2025

AP® Physics 1: Algebra-Based

Sample Student Responses and Scoring Commentary

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Free-Response Question 3

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

A

For describing a procedure that includes **both** of the following: **Point A1**

- Attaching the block to the meterstick
- Measuring the force exerted on the left end of the meterstick while the block is attached

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

Examples of acceptable responses may include the following:

- Repeating the force measurement for one location of the block
- Collecting force measurements for multiple locations of the block

Example Response

Attach the block of unknown mass m_0 through one of the small holes in the meterstick. Measure the distance from the stand to the block. Record the force reading from the spring scale when the meterstick is horizontal. Repeat data collection by attaching the block to the meterstick through a different small hole in the meterstick. Repeat the measurements by attaching the block at each of the small hole locations numerous times.

B For indicating appropriate quantities that can be plotted so that m_0 can be determined **Point B1**

Scoring Notes:

- Any response that correctly identifies the functional dependence between force and distance 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.
- This point may be earned independently of the response in part A.

For describing how the slope is related to the unknown mass m_0 **Point B2**

Examples of acceptable responses may include the following:

Graph	Analysis
Force as a function of the distance from the stand to the block	The slope is equal to m_0 times g divided by the distance from the stand to the spring scale. OR m_0 is equal to the slope times the distance from the stand to the spring scale divided by g.
Force as a function of the ratio of the distance from the stand to the block to the distance from the stand to the spring scale	The slope is equal to m_0 times g. OR m_0 is equal to the slope divided by g.
Force as a function of g times the distance from the stand to the block	The slope is equal to m_0 divided by the distance from the stand to the spring scale. OR m_0 is equal to the slope times the distance from the stand to the spring scale.
Force as a function of g times the ratio of the distance from the stand to the block to the distance from the stand to the spring scale	The slope is equal to m_0. OR m_0 is equal to the slope.
Force times the distance from the stand to the spring scale as a function of the distance from the stand to the block	The slope is equal to m_0 times g. OR m_0 is equal to the slope divided by g.
Force times the distance from the stand to the spring scale as a function of g times the distance from the stand to the block	The slope is equal to m_0. OR m_0 is equal to the slope.

Example Response

A graph of the force as a function of the distance from the stand to the block could be used to determine the unknown mass. The slope of the graph times the distance from the stand to the spring scale divided by g will result in the value of the unknown mass m_0.

C **(i)** For listing a quantity that could be plotted on the vertical axis to produce a linear graph whose slope can be used to determine the mass of the meterstick[1] **Point C1**

Examples of acceptable responses may include the following:

- F_T
- $\frac{F_T}{g}$
- $\frac{6}{5}\frac{F_T}{g}$
- $\frac{6}{5}F_T$

Scoring Note: Any response that correctly identifies the functional dependence between tension and angle earns this point, regardless of any coefficients that contain numbers or physical/fundamental constants.

Example Response

Vertical axis: F_T

(ii) For labeling the vertical axis (including units) 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 indicated on the axes
- The quantities indicated in Table 2

(iii) For drawing an appropriate best-fit line that approximates the trend of the plotted data **Point C4**

Scoring Note: If the graph produced is nonlinear, then a line or curve that approximates the trend of that data can earn this point.

[1]Update made post-scoring to correct typo that did not impact scoring.

