2025

AP® Physics C: Mechanics

Sample Student Responses and Scoring Commentary

Inside:

Free-Response Question 3

- ☑ **Scoring Guidelines**
- ☑ **Student Samples**
- ☑ **Scoring Commentary**

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

A

For describing a procedure that includes measuring h and the speed of the block as the block moves across the surface — **Point A1**

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

Examples of acceptable responses may include the following:

- Repeating the experiment multiple times for the same value of h
- Repeating the experiment for multiple values of h

Example Response

Measure the height h at which the block-box system is released. Measure the speed of the block as the block slides across the horizontal surface. Repeat the measurement of the speed of the block for varying release heights.

B

For describing a graph that has linear trend that can be used to find g — **Point B1**

Examples of acceptable responses include the following:

- v^2 vs. $2h$
- $\frac{1}{2}v^2$ vs. h
- v^2 vs. h
- v vs. $\sqrt{h}$

Scoring Notes:

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

For correctly relating the slope of the best-fit line to g — **Point B2**

Examples of acceptable responses include the following:

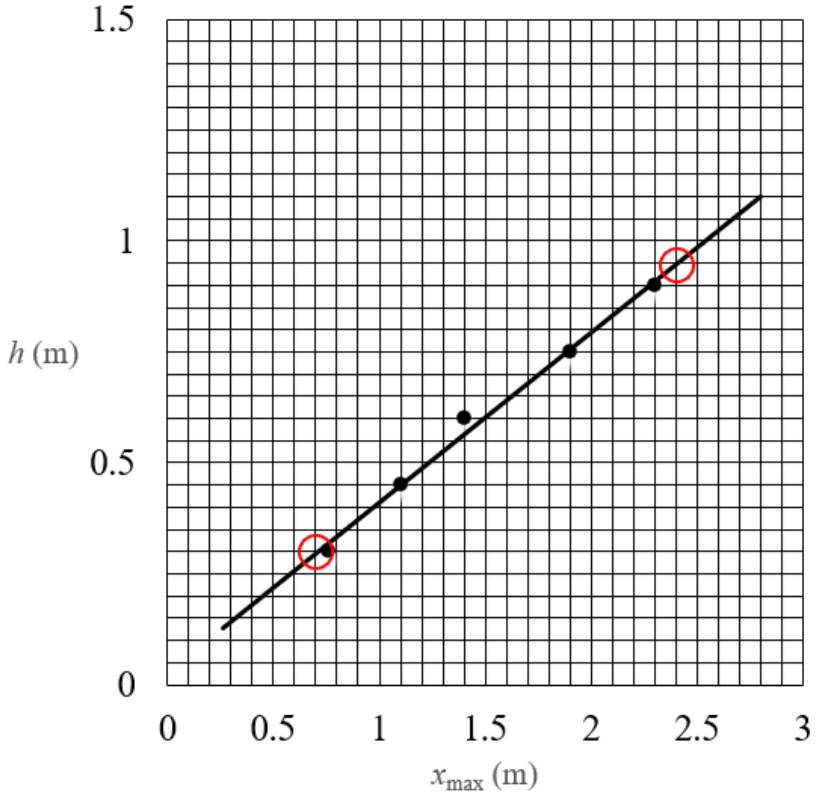
Graph	Analysis
v^2 vs. $2h$	slope = g
$\frac{1}{2}v^2$ vs. h	slope = g
v^2 vs. h	slope = $2g$
v vs. $\sqrt{h}$	slope = $\sqrt{2g}$

Example Response

Plot v^2 on the vertical axis and $2h$ on the horizontal axis. The slope of the best-fit line is equal to g.

