2026

AP® Physics C: Electricity and Magnetism

Scoring Guidelines

Question 1: Mathematical Routines (MR) — 10 points

A	**(i)**	For a multistep derivation that includes the equation $\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{\text{enc}}$ or an equivalent equation **Scoring Note**: Vector notation and line integral notation are not required for this point to be earned.	**Point A1**
		For indicating that $\oint d\ell = 2\pi a$ **Scoring Note:** Line integral notation is not required for this point to be earned.	**Point A2**
		For substituting $dA = 2\pi r dr$ and $J = Cr$ into $I = \int \vec{J} \cdot d\vec{A}$ **Scoring Note:** Limits of integration are not required for this point to be earned.	**Point A3**
		For limits of integration from 0 to a for the current integral (e.g., $I_{\text{enc}} = \int_0^a J dA$)	**Point A4**
		For a correct expression (e.g., $B = \dfrac{\mu_0}{2\pi a}\left(\dfrac{2\pi C a^3}{3}\right)$, $B = \dfrac{\mu_0 C a^2}{3}$, or algebraic equivalent)	**Point A5**

Example Response

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{\text{enc}}$$

$$B(2\pi a) = \mu_0 I_{\text{enc}}$$

$$B = \frac{\mu_0 I_{\text{enc}}}{2\pi a}$$

$$I = \int \vec{J} \cdot d\vec{A}$$

$$dA = 2\pi r dr$$

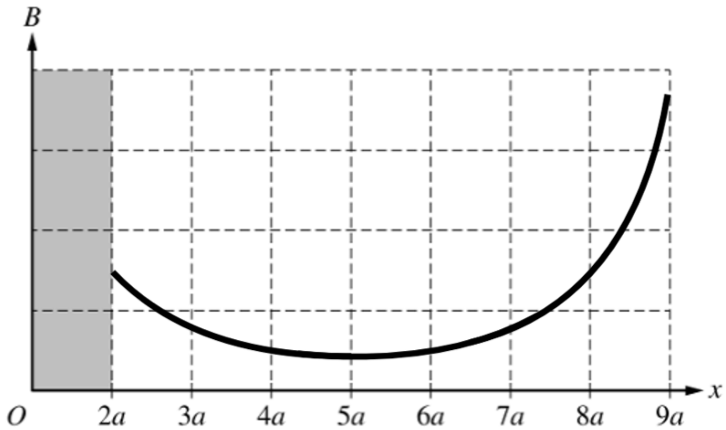
$$I_{\text{enc}} = \int_0^a Cr(2\pi r dr) = 2\pi C \int_0^a r^2 dr$$

$$I_{\text{enc}} = 2\pi C\left[\frac{r^3}{3}\right]_0^a = \frac{2\pi C a^3}{3}$$

$$\therefore B = \frac{\mu_0}{2\pi a}\left(\frac{2\pi C a^3}{3}\right) = \frac{\mu_0 C a^2}{3}$$

(ii)	For a curve that has a minimum between $x = 4a$ and $x = 6a$	**Point A6**
	For a curve that is concave up everywhere with a value at $x = 9a$ that is greater than the value at $x = 2a$	**Point A7**

Example Response



B	For a multistep derivation that includes $\vec{F} = q\left(\vec{v} \times \vec{B}\right)$ **Scoring Note:** Vector notation is not required for this point to be earned.	**Point B1**
	For indicating that the net magnetic field (or net force) due to the currents in the wires is equal to the combination of the fields (or forces) from both wires	**Point B2**
	For a correct expression (e.g., $F = \dfrac{\mu_0 I_0 Q v}{5\pi a}$)	**Point B3**

Example Response

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{\text{enc}}$$

Wire S

$$B_{\text{S}}\left(2\pi(5a)\right) = \mu_0 I_0$$

$$B_{\text{S}} = \frac{\mu_0 I_0}{10\pi a}$$

Wire T

$$B_{\text{T}}\left(2\pi(10a - 5a)\right) = \mu_0 I_0$$

$$B_{\text{T}} = \frac{\mu_0 I_0}{10\pi a}$$

Net Magnetic Field

$$B = B_{\text{S}} + B_{\text{T}} = \frac{\mu_0 I_0}{10\pi a} + \frac{\mu_0 I_0}{10\pi a} = \frac{\mu_0 I_0}{5\pi a}$$

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$F = qvB$$

$$F = \frac{\mu_0 I_0 Q v}{5\pi a}$$

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

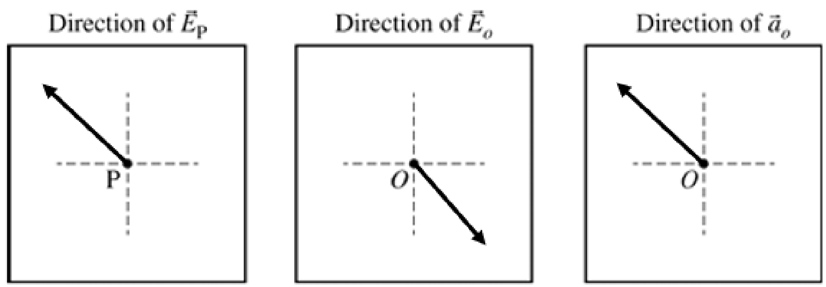
A

For drawing an arrow that is up and to the left above the horizontal axis for the direction of $\vec{E}_{\mathrm{P}}$ — **Point A1**

