AP® PHYSICS B
2007 SCORING GUIDELINES

General Notes About 2007 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth one point, and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive and expression it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics exam equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections—Student Presentation" in the *AP Physics Course Description* .

4. The scoring guidelines typically show numerical results using the value $g = 9.8 \text{ m/s}^2$, but use of 10 m/s^2 is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

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Question 6

10 points total **Distribution of points**

(a) 2 points

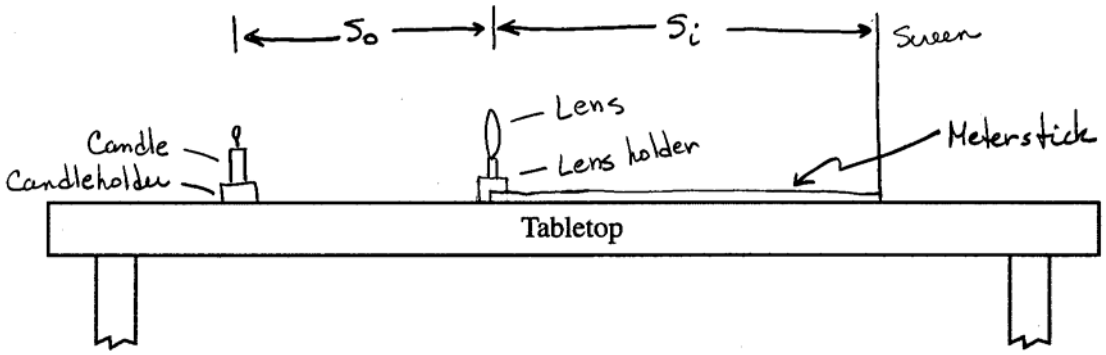
For a clear and complete method of <u>estimating</u> the focal length by focusing the image of the tree on a screen <u>and</u> stating that the distance between the image and the lens is the focal length — 2 points

<u>Partial credit:</u>

1 point only was awarded if the method above was incomplete.

1 point only was awarded if the distances s_o (tree to lens) and s_i (lens to image) were measured or estimated, and then the numbers were used in the thin lens equation to <u>calculate</u> the focal length.

(b) and (c) 3 points



For showing a functional setup involving an object, the lens, and a screen — 1 point

For having the lens and the distances s_o and s_i labeled correctly on the diagram — 1 point

For labeling on the diagram all the equipment checked in (b) (must have a functional setup to earn this point) — 1 point

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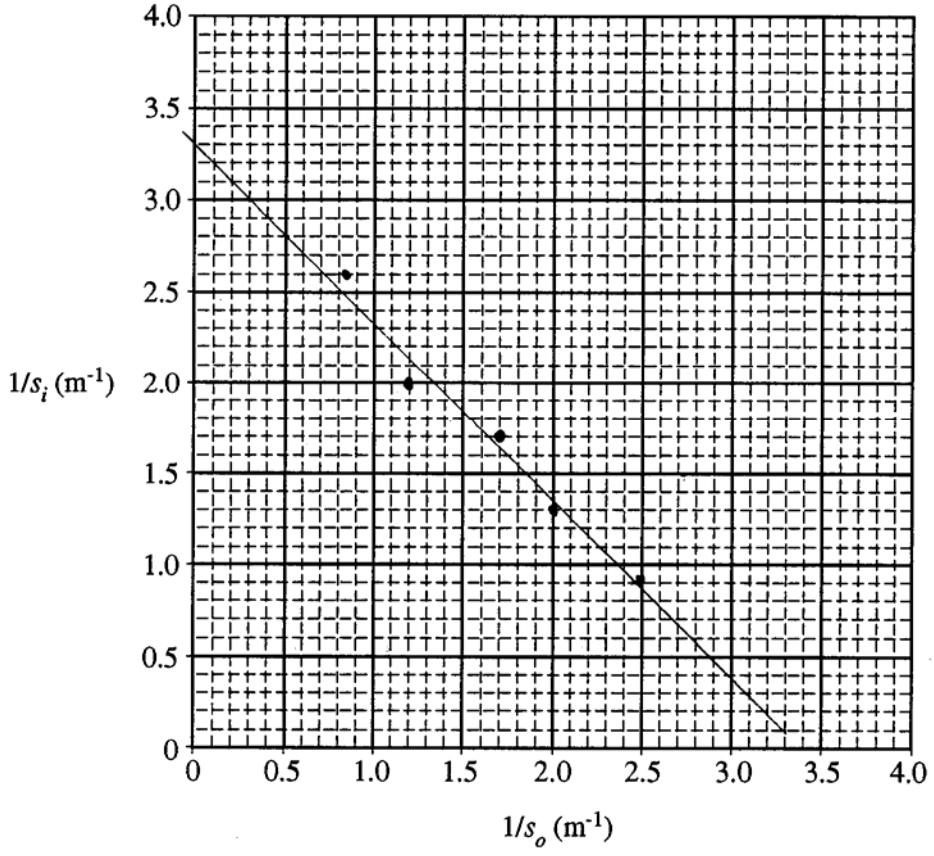
Question 6 (continued)

