2025

AP® Physics 2: Algebra-Based

Scoring Guidelines

Question 1: Mathematical Routines (MR) — 10 points

A (i) For indicating that the magnetic field is directed into the page in Figure 2 — **Point A1**

For indicating **one** of the following: — **Point A2**

- The magnetic force is directed in the $+y$ -direction in Figure 3.
- If the direction is out of the page in Figure 2, the magnetic force is directed in the $-y$ -direction in Figure 3.

Example Response

Magnetic Field from Wire 2 at Point P

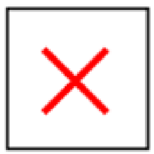


Figure 2

Magnetic Force on Wire 1 by Wire 2

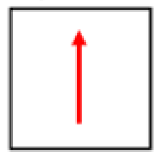


Figure 3

(ii) For a multistep derivation that includes $B = \dfrac{\mu_0 I}{2\pi r}$, $\sum \vec{F} = 0$, an equation that is equivalent to one of the equations listed, or a relevant equation — **Point A3**

Scoring Note: Vector notation is not required for this point to be earned.

For a correct expression for the magnitude of the magnetic field due to the current in Wire 2 along Wire 1 (e.g., $B_2 = \dfrac{\mu_0 I}{2\pi d}$) — **Point A4**

For a substitution of $2I$ for a current term in **one** of the following expressions: — **Point A5**

- The magnitude of the magnetic field due to the current in Wire 3 along Wire 1 (e.g., $\dfrac{\mu_0 (2I)}{2\pi d_3}$)
- The magnitude of the magnetic force exerted on Wire 1 due to the current in Wire 3 (e.g., $I\ell \dfrac{\mu_0 (2I)}{2\pi d_3}$)

For equating the magnitudes of the magnetic fields from or the force per unit length exerted by the currents in wires 2 and 3 along Wire 1, consistent with point A5 (e.g., $\dfrac{\mu_0 I}{2\pi d} = \dfrac{\mu_0 (2I)}{2\pi d_3}$) — **Point A6**

For a correct expression for $|y_3|$ (e.g., $|y_3| = 2d$) — **Point A7**

Scoring Note: A correct, isolated, final expression earns points A4, A5, A6, and A7.

Example Response

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B_2 = \frac{\mu_0 I}{2\pi d}$$

$$B_3 = \frac{\mu_0 (2I)}{2\pi d_3}$$

$$B_2 = B_3$$

$$\frac{\mu_0 I}{2\pi d} = \frac{\mu_0 (2I)}{2\pi d_3}$$

$$d_3 = 2d$$

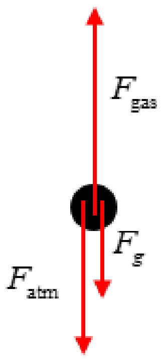
$$y_3 = -2d$$

B	For indicating that the induced current in the loop is clockwise	**Point B1**
	For indicating **one** of the following: • The direction of the magnetic field due to the currents in wires 1 and 2 is into the page inside the loop. • The magnetic flux through the loop due to the currents in wires 1 and 2 is into the page.	**Point B2**
	For correctly relating the change in the absolute value of the magnetic flux to the direction of the induced magnetic field produced by the induced current in the loop **Scoring Note:** This point is checking for a correct application of Lenz's law to the direction of the magnetic field chosen in point B2.	**Point B3**
	Example Response *Clockwise. The magnetic field from wires 1 and 2 is directed into the page within the loop, and the absolute value of the magnetic flux through the loop decreases as the loop moves away from the wires. This means that the induced magnetic field produced by the induced current in the loop must also be into the page.*	

Question 2: Translation Between Representations (TBR) — 12 points

A	For drawing an appropriately labeled arrow downward to represent the direction of the force F_g of gravity that is exerted on the piston	**Point A1**
	For drawing an appropriately labeled arrow downward to represent the direction of the force F_{atm} of the atmosphere that is exerted on the piston	**Point A2**
	For drawing an appropriately labeled arrow upward to represent the direction of the force F_{gas} of the gas that is exerted on the piston	**Point A3**