Example Response

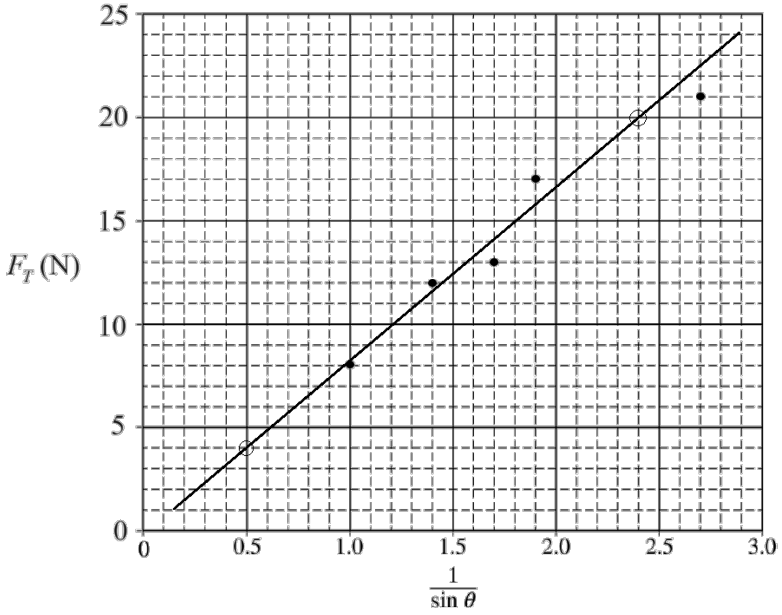

Figure 3

D For correctly relating the slope of the best-fit line to the value of M **Point D1**

Examples of acceptable responses may include the following:

Graph	Analysis
F_T vs. $\frac{1}{\sin\theta}$	$\text{slope} = \frac{5}{6}Mg$ OR $M = \frac{6}{5}\frac{\text{slope}}{g}$
$\frac{F_T}{g}$ vs. $\frac{1}{\sin\theta}$	$\text{slope} = \frac{5}{6}M$ OR $M = \frac{6}{5}\text{slope}$
$\frac{6}{5}\frac{F_T}{g}$ vs. $\frac{1}{\sin\theta}$	$\text{slope} = M$ OR $M = \text{slope}$
$\frac{6}{5}F_T$ vs. $\frac{1}{\sin\theta}$	$\text{slope} = Mg$ OR $M = \frac{\text{slope}}{g}$

For a value of M within a range of $0.90\,\text{kg}$ to $1.15\,\text{kg}$ **Point D2**

Example Response

$F_T = \frac{5Mg}{6\sin\theta}$

$F_T = \frac{5}{6}Mg\frac{1}{\sin\theta}$

$\text{slope} = \frac{5}{6}Mg$

$M = \frac{6(\text{slope})}{5g}$

$\text{slope} = \frac{20\text{ N} - 4\text{ N}}{2.4 - 0.5}$

$\text{slope} = 8.4\text{ N}$

$M = \frac{(6)(8.4\text{ N})}{(5)\left(9.8\ \frac{\text{N}}{\text{kg}}\right)}$

$M = 1.0\,\text{kg}$

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: Version J

PART A

① Hang the block at 90 cm mark of the meterstick.

② Apply a downward force on the fixed spring scale until the meterstick is completely balanced. Record the magnitude of applied force on the spring scale. Repeat this step for three trials.

③ Repeat step ②, but with blocks hung on different hole on the right side of the stand. Perform step ③ by hanging the block at 60cm, 70cm, and 80cm marks.

PART B

On the part A scenario, there were one torque on the each side regarding the pivot point. When the stick was balanced, $\tau_{\text{spring scale}} = \tau_{\text{block}}$, meaning $0.5 F_a = m_o g d$, where F_a is magnitude of applied force and d is distance from the stand (pivot point) and the block. Therefore, when the graph is plotted with vertical axis of F_a and horizontal axis of d, the slope of linear graph is equal to $\frac{m_o g}{0.5}$. By multiplying the slope by $\frac{0.5}{g}$, we can determine value of m_o.

