____ Horizontal Axis: _____

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



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

2018 AP[®] PHYSICS 1 FREE-RESPONSE QUESTIONS

- (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 _____ No

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.

AP[®] PHYSICS 1

2018 SCORING GUIDELINES

Question 2

12 points total

Distribution
of points

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 below.

Lab Station	A (m^2)	ℓ (m)	ΔV (V)	R (Ω)	Example: RA ($\Omega \cdot \text{m}^2$)	Example: ℓ/A (m^{-1})
1	0.00049	0.030	1.02	23.6	0.012	61
2	0.00049	0.050	2.34	31.5	0.015	102
3	0.00053	0.080	3.58	61.2	0.032	151
4	0.00057	0.150	6.21	105.0	0.060	263

- (a) LO / SP: 1.E.2.1 / 4.1; 5.B.9.3 / 2.2; 5.C.3.2 / 4.1, 5.1

7 points

The students want to determine the resistivity of the dough cylinders.

- i. 2 points

Indicate below 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.

Vertical Axis: _____ Horizontal Axis: _____

For quantities derived from R , ℓ , and A only		1 point
For choosing two quantities that, graphed together, can be used to determine the resistivity		1 point

AP[®] PHYSICS 1

2018 SCORING GUIDELINES

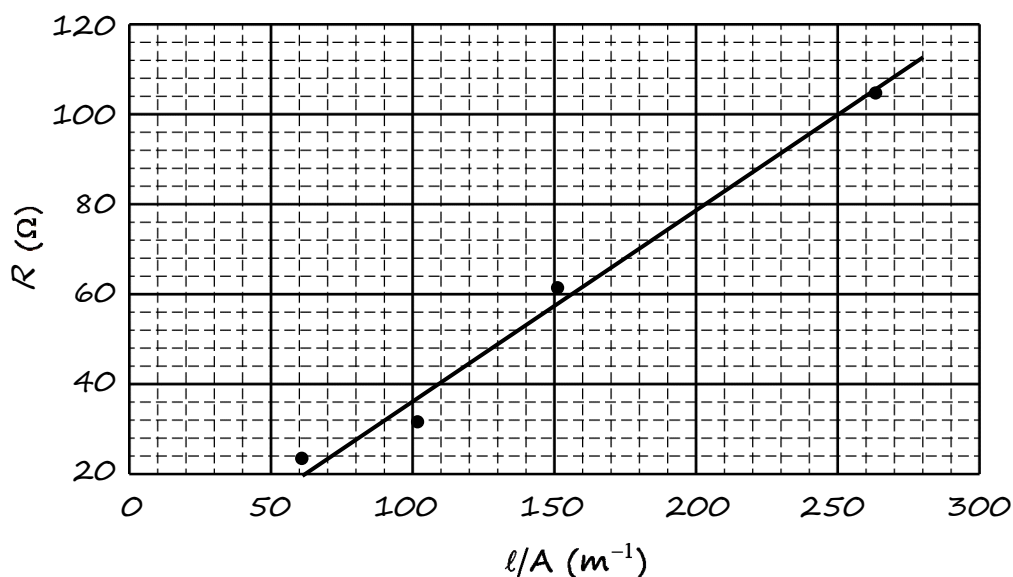
Question 2 (continued)

**Distribution
of points**

(a) (continued)

ii. 3 points

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



<u>Note:</u> The following points can be earned only if the graphed points correspond to the quantities chosen in (a)(i).		
For a linear scale where the plotted data uses at least half the grid		1 point
For labeling both axes, with units as appropriate		1 point
For data points plotted that represent the appropriate trend based on chosen quantities <u>Note:</u> The appropriate trend depends on the choice of graphed quantities and may be e.g., linear, inversely proportional, etc.		1 point

AP[®] PHYSICS 1

2018 SCORING GUIDELINES

Question 2 (continued)

**Distribution
of points**

(a) (continued)

iii. 2 points

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

For correctly using the slope of the graph to find the resistivity or a statement that a calculator was used to find the appropriate value from the graph		1 point
For a correct value of the resistivity $\rho = 0.42 \, \Omega \cdot \text{m}$ (± 0.03) calculated from graph or data		1 point

(b) LO / SP: 1.E.2.1 / 4.1

1 point

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 ☐ No

Briefly justify your reasoning.

Correct answer: “No” <u>Note</u> : If the wrong selection is made, the explanation is not graded.		
For indicating that resistivity only depends on material, not shape		1 point

(c) LO / SP: 1.E.2.1 / 4.1; 5.B.9.2 / 4.2; 5.B.9.3 / 2.2; 5.C.3.2 / 4.1, 4.2; 5.C.3.3 / 1.4, 2.2

4 points

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.

For explicitly or implicitly controlling all variables (e.g., length and area) except for temperature		1 point
For a plausible way to change the temperature of the dough		1 point
For indicating that the temperature will be varied		1 point
For a valid and feasible experiment in which resistance, OR voltage and current, are appropriately measured		1 point
Example: Make two dough cylinders of the same length and cross-sectional area. Keep one cylinder at room temperature, and heat the other cylinder on a hot plate to 30°C (measured with a thermometer). Apply the same voltage to each cylinder (measured with a voltmeter), and measure the current through each cylinder with an ammeter.		

AP[®] PHYSICS 1

2018 SCORING GUIDELINES

Question 2 (continued)

Learning Objectives (LO)

- LO 1.E.2.1:** The student is able to choose and justify the selection of data needed to determine resistivity for a given material. [See Science Practice 4.1]
- LO 5.B.9.2:** The student is able to apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule ($\Delta V = 0$) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. [See Science Practices 4.2, 6.4, and 7.2]
- LO 5.B.9.3:** The student is able to apply conservation of energy (Kirchhoff's loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, one parallel branch. [See Science Practices 2.2, 6.4, and 7.2]
- LO 5.C.3.2:** The student is able to design an investigation of an electrical circuit with one or more resistors in which evidence of conservation of electric charge can be collected and analyzed. [See Science Practices 4.1, 4.2, and 5.1]
- LO 5.C.3.3:** The student is able to use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit. [See Science Practices 1.4 and 2.2]