Example Response



B	For a multistep derivation that includes $U = \frac{3}{2}nRT$, $U = \frac{3}{2}Nk_BT$, $PV = nRT$, $PV = Nk_BT$, $\vec{a}_{\text{sys}} = \frac{\sum \vec{F}}{m_{\text{sys}}} = \frac{\vec{F}_{\text{net}}}{m_{\text{sys}}}$, $\sum \vec{F} = 0$, $P = \frac{F_\perp}{A}$, an equation that is equivalent to one of the equations listed, or a relevant equation **Scoring Note:** Vector notation is not required for this point to be earned.	**Point B1**
	For correctly relating the internal energy of the gas to $PV = nRT$ or $PV = Nk_BT$ (e.g., $U = \frac{3}{2}PV$) **Scoring Note:** This point can be earned if the response refers to a generic pressure instead of an absolute pressure.	**Point B2**
	For an expression for **one** of the following: • The correct absolute pressure P of the gas (e.g., $PA - P_{\text{atm}}A - Mg = 0$ or $P = P_{\text{atm}} + \frac{Mg}{A}$). • The absolute pressure of the gas that is consistent with an incorrect diagram provided in part A.	**Point B3**
	For an expression for the internal energy of the gas that is consistent with the expression for the pressure P of the gas that is derived for point B3 (e.g., $U = \frac{3}{2}\left(P_{\text{atm}} + \frac{Mg}{A}\right)V_0$) **Scoring Note:** A correct, isolated, final expression earns points B2, B3, and B4.	**Point B4**

Example Response

$$\vec{a}_{sys} = \frac{\sum \vec{F}}{m_{sys}} = \frac{\vec{F}_{net}}{m_{sys}}$$

$$\Sigma \vec{F} = 0$$

$$P = \frac{F_{\perp}}{A}$$

$$PA - P_{atm}A - F_g = 0$$

$$PA - P_{atm}A - Mg = 0$$

$$P - P_{atm} - \frac{Mg}{A} = 0$$

$$P = P_{atm} + \frac{Mg}{A}$$

$$U = \frac{3}{2}nRT$$

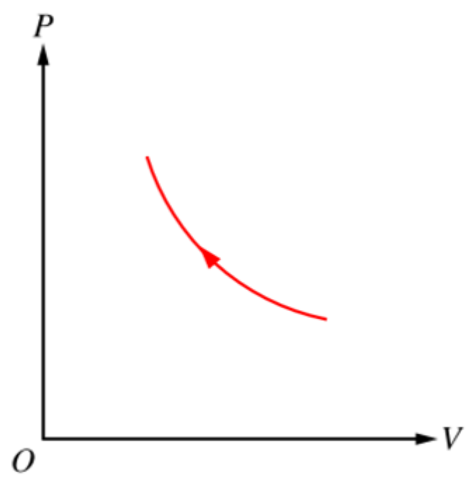
$$PV = nRT$$

$$U = \frac{3}{2}PV$$

$$U = \frac{3}{2}\left(P_{atm} + \frac{Mg}{A}\right)V_0$$

C	For drawing a line or curve that connects a point in the lower right region of the diagram to the upper left region of the diagram	**Point C1**
	For drawing a curve that is concave up	**Point C2**
	For drawing an arrow that points from a greater to a lesser volume or from a lesser to a greater pressure	**Point C3**

Example Response



D

For indicating $T_{\text{new}} > T_0$ or an indication that is consistent with incorrect features of the diagram in part A, an incorrect derivation in part B, or incorrect features of the graph in part C — **Point D1**

For **one** of the following: — **Point D2**

- A correct justification that indicates that the pressure of the gas has increased for the same volume using features of the diagram in part A, the derivation in part B, or features of the graph in part C
- A correct justification that indicates that the volume of the gas has increased for the same pressure using features of the diagram in part A, the derivation in part B, or features of the graph in part C
- A justification that is consistent with incorrect features of the diagram in part A, an incorrect derivation in part B, or incorrect features of the graph in part C