For drawing an arrow that is down and to the right below the horizontal axis for the direction of $\vec{E}_O$ — **Point A2**

For drawing an arrow for $\vec{a}_O$ that is directed opposite the arrow drawn for the direction of $\vec{E}_O$ — **Point A3**

Example Response



B

For a multistep derivation that includes the equation $\vec{E} = k\int \frac{dq}{r^2}\hat{r}$ — **Point B1**

Scoring Note: Vector notation and unit vector notation are not required for this point to be earned.

For a substitution of a correct expression for dq that includes λ (e.g., $dq = \lambda dx$ or $dq = \lambda dy$) — **Point B2**

For an attempt to solve the integral for a component of the net electric field that includes correct limits — **Point B3**

For a correct vector addition of the derived electric fields for both rods resulting in an expression in terms of L, λ, and physical constants — **Point B4**

Example Response

Determine magnitude E_T of the electric field due to Rod T at the origin.

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r^2}\hat{r}$$

$$E_T = -k\int\left(\frac{1}{y^2}\right)dq$$

$$dq = \lambda\, dy$$

$$E_T = -k\lambda\int_L^{3L}\frac{dy}{y^2}$$

$$E_T = k\lambda\left(\frac{1}{y}\right)\Bigg|_L^{3L}$$

$$E_T = k\lambda\left(\frac{1}{3L}\right) - k\lambda\left(\frac{1}{L}\right) = -\frac{2}{3}\frac{k\lambda}{L}$$

Magnitude E_S of the electric field due to Rod S is equal to E_T.

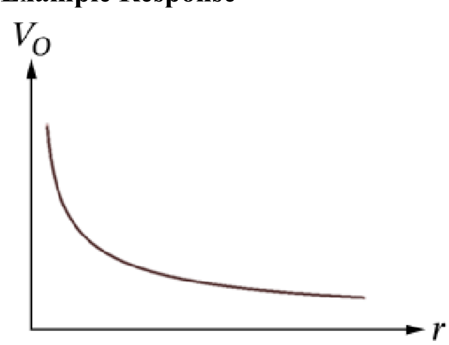
$$E_O = \sqrt{(E_S)^2 + (E_T)^2} = \sqrt{2(E_T)^2}$$

$$E_O = \sqrt{2\left(\frac{2}{3}\frac{k\lambda}{L}\right)^2}$$

$$\therefore E_O = \frac{2\sqrt{2}}{3}\frac{k\lambda}{L}$$

C	For a curve that always decreases as r increases	**Point C1**
	For a curve with a slope whose absolute value always decreases as r increases	**Point C2**
	For a curve that approaches zero as r increases and approaches infinity as r decreases	**Point C3**

Example Response



D	For indicating that V_O is zero for all values of r	**Point D1**
	For a justification that indicates that the linear charge densities are equal in magnitude but opposite in sign and the rods are always the same distance from the origin	**Point D2**
	Example Response *The rods are identical in length but have equal and opposite linear charge densities. Electric potential is a scalar, and the electric potentials at the origin from the rods cancel because the rods are always the same distance from the origin. Therefore,* $V_O = 0$.	

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

A (i) For indicating that the potential difference across the capacitor or the inductor is measured over time — **Point A1**

(ii) For indicating a reasonable method of reducing experimental uncertainty — **Point A2**

Examples of acceptable responses may include the following:

- Different capacitors are used in subsequent trials
- Multiple trials are completed with the same capacitor

Example Response

Measure the potential difference across the capacitor as a function of time after the switch is closed for long enough to measure the period of oscillation. Repeat the procedure with different capacitors in subsequent trials.

B (i) For indicating appropriate quantities that can be graphed to determine L_1, consistent with the response in part A (i), such as: — **Point B1**

- T as a function of $\sqrt{C}$
- T^2 as a function of C
- Angular frequency ω as a function of $\sqrt{\dfrac{1}{C}}$

Scoring Note: Responses that include the reciprocals of the preceding examples, in addition to other equivalent graphs, also earn this point.

(ii) For correctly relating an appropriate feature of the graph to L_1 — **Point B2**

Example Response

Graph T as a function of $2\pi\sqrt{C}$ *. The slope of the best-fit line is equal to* $\sqrt{L_1}$.