Question 3: Version J continues 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: Version J

PART C

Vertical axis: F_T Horizontal axis: $\frac{1}{\sin\theta}$

F_T (N)	$\frac{1}{\sin\theta}$
21	2.7
17	1.9
13	1.7
12	1.4
8	1.0

Table 2

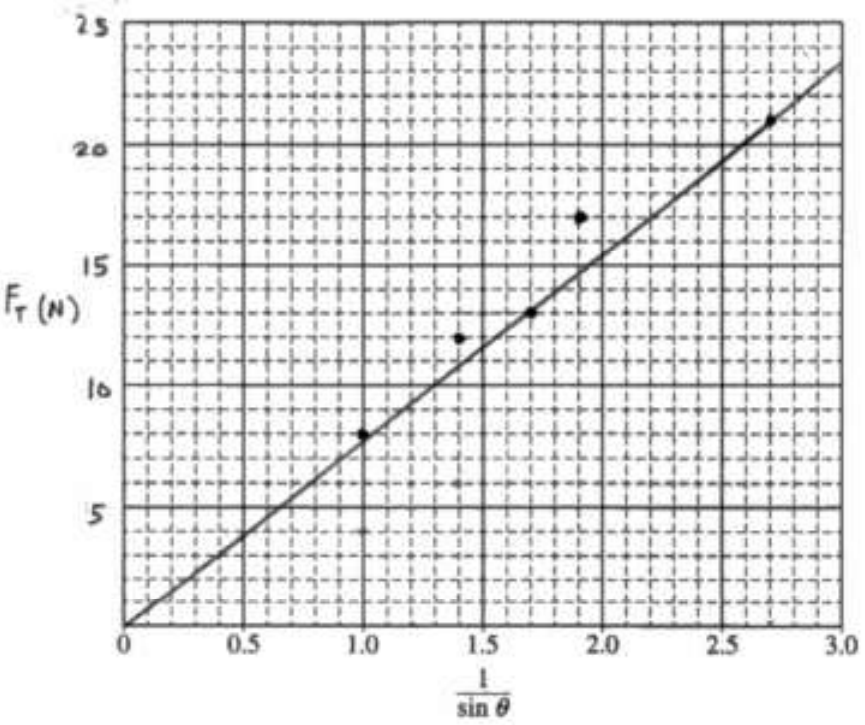

Figure 3

PART D

Slope = $\frac{5}{6}Mg = 7.8$

$M = 0.96$ kg.

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: Version J

PART A

An experiment that could allow students to find m_b is one like this. First, you would find the distance from the axis to either the spring scale is hung. Then, you would hang the mass on the opposite side of the meterstick the same distance away. After that, reading the spring scale would give you your mass for m_b.

PART B

Data from part A could be graphed in a linear fashion comparing the spring scale and m_b. The graph could then be read to see m_b

Question 3: Version J continues 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: Version J