Scoring Notes:

- If the justification is consistent with incorrect features of the diagram in part A, an incorrect derivation in part B, or incorrect features of the graph in part C, and the justification is consistent with an incorrect selection, points D1 and D2 are earned.
- If the justification is consistent with incorrect features of the diagram in part A, an incorrect derivation in part B, or incorrect features of the graph in part C, but the justification is not consistent with an incorrect selection, only point D2 is earned.
- If the justification is not consistent with incorrect features of the diagram in part A, an incorrect derivation in part B, or incorrect features of the graph in part C, but $T_{\text{new}} > T_0$ is selected, only point D1 is earned.

Example Responses

Using the representation from part A if the response considers the volume of the gas at time t_0 and the final volume of the gas after the process described in part D

- *For the piston to remain in equilibrium, the increase in weight from the block would require a greater force, and, therefore, pressure, from the gas on the piston. Because the two volumes are equal, a greater pressure will correspond to a greater temperature. Therefore, $T_{\text{new}} > T_0$.*

Using the representation from part B

- *According to the derivation in part B, if volume increases while pressure remains constant, the internal energy of the gas increases, and, therefore, the temperature will increase. Therefore, $T_{\text{new}} > T_0$.*
- *According to the derivation in part B, the added mass on the piston when the volume is back to the original volume increases the internal energy of the gas. Thus, the temperature increases. Therefore, $T_{\text{new}} > T_0$.*

Using the representation from part C if the response considers the volume of the gas at time t_f and the final volume of the gas after the process described in part D

- *Looking at the graph, if the volume is increased at constant pressure, from the end of the curve that I drew, the product of pressure and volume, and therefore, temperature, will be greater at the end of this process than at the beginning. Therefore, $T_{\text{new}} > T_0$.*

Using the representation from part C if the response considers the volume of the gas at time t_0 and the final volume of the gas after the process described in part D

- *According to the graph in part C, the pressure of the gas at the end of the process in part C is greater than that at the beginning of the process. For the gas to occupy the original volume (at time t_0), the final gas pressure must be greater than the original gas pressure. Therefore,* $T_{\text{new}} > T_0$.
- *According to the graph in part C, if the pressure is increased by the added block, and the volume is the same from the beginning of the curve that I drew, the product of pressure and volume, and, therefore, temperature, will be greater at the end of this process than at the beginning. Therefore,* $T_{\text{new}} > T_0$.

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

A	For a procedure that includes **both** of the following measurements: • The dimensions of the capacitor • A current	**Point A1**
	For a procedure that indicates an appropriate method of reducing experimental uncertainty (e.g., Repeat the procedure multiple times.)	**Point A2**
	Example Responses *Measure the length of one side of a capacitor plate. Measure the separation distance between the plates. Construct a circuit that includes the battery and the resistor. Measure the current in the resistor. Repeat measurements of current in the resistor for the described closed circuit.* *Measure the length of one side of a capacitor plate. Measure the separation distance between the plates. Construct a circuit that includes the battery, resistor, and capacitor. Measure the initial current in the resistor after the closed circuit is constructed. Disconnect the capacitor from the circuit, discharge the capacitor, and repeat the procedure.*	
B	For indicating that $\tau = R_{eq}C_{eq}$ can be used to calculate τ	**Point B1**
	For **both** of the following: • A correct relationship between resistance, the emf of the battery, and current (e.g., $R_{eq} = \frac{\mathcal{E}}{I}$) • A correct relationship between capacitance, the area of a capacitor plate, and the distance between the capacitor plates (e.g., $C_{eq} = \varepsilon_0 \frac{A}{d}$)	**Point B2**
	Example Responses $\tau = R_{eq}C_{eq}$ *can be used to determine* τ. R_{eq} *can be determined by using* $R_{eq} = \frac{\mathcal{E}}{I}$, *where I is the current in the resistor when the resistor is connected to the battery.* C_{eq} *can be determined by using* $C_{eq} = \varepsilon_0 \frac{A}{d}$, *where d is the distance between the capacitor plates and A is the square of the length of a capacitor plate.* $\tau = R_{eq}C_{eq}$ *can be used to determine* τ. R_{eq} *can be determined by using* $R_{eq} = \frac{\mathcal{E}}{I}$, *where I is the initial current in the resistor when the resistor is connected in series with the battery and the capacitor.* C_{eq} *can be determined by using* $C_{eq} = \varepsilon_0 \frac{A}{d}$, *where d is the distance between the capacitor plates and A is the square of the length of a capacitor plate.*	