Distribution of points

(d) 2 points



For all data points from the table plotted correctly — 1 point

For a best-fit straight line (i.e., two points above and two points below the line and/or intercepts on axes close to $3.35\ m^{-1}$) — 1 point

Question 6 (continued)

Distribution of points

(e) 3 points

For a clear and accurate solution with the correct answer in the range 0.28 m to 0.32 m with units (The two most common approaches to doing this are illustrated below.) — 3 points

Approach 1:

Pick a point on the best-fit line (not a data point)

For example, for the graph shown in part (d), one point on the line is (1.0, 2.3).

$\frac{1}{s_o} = 1.0\ \text{m}^{-1}$, $\frac{1}{s_i} = 2.3\ \text{m}^{-1}$

$\frac{1}{f} = \frac{1}{s_i} + \frac{1}{s_o} = 1.0\ \text{m}^{-1} + 2.3\ \text{m}^{-1} = 3.3\ \text{m}^{-1}$

$f = \frac{1}{3.3\ \text{m}^{-1}}$

$f = 0.30\ \text{m}$

Approach 2:

$\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f}$

$\frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o}$

So $\frac{1}{f}$ is the *y* intercept of a graph of $\frac{1}{s_i}$ versus $\frac{1}{s_o}$

For example, for the graph shown in part (d) the *y* intercept is $3.3\ \text{m}^{-1}$

So $\frac{1}{f} = 3.3\ \text{m}^{-1}$

$f = \frac{1}{3.3\ \text{m}^{-1}}$

$f = 0.30\ \text{m}$

Partial credit:

2 points only were awarded for a mostly complete solution where either units were missing or it was unclear that the best-fit line was used (e.g., not using numbers from the best-fit line if Approach 1 was used, or not showing the idea of using the intercept if Approach 2 was used).

1 point only was awarded either for a correct answer with units where it was not clear how the answer was obtained, or for using the lens equation with data from the line where there was no final answer.

6. (10 points)

You are asked to experimentally determine the focal length of a converging lens.

(a) Your teacher first asks you to estimate the focal length by using a distant tree visible through the laboratory window. Explain how you will estimate the focal length.

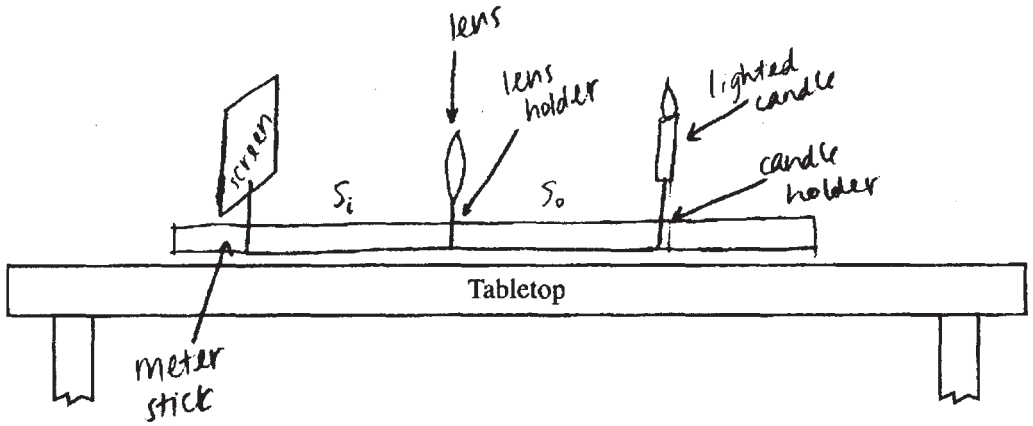
The distant tree is essentially at infinity. Given the formula $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ (where f is the focal length, d_o is the distance of the object and d_i is the distance of the image), this becomes $\frac{1}{f} = \frac{1}{\infty} + \frac{1}{d_i}$, or $\frac{1}{f} = \frac{1}{d_i}$. Find the distance of the image of the tree from the lens, and this will approximately equal the focal length.