C	**(i)**	For indicating appropriate quantities that could be plotted to produce a linear graph that can be used to determine μ, such as h **vs.** x_{max} **Scoring Note:** Reponses that include the reciprocal of the preceding example, in addition to other equivalent graphs, also earn this point.	**Point C1**
	(ii)	For labeling the axes (including units) with a linear scale	**Point C2**
		For plotting data points consistent with **one** of the following: • The quantities indicated in part C (i) • The quantities provided in Table 2 • The axes indicated on the grid	**Point C3**
	(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 to the value of μ **Point D1**

Examples of acceptable responses includes the following:

Graph	Analysis
h vs. $x_{\max}$	slope = μ

For a value of μ within a range of 0.30 to 0.50 **Point D2**

Example Response

$E_0 + W = E_f$

$mgh - F_f x_{\max} = 0$

$mgh = \mu mgx_{\max}$

$h = \mu x_{\max}$

$y = mx + b$

$h = \mu x_{\max}$

slope = μ

$$\text{slope} = \frac{0.95\ \text{m} - 0.30\ \text{m}}{2.4\ \text{m} - 0.70\ \text{m}}$$

slope = 0.38

μ = slope = 0.38

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

Question 3

PART A

$mgh = \frac{1}{2}mv^2$ $\quad v^2 = (2g)h$

$2gh = v^2$

1. Bring the box up a certain height, and measure the distance from the floor to the center of mass of the block using a metrostick.
2. Release the box and measure the velocity of the block using a motion sensor
3. Repeat steps 1-2: multiple times at different heights, and at each height take multiple trials to reduce error.

PART B

Graphing the velocity squared on the y-axis and height on the x-axis would result in a linear line, where the slope is 2g. Find the slope and solve for g.

Question 3 is continued on the next page.

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

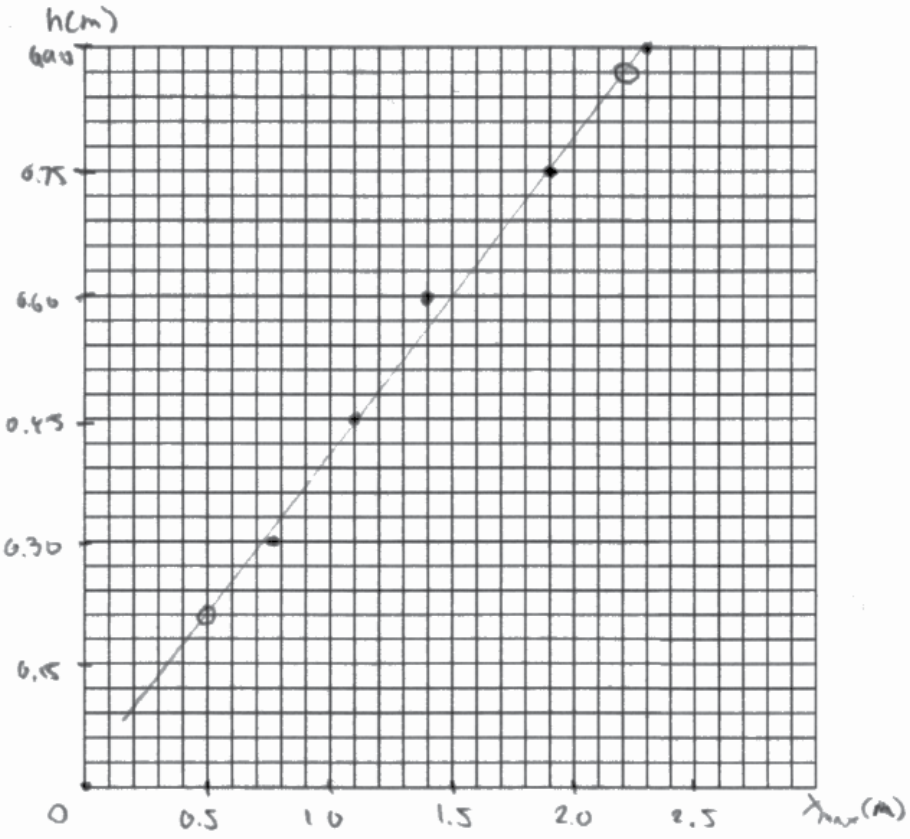
Question 3

PART C

Vertical axis: h(m) Horizontal axis: x_{max} (m)