C **(i)** For indicating appropriate quantities that can be plotted to produce a linear graph to determine C — **Point C1**

Scoring Note: Any response that correctly identifies the functional dependence between varied quantities earns this point, regardless of any coefficients that contain numbers or physical/fundamental constants, or which axis is chosen to graph each of those quantities.

Example Responses

q *as a function of* $|\Delta V|$

$|\Delta V|$ *as a function of* q

$\frac{1}{q}$ *as a function of* $\frac{1}{|\Delta V|}$

$\frac{1}{|\Delta V|}$ *as a function of* $\frac{1}{q}$

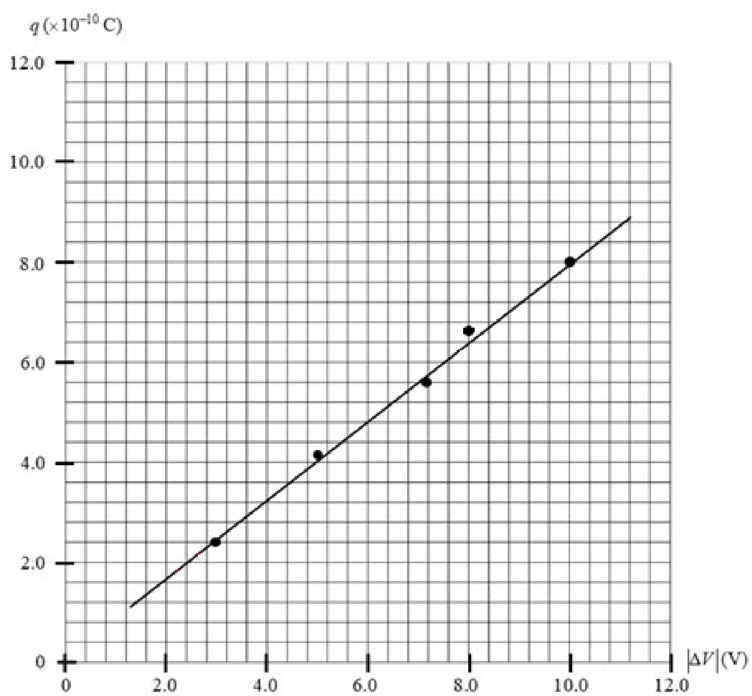
(ii) For labeling the axes (including units) with a linear scale — **Point C2**

For correctly plotting the 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 point C2

(iii) 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 straight line graph to $q = C|\Delta V|$ or a correct equation that is consistent with an appropriate graph that can be used to determine C (e.g., $\frac{\Delta q}{\Delta|\Delta V|} = \text{slope} = C$) **Point D1**

Example Responses

The slope of q *as a function of* $|\Delta V|$ *is C.*

The slope of $|\Delta V|$ *as a function of q is* $\frac{1}{C}$.

The slope of $\frac{1}{q}$ *as a function of* $\frac{1}{|\Delta V|}$ *is* $\frac{1}{C}$.

