2025

AP® Physics 2: Algebra-Based

Sample Student Responses and Scoring Commentary

Inside:

Free-Response Question 1

☑ Scoring Guidelines

☑ Student Samples

☑ Scoring Commentary

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

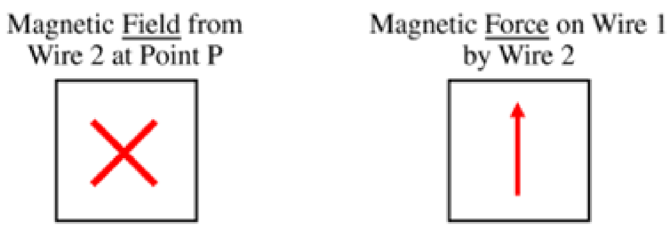


Figure 2   Figure 3

(ii) For a multistep derivation that includes $B = \frac{\mu_0 I}{2\pi r}$, $\sum \vec{F} = 0$, 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., $B_2 = \frac{\mu_0 I}{2\pi d}$) — **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., $\frac{\mu_0 (2I)}{2\pi d_3}$)
- The magnitude of the magnetic force exerted on Wire 1 due to the current in Wire 3 (e.g., $I\ell \frac{\mu_0 (2I)}{2\pi d_3}$)

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., $\frac{\mu_0 I}{2\pi d} = \frac{\mu_0 (2I)}{2\pi d_3}$) — **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.*	

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 1: Version J

PART A

$F_B = ILB$

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

$F_B = \frac{I_1 L_1 \mu_0 I_{other}}{2\pi r}$

$F_{B_2} + F_{B_3} = 0$

$F_{B_2} = -F_{B_3}$

$I_2 = +I$

$I_3 = +2I$

Symbols	
X Into the page	● Out of the page

Magnetic Field from Wire 2 at Point P

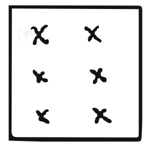
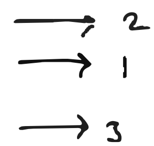


Figure 2

Magnetic Force on Wire 1 by Wire 2

Figure 3



$\frac{(I) L_1 \mu_0 (I)}{2\pi (d)} = -\frac{(I) L_1 \mu_0 (2I)}{2\pi y_3}$

$\frac{I^2 L_1 \mu_0}{2\pi d} = -\frac{2I^2 L_1 \mu_0}{2\pi y_3}$

$\frac{1}{d} = -\frac{2}{y_3}$

$\boxed{y_3 = -2d}$

PART B

✓ Clockwise ____ Counterclockwise ____ There is no induced current in the loop.

The magnetic field generated by Wires 1 and 2 is in the -z direction where the loop is initially placed. As the loop moves in the -y direction, the strength of the external field from the wires decreases according to the equation $B = \frac{\mu_0 I}{2\pi r}$ as r increases. This creates a change in flux and induces a magnetic field in the loop in the -z direction (opposing the change in external field) and a clockwise current.

Go to Question 2 in Bluebook when you're done with this question.

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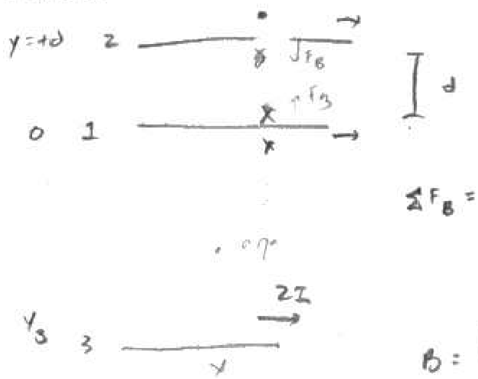
Question 1: Version J

PART A



Symbols	
✕ Into the page	● Out of the page

Magnetic Field from Wire 2 at Point P

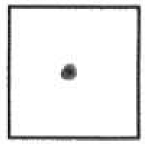


Figure 2

Magnetic Force on Wire 1 by Wire 2

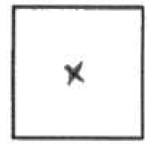


Figure 3

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

$F_B = I \ell B \sin\theta$

$\Sigma F_B = F_{B1,2} + F_{B1,3} = 0$

$\Sigma B = \frac{\mu_0 I}{2\pi d} + \frac{\mu_0 2I}{2\pi Y_3}$

$\frac{\mu_0 2I}{2\pi Y_3} = -\frac{\mu_0 I}{2\pi d}$

$2\pi Y_3 (-\mu_0 I) = 2\pi d (\mu_0 2I)$

$Y_3 = \frac{d \mu_0 2I}{-\mu_0 I}$

$Y_3 = -2d$

PART B

X Clockwise ____ Counterclockwise ____ There is no induced current in the loop.

Wire 1 will have magnetic field going into page on the side of the loop. Therefore, using the right hand rule where magnetic field is in and velocity is down, the induced current will move clockwise.