h(m)	x_{max}(m)
0.30	0.76
0.45	1.10
0.60	1.40
0.75	1.96
0.90	2.30

Table 2



PART D

$P_1(0.5, 0.21)$ $P_2(2.2, 0.87)$

$$\text{Slope} = \frac{0.87 - 0.21}{2.2 - 0.5} = 0.39$$

$h = M x_{max}$

Slope $= M = 0.39$

$W_e = F_s \cdot x_{max}$

$= F_N \cdot M \cdot x_{max}$

$mgh = mgM \cdot x_{max}$

$h = M \cdot x_{max}$

Go to Question 4 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 3

PART A

release the block from different heights H and record the velocity v of the block when it leaves the box using the motion sensor. Repeat multiple times at differing H's, & repeat any trials that don't line up w/ collected data.

$mgh = 1/2 mv^2$ $g = \frac{v^2}{2h}$ $x = v_0 t$

PART B

$E_i = E_f$

$mgh = \frac{1}{2}mv^2$

$Hg = \frac{1}{2}v^2$

$v^2 = 2Hg$

graph v^2 on the y-axis and $2H$ on the x-axis

the slope of this graph will be g

Question 3 is continued on the next page.

$x = v(t) - \frac{1}{2}at^2$ $x + \frac{1}{2}\mu g t^2 = v t$ FDCFR

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

$v = x + \frac{1}{2}\mu g t^2$ / t $2x = at^2$ $a = \frac{2x}{t^2}$ $x = \frac{1}{2}at^2$

Question 3

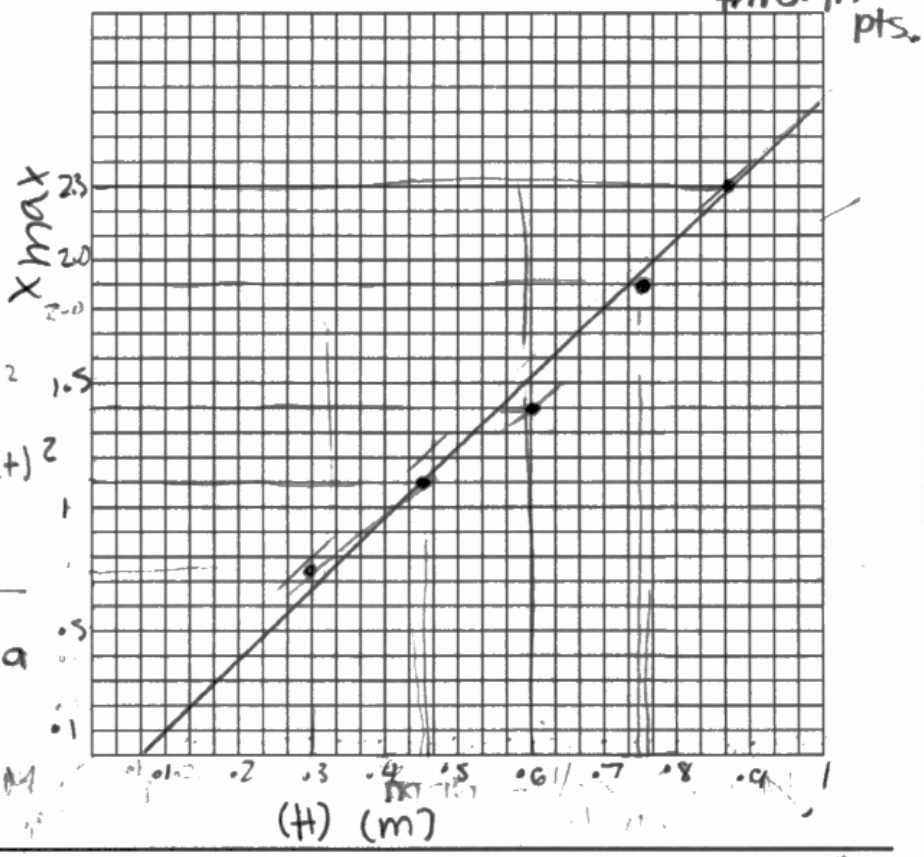
PART C

Vertical axis: x_{max} Horizontal axis: H (m)