C (i) For indicating appropriate quantities that can be graphed to determine L_2, for example: — **Point C1**

- $\Delta V_{\text{Battery}} - IR$ as a function of $\dfrac{dI}{dt}$
- ΔV_L as a function of $\dfrac{dI}{dt}$

Scoring Note: This point may be earned:

- If the vertical and horizontal variables are reversed
- For other equivalent graphs

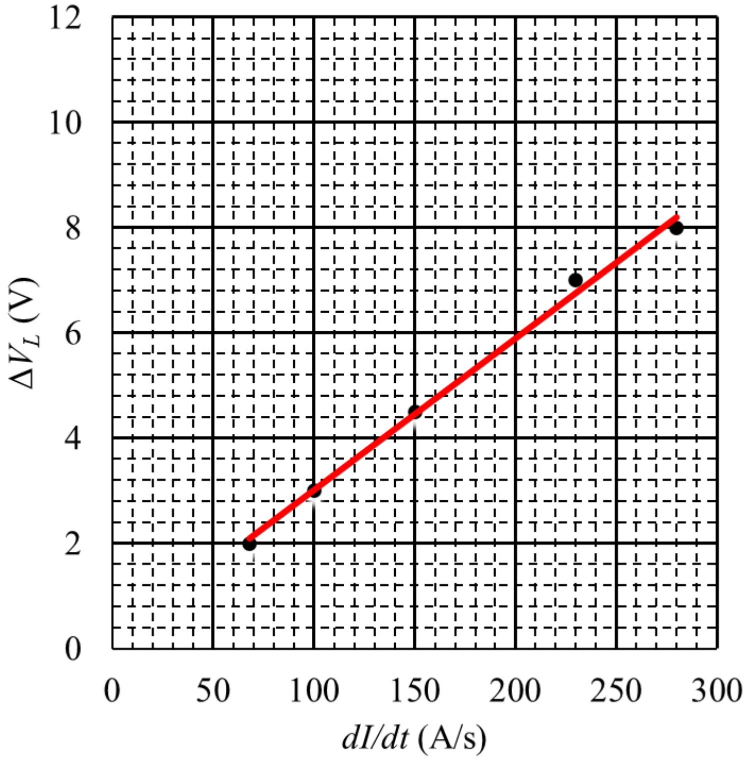
(ii) For labeling **both** axes (including units where appropriate) with a linear scale — **Point C2**

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

(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 best-fit line of the graph to L_2	**Point D1**
	For a value of L_2 that is within a range of $0.026\ \text{H}$ to $0.032\ \text{H}$	**Point D2**

Example Response

Determine the Potential Difference Across the Inductor:

$$\Delta V_{\text{Battery}} - \Delta V_R - \Delta V_L = 0$$

$$\Delta V_L = \Delta V_{\text{Battery}} - \Delta V_R$$

$$\Delta V_L = \Delta V_{\text{Battery}} - IR$$

Determine the Inductance of the Inductor:

$$|\Delta V_L| = L\frac{dI}{dt}$$

$$\text{slope} = L = \frac{\Delta(|\Delta V_L|)}{\Delta\left(\frac{dI}{dt}\right)}$$

$$\frac{\Delta(|\Delta V_L|)}{\Delta\left(\frac{dI}{dt}\right)} = \frac{(7.7\ \text{V}) - (5.3\ \text{V})}{(260\ \text{A/s}) - (180\ \text{A/s})}$$

$$\therefore L_2 = 0.03\ \text{H}$$

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

A	For indicating that I is counterclockwise	**Point A1**
	For indicating that the magnitude of the magnetic field is decreasing	**Point A2**
	For indicating that the induced magnetic field will oppose the changing flux through the loop	**Point A3**
	Example Response *During the time interval, the magnetic field is directed in the +z-direction and is decreasing in magnitude. To oppose this change in flux through the loop, the induced magnetic field must also be directed in the +z-direction. Therefore, a counterclockwise current is induced in the loop.*	
B	For a multistep derivation that includes $\Phi_B = \int \vec{B} \cdot d\vec{A}$, $\varepsilon = -\frac{d\Phi_B}{dt}$, or $I = \frac{\Delta V}{R}$ **Scoring Note:** Vector notation is not required for this point to be earned.	**Point B1**
	For substituting $B_0 \cos\left(2\pi \frac{t}{t_1}\right)$ for B into an equation for magnetic flux	**Point B2**
	For a correct expression (e.g., $I = \frac{2\pi s^2 B_0}{t_1 R} \sin\left(2\pi \frac{t}{t_1}\right)$) **Scoring Note:** Sign will not be considered when awarding this point.	**Point B3**

Example Response

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

$$\Phi_B = B_0 \cos\left(2\pi \frac{t}{t_1}\right) s^2$$

$$\varepsilon = -\frac{d\Phi_B}{dt}$$

$$\varepsilon = -B_0 s^2 \frac{d}{dt}\left(\cos\left(2\pi \frac{t}{t_1}\right)\right)$$

$$\varepsilon = \frac{2\pi s^2 B_0}{t_1} \sin\left(2\pi \frac{t}{t_1}\right)$$

$$I = \frac{\Delta V}{R} = \frac{\varepsilon}{R}$$

$$I = \frac{2\pi s^2 B_0}{t_1 R} \sin\left(2\pi \frac{t}{t_1}\right)$$

C	For indicating $I_2 > I_1$	**Point C1**
	For a justification that correctly references the functional dependence of the current on s and R in the expression derived in part B	**Point C2**
	Example Response $I_2 > I_1$. *The side length and the resistance of the loop doubles. The derivation in part B shows that the current is proportional to the square of the side length and inversely proportional to R, so the current increases.*	