Go to Question 2 in Bluebook when you're done with this question.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 1: Version J

PART A

Symbols

X Into the page ● Out of the page

Magnetic Field from Wire 2 at Point P

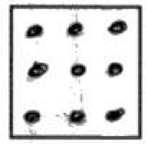


Figure 2

Magnetic Force on Wire 1 by Wire 2

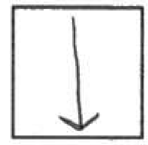


Figure 3

$\ell = d$

$F_{B_2} = -F_{B_3}$

~~$I\ell B\sin\theta$~~ $=$ ~~$-I\ell B\sin\theta$~~

$d = -d$

$y = d$ $\boxed{y_3 = -d}$

PART B

X Clockwise ____ Counterclockwise ____ There is no induced current in the loop.

Since wires 1 and 2 have current running in the same direction, they repel each other and their forces are acting in opposite directions. the force due to wire 1 acts on the loop causing it to move and inducing the same clockwise current.

Go to Question 2 in Bluebook when you're done with this question.

Question 1

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

NEW for 2025: The question overviews can be found in the *Chief Reader Report on Student Responses* on AP Central.

Sample: 1A
Score: 10

Part A (i) earned both points. The first point (A1) was earned because the response indicates that the magnetic field is into the page with multiple X drawings in Figure 2. The second point (A2) was earned because the response indicates that the direction of the magnetic force is up with an arrow pointing up in Figure 3. Part A (ii) earned five out of five points. The first point (A3) was earned because the response includes a multistep derivation starting with the equation for the magnetic force exerted on a current-carrying wire. The second point (A4) was earned because the response includes an expression for the magnetic field due to the current in Wire 2 along Wire 1 with correct variables of current and distance between these wires. The third point (A5) was earned because the response includes a substitution of twice the current into an expression of the magnetic field due to the current in Wire 3 along Wire 1. The fourth point (A6) was earned because the response includes setting the magnetic force Wire 2 exerts on Wire 1 equal to the magnetic force Wire 3 exerts on Wire 1. The fifth point (A7) was earned because the response indicates a correct expression of $-2d$.

Part B earned all three points. The first point (B1) was earned because the response indicates the induced current is clockwise. The second point (B2) was earned because the response indicates the magnetic field in the loop is in the -z-direction. The third point (B3) was earned because the response indicates that as the loop moves, the external field in the loop decreases. This creates a change in magnetic flux "and induces a magnetic field in the loop in the -z direction," which is a correct application of Lenz's law.

Sample: 1B
Score: 7

Part A (i) did not earn either point. The first point (A1) was not earned because the response indicates that the magnetic field is out of the page by drawing a dot in Figure 2. The second point (A2) was not earned because the response indicates that the direction of the magnetic force is into the page with an X 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. Part A (ii) earned five out of five points. The first point (A3) was earned because the response includes a multistep derivation starting with setting the sum of the forces equal to zero. The second point (A4) was earned because the response includes an expression for the magnetic field from Wire 2 along Wire 1 with correct variables of current and distance between these wires. The third point (A5) was earned because the response includes a substitution of twice the current into an expression of the magnetic field due to Wire 3 along Wire 1. The fourth point (A6) was earned because the response includes setting the magnetic field due to Wire 2 along Wire 1 equal to the magnetic field due to Wire 3 along Wire 1. The fifth point (A7) was earned because the response indicates a correct expression of $-2d$.

Part B earned two out of three points. The first point (B1) was earned because the response indicates that the induced current is clockwise. The second point (B2) was earned because the response states that the "magnetic field going into page on the side of the loop." The third point (B3) was not earned because the response does not relate a change in magnetic flux to the induced current in the loop.

Question 1 (continued)

Sample: 1C
Score: 4

Part A (i) earned one out of two points. The first point (A1) was not earned because the response indicates that the magnetic field is out of the page with multiple dot drawings in Figure 2. The second point (A2) was earned because the response indicates that the direction of the magnetic force is down with a single down arrow in Figure 3, which is consistent with an out of the page drawing in Figure 2. Part A (ii) earned two out of seven points. The first point (A3) was earned because the response includes a multistep derivation starting with setting the magnetic force that Wire 2 exerts on Wire 1 equal to the negative magnitude of the magnetic force that Wire 3 exerts on Wire 1. The second point (A4) was not earned because the response does not include an expression for the magnetic field from Wire 2 along Wire 1. The third point (A5) was not earned because the response does not include a substitution of twice the current into an expression of the magnetic field from Wire 3 along Wire 1. The fourth point (A6) was earned because the response includes setting the magnetic force Wire 2 exerts on Wire 1 equal to the negative magnitude of the magnetic force Wire 3 exerts on Wire 1. The fifth point (A7) was not earned because the response does not indicate a correct expression.

Part B earned one out of three points. The first point (B1) was earned because the response indicates that the induced current is clockwise. The second point (B2) was not earned because the response does not indicate the direction of the magnetic field in the loop due to currents in Wire 1 and Wire 2. The third point (B3) was not earned because the response does not indicate that the current in the loop is induced due to a change in magnetic flux through the loop.