$x = \mu H$ ← fake eq for follow through pts.

H	x_{max}
.30	.76
.45	1.10
.6	1.40
.75	1.90
.9	2.3

Table 2



$x = v_{x0} + \frac{1}{2}at^2$

$x = v_x + \frac{1}{2}\mu g (t)^2$

$\mu g = \frac{2 x_{max}}{t^2}$

$\mu g = a$

$v = \mu H$

PART D

(.45, 1.1)

(.9, 2.3)

$x = \mu H$

$\frac{2.3 - 1.1}{.9 - .45} = 2.66 = \mu$

Go to Question 4 in Bluebook when you're done with this question.

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Question 3

PART A

After gathering all materials such as the box, the block, the rod, the stopper, the meter stick and the motion sensor, set everything into place. Using the metter stick, choose a desired height for the box and the block to be dropped from and record the speed of the block as well as the corresponding drop height. Repeat the process seven times at the least recording different drop heights for each piece of data.

PART B

The data can be graphed as a speed-vs.-height ratio to determine a linear fit inorder to determine the value of g.

Question 3 is continued on the next page.

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

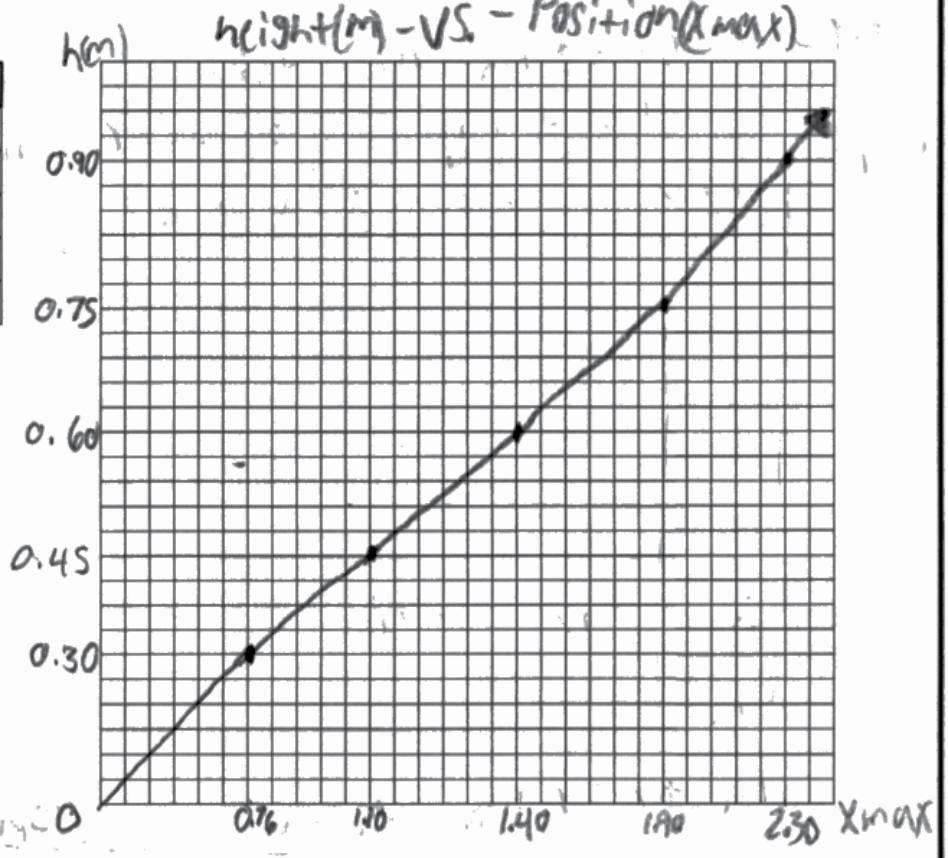
Question 3

PART C

Vertical axis: height(m) Horizontal axis: Xmax

h(m)	Xmax
0.30	0.76
0.45	1.1
0.60	1.4
0.75	1.9
0.90	2.3

Table 2



PART D

$M = \frac{1}{2}x + b$

Go to Question 4 in Bluebook when you're done with this question.

Question 3

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: 3A
Score: 10

Part A earned both points. The first point (A1) was earned because the procedure described includes measurements of both the block's height and velocity. The second point (A2) was earned for proposing a method to reduce uncertainty by repeating the experiment multiple times for a given height and by testing multiple heights.

Part B earned both points. The first point (B1) was earned for identifying appropriate quantities to plot that would produce a linear relationship to determine g. The second point (B2) was earned for explaining how the slope of that graph can be used to calculate g.

Part C (i) earned the point. The point (C1) was earned for identifying quantities that can be plotted to produce a linear graph used to find μ. Part C (ii) earned both points. The first point (C2) was earned because the axes are labeled correctly, using a linear scale and proper units. The second point (C3) was earned for plotting data points consistent with part C (i). Part C (iii) earned the point. The point (C4) was earned for including an appropriate best-fit line that reflects the overall trend of the data.

Part D earned both points. The first point (D1) was earned for correctly relating the slope of the best-fit line to the coefficient of friction μ. The second point (D2) was earned for indicating a numerical value for μ within the given range.