PART C

Vertical axis: $\frac{1}{\cos\theta}$ Horizontal axis: $\frac{1}{\sin\theta}$

θ (deg)	F_T (N)
68	122
54	36
51	417
45	63
10	98

Table 2

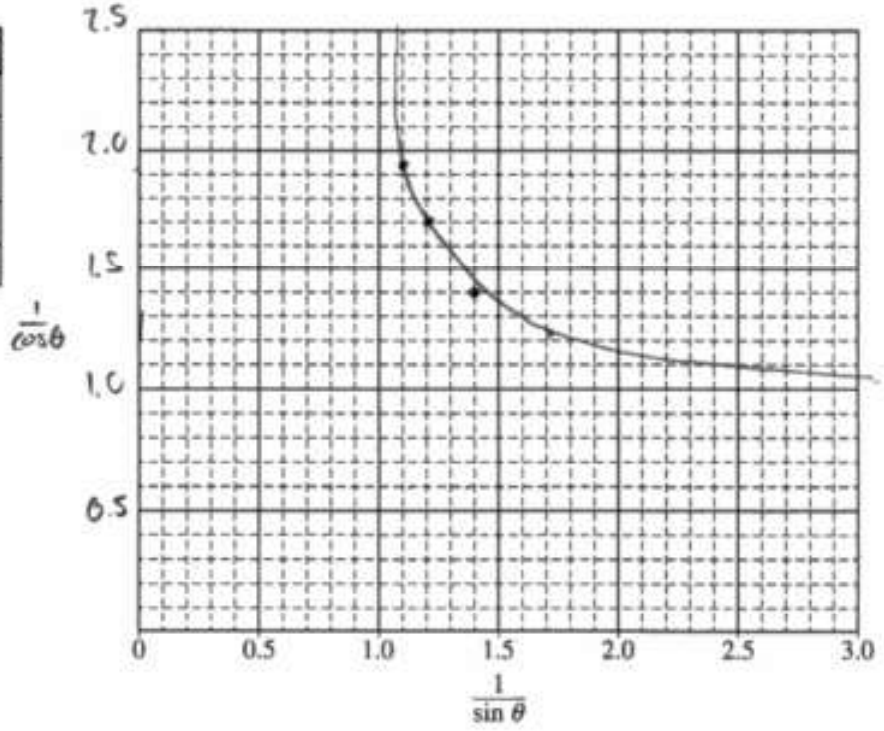

Figure 3

PART D

$m = 3.5$ kg

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: Version J

PART A

Equipment:
Spring scale, measures F_g on block, F_g, N, mg

Procedure:
- ~~Place~~ attatch block to spring scale
- Measure the force exerted and notate this. It is the force of gravity on the block.
- Repeat to reduce expirimental uncertainty 3-5 times

PART B

The Force of gravity on the block is your y and gravity is your x. gravity will stay the same but F_g may be different if you use different masses during trials. To find ~~the~~ the mass just find the slope of the line. Since $F_g = mg$, $F_g/g = m$, so by finding the slope, which is Y/X, you'll find your mass

Question 3: Version J continues 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: Version J

PART C

Vertical axis: F_T Horizontal axis: $\frac{1}{\sin\theta}$

$1/\sin\theta$	F_T
2.67	21
1.94	17
1.70	13
1.41	12
1.02	8

Table 2

F_T

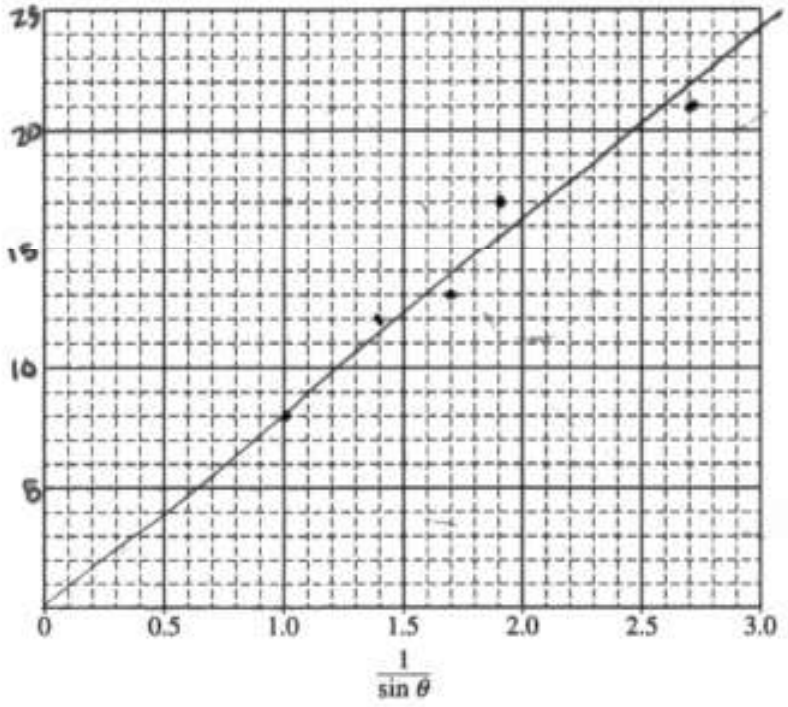

Figure 3

PART D

Sub in

$\frac{F_T}{\frac{1}{\sin\theta}} = F_T \sin\theta$ ← slope

$8(1.0) = 8 = M$

1 experimental value for Mass is 8

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 response describes a procedure that includes measuring the force exerted by the spring scale on the meterstick when the block is attached at the 90 cm location. The second point (A2) was earned because the response indicates hanging the block "on different hole," which is a reasonable method for reducing experimental uncertainty.

