Question 3: Experimental Design and Analysis (LAB) — 10 points

A

For a procedure in which the length of and the current in the circuit element are measured, and the cross-sectional area of the circuit element is determined — **Point A1**

For a procedure that indicates a reasonable method of reducing experimental uncertainty — **Point A2**

Examples of acceptable responses may include the following:

- Making different measurements of the current in the circuit element
- Varying the potential difference of the power supply

Example Response

Measure the length and diameter of the circuit element. Use the diameter to calculate the area of the circuit element. Measure the current in the circuit element. Repeat the procedure multiple times for different potential difference settings on the variable power supply.

B

For indicating quantities that can be graphed appropriately to determine ρ_1, consistent with the procedure from part A, such as potential difference as a function of current — **Point B1**

Scoring Notes:

- Responses that include the reciprocals of the preceding example, in addition to other equivalent graphs, also earn this point.
- This point may be earned independently of the response in part A.

For a correct analysis of the graph, consistent with the first point of part B — **Point B2**

Example Response

Graph the potential difference across the circuit element as a function of the current in the circuit element. Use the slope of the graph, which is $\frac{\rho_1 \ell}{\pi r^2}$*, where* ℓ *is the length of the circuit element and r is equal to the radius of the circuit element, to determine* ρ_1*.*

C **(i)**

For indicating appropriate quantities that could be plotted on the graph to determine ρ_2, for example R as a function of L — **Point C1**

Scoring Note: This point may be earned:

- if the vertical and horizontal variables are reversed.
- for other equivalent graphs.

(ii)

For labeling the axes (including units) with a linear scale — **Point C2**

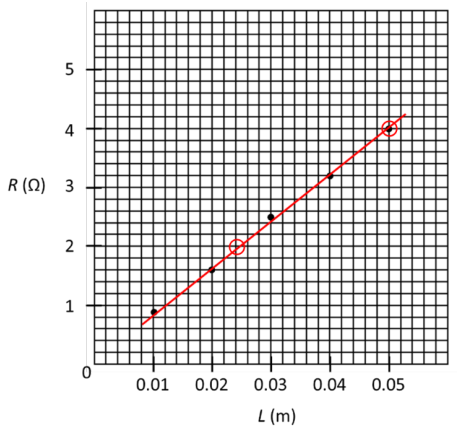
(iii)

For correctly plotting data points consistent with **one** of the following: — **Point C3**

- The quantities indicated in part C (i)
- The quantities provided in the table
- The axes indicated in the first point of part C (ii)

For drawing a line or curve that approximates the trend of the plotted data — **Point C4**

Example Response



D

For correctly relating the slope of the best-fit line to ρ_2 — **Point D1**

(e.g., $\frac{\Delta R}{\Delta L} = \text{slope} = \frac{\rho_2}{A}$)

For a value for ρ_2 that is between $3.5\times10^{-4}\ \Omega\cdot\text{m}$ and $4.5\times10^{-4}\ \Omega\cdot\text{m}$ — **Point D2**

Example Response

$$\text{slope} = \frac{\Delta R}{\Delta L}$$

$$\frac{\Delta R}{\Delta L} = \frac{4.0\ \Omega - 2.0\ \Omega}{0.050\ \text{m} - 0.024\ \text{m}}$$

$$\frac{\Delta R}{\Delta L} = 77\ \frac{\Omega}{\text{m}}$$

$$R = \frac{\rho L}{A}$$

$$R = \left(\frac{\rho_2}{A}\right) L$$

$$\text{slope} = \frac{\rho_2}{A}$$

$$\rho_2 = A(\text{slope})$$

$$\rho_2 = \left(5.0\times10^{-6}\ \text{m}^2\right)\left(77\ \frac{\Omega}{\text{m}}\right)$$

$$\rho_2 \approx 3.9\times10^{-4}\ \Omega\cdot\text{m}$$