Sample: 3B
Score: 7

Part A earned both points. The first point (A1) was earned for describing a procedure that includes measuring the height and velocity of the block. The second point (A2) was earned for proposing a valid method to reduce uncertainty by repeating the experiment at different heights.

Part B earned both points. The first point (B1) was earned for identifying variables that can be plotted to establish a linear trend and calculate g. The second point (B2) was earned for explaining how to use the slope of the graph to determine g.

Part C (i) earned the point. The point (C1) was earned for identifying correct quantities to graph in order to determine μ. Part C(ii) earned one of two points. The first point (C2) was not earned because the axis labels did not include units for all quantities—only height was labeled with units. The second point (C3) was earned for plotting data consistent with part C (i). Part C (iii) earned the point. The point (C4) was earned for including an appropriate best-fit line that follows the trend of the data.

Part D did not earn either point. The first point (D1) was not earned because the slope of the best-fit line was not related to the value of μ. The second point (D2) was not earned due to the absence of a correct value for μ.

Question 3 (continued)

Sample: 3C
Score: 4

Part A earned both points. The first point (A1) was earned because the procedure includes measuring the height and velocity of the block. The second point (A2) was earned for suggesting a method to reduce uncertainty by repeating the experiment at different heights.

Part B did not earn either point. The first point (B1) was not earned because the quantities identified would not yield a linear trend when plotted. The second point (B2) was not earned as the slope of the graph is not correctly interpreted to determine g.

Part C (i) earned the point. The point (C1) was earned for suggesting appropriate quantities to graph in order to determine μ. Part C (ii) earned one out of two points. The first point (C2) was not earned because the axis label for x_{max} lacks units. The second point (C3) was earned for correctly plotting data points as outlined in part C (i). Part C (iii) did not earn the point. The point (C4) was not earned because the data points are connected directly rather than approximated with a best-fit line.

Part D did not earn either point. The first point (D1) was not earned because the slope of the best-fit line is not related to the coefficient of friction μ. The second point (D2) was not earned due to the absence of a stated value for μ.