The slope of $\frac{1}{|\Delta V|}$ *as a function of* $\frac{1}{q}$ *is C.*

For a value for C that is approximately equal to 8×10^{-11} F, within the range $7 \times 10^{-11}\ \text{F} \le C \le 9 \times 10^{-11}\ \text{F}$ **Point D2**

Scoring Notes:

- If the slope of the plotted data points is equal to the quantity that is supposed to be determined, a correct, isolated final value earns points D1 and D2.
- If the slope of the plotted data points is not equal to the quantity that is supposed to be determined, a correct, isolated final value earns point D2 only.

Example Response

$$\text{slope} = \frac{\Delta q}{\Delta|\Delta V|}$$

$$\frac{\Delta q}{\Delta|\Delta V|} = \frac{(6.4 \times 10^{-10}\ \text{C}) - (2.0 \times 10^{-10}\ \text{C})}{8.0\ \text{V} - 2.4\text{V}}$$

$$\frac{\Delta q}{\Delta|\Delta V|} = 7.9 \times 10^{-11}\ \frac{\text{C}}{\text{V}}$$

$$C = \frac{Q}{\Delta V}$$

$$q = C|\Delta V|$$

$$\text{slope} = C$$

$$C \approx 8 \times 10^{-11}\ \text{F}$$

Question 4: Qualitative Quantitative Translation (QQT) — 8 points

A

For indicating **one** of the following: **Point A1**

- The claim is correct if a justification is not provided.
- An indication about the claim that is consistent with the justification provided.

For a correct comparison of **one** of the following: **Point A2**

- The wavelength of violet light is shorter than the wavelength of red light.
- The frequency of violet light is greater than the frequency of red light.

For indicating that a shorter wavelength corresponds to a shorter path length difference, resulting in a shorter distance between the center of Band A and the center of the central bright band **Point A3**

Example Response

The claim is correct. The wavelength of violet light is shorter than that of red light. This shorter wavelength leads to a shorter path length difference for violet light as compared to red light. This corresponds to a shorter distance between Band A and the central band.

B

For a multistep derivation that includes $d\left(\frac{y_{max}}{L}\right) \approx m\lambda$, $d\sin\theta = m\lambda$, $\Delta D = m\lambda$, $\Delta D = d\sin\theta$, $\Delta D \approx d\left(\frac{y_{max}}{L}\right)$, $d\sin\theta \approx d\left(\frac{y_{max}}{L}\right)$, $\sin\theta \approx \left(\frac{y_{max}}{L}\right)$, $\tan\theta \approx \left(\frac{y_{max}}{L}\right)$, $\theta \approx \left(\frac{y_{max}}{L}\right)$, an equation that is equivalent to one of the equations listed, or a relevant equation **Point B1**

For a substitution of $\frac{c}{f}$ for λ **Point B2**

For correctly relating y_{max} to the orders of bands A and B **Point B3**

(e.g., $2\left(y_{max,\,2} - y_{max,\,0}\right) = 2\left(\frac{(2)cL}{fd}\right)$)

Scoring Note: A correct, isolated, final expression earns points B2 and B3.

Example Response

$$d\left(\frac{y_{\text{max}}}{L}\right) \approx m\lambda$$

$$\lambda = \frac{c}{f}$$

$$d\left(\frac{y_{\text{max}}}{L}\right) = m\frac{c}{f}$$

$$y_{\text{max}} = \frac{mcL}{fd}$$

$$\Delta y = 2\left(y_{\text{max, 2}} - y_{\text{max, 0}}\right)$$

$$\Delta y = 2\left(\frac{(2)cL}{fd}\right)$$

$$\Delta y = \frac{4cL}{fd}$$

C	For correctly indicating that the expression derived in part B is or is not consistent with the answer provided in part A	**Point C1**
	For a justification that includes the consistent functional dependence between the spacing between bright bands on the screen and the frequency or wavelength of light	**Point C2**

Example Response

My derivation in part B is consistent with my answer in part A. Violet light has a greater frequency than red light. Because $\Delta y = \frac{4cL}{fd}$*, a greater frequency for violet light results in a shorter distance between bright bands.*