Part B earned both points. The first point (B1) was earned because the response indicates appropriate quantities that can be plotted so that the block's mass can be determined using the slope. Specifically, the response states that "d is distance from the stand (pivot point) and the block." The second point (B2) was earned because the response explains how the slope of the graph can be used to determine the block's mass.

Part C (i) earned the point. The point (C1) was earned because the response indicates that the force of tension is plotted on the vertical axis. Part C (ii) earned both points. The first point (C2) was earned because the response labels the vertical axis correctly using a linear scale and includes appropriate units. The second point (C3) was earned because the data points are plotted correctly and are consistent with the values presented in part C (i). Part C (iii) earned the point. The point (C4) was earned because the response includes a best-fit line that appropriately represents the trend in the data.

Part D earned both points. The first point (D1) was earned because the response correctly relates the slope of the best-fit line to the mass of the meterstick. The second point (D2) was earned because the response identifies a value in the acceptable range for the mass of the meterstick.

Question 3 (continued)

Sample: 3B
Score: 5

Part A earned one out of two points. The first point (A1) was earned because the response describes a procedure that includes measuring the force exerted by the spring scale on the meterstick when the block is attached to the right end of the meterstick. The second point (A2) was not earned because the response does not indicate that more than one force measurement should be taken or that the block should be hung at different locations, which would be necessary to reduce experimental uncertainty.

Part B earned one out of two points. The first point (B1) was earned because the response states that "data from part A could be graphed." In part A the response includes measuring the reading from the spring scale and the distance between the block and the stand and indicates that the block should be attached "the same distance away." The second point (B2) was not earned because the response does not indicate a way to use the slope of the graph to determine the block's mass.

Part C (i) did not earn the point. The point (C1) was not earned because the response incorrectly indicates that $\frac{1}{\cos\theta}$ should be plotted on the vertical axis, which will not produce a linear function. Part C (ii) earned both points. The first point (C2) was earned because the vertical axis is labeled with the indicated quantity, and the omission of a unit is appropriate. The response also uses a linear scale, and although the range of the scale does not accommodate all data points, it does accommodate four of the five. The second point (C3) was earned because three of the plotted data points are consistent with the values of $\frac{1}{\cos\theta}$ for the given angles. Part C (iii) earned the point. The point (C4) was earned because the response includes an appropriate best-fit curve that matches the general trend of the plotted data.

Part D did not earn either point. The first point (D1) was not earned because the response does not correctly relate the slope of the best-fit line to the mass of the meterstick. The second point (D2) was not earned because the indicated mass of the meterstick falls outside the accepted range of $0.90\,\text{kg}$ to $1.15\,\text{kg}$.

Question 3 (continued)

Sample: 3C
Score: 4

Part A earned one out of two points. The first point (A1) was not earned because the response does not indicate that the block should be attached to the meterstick. The second point (A2) was earned because the response states that the block's weight should be measured three to five times, which would reduce experimental uncertainty.

Part B did not earn either point. The first point (B1) was not earned because the response describes a graph with the weight of several different blocks on the vertical axis and constant gravitational acceleration on the horizontal axis. This configuration would not produce a slope that could be used to determine the mass of the block. The second point (B2) was not earned because the response does not correctly explain how the mass of the block can be found using the described graph.

Part C (i) earned the point. The point (C1) was earned because the response correctly indicates that the force of tension is plotted on the vertical axis. Part C (ii) earned one out of two points. The first point (C2) was not earned because the vertical axis label does not include units. The second point (C3) was earned because the data points are plotted correctly and are consistent with the values given in part C (i). Part C (iii) earned the point. The point (C4) was earned because the response includes a best-fit line that appropriately reflects the trend in the data.

Part D did not earn either point. The first point (D1) was not earned because the response does not correctly relate the slope of the best-fit line to the mass of the meterstick. The second point (D2) was not earned because the indicated value for the meterstick's mass does not fall within the accepted range of $0.90\ \text{kg}$ to $1.15\ \text{kg}$.