To verify the value of the focal length, you are to measure several object distances s_o and image distances s_i using equipment that can be set up on a tabletop in the laboratory.

(b) In addition to the lens, which of the following equipment would you use to obtain the data?

✓ Lighted candle	✓ Candleholder	___ Desk lamp	___ Plane mirror
___ Vernier caliper	✓ Meterstick	___ Ruler	✓ Lens holder
___ Stopwatch	✓ Screen	___ Diffraction grating	

(c) On the tabletop below, sketch the setup used to obtain the data, labeling the lens, the distances s_o and s_i, and the equipment checked in part (b).



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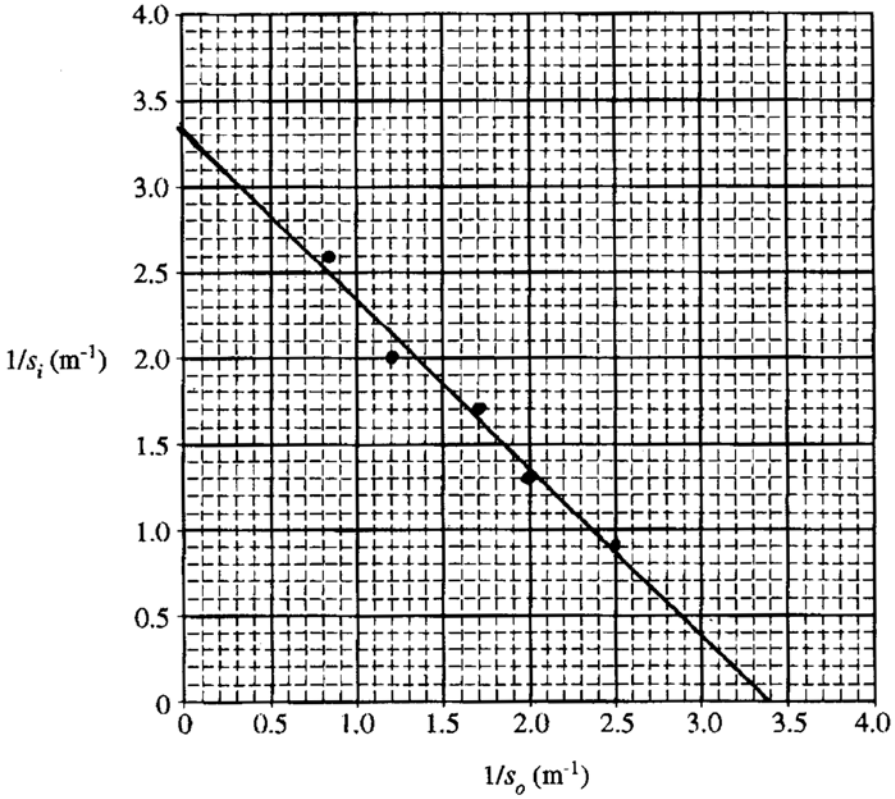
You are to determine the focal length using a linear graph of $1/s_i$ versus $1/s_o$. Assume that you obtain the following data for object distance s_o and image distance s_i.

Trial #	s_o (m)	s_i (m)	$1/s_o$ (m^{-1})	$1/s_i$ (m^{-1})
1	0.40	1.10	2.5	0.91
2	0.50	0.75	2.0	1.3
3	0.60	0.60	1.7	1.7
4	0.80	0.50	1.2	2.0
5	1.20	0.38	0.83	2.6

(d) On the grid below, plot the points in the last two columns of the table above and draw a best-fit line through the points.



(e) Calculate the focal length from the best-fit line.

$\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}$

given point (1.5, 1.85)

$\left(\frac{1}{s_o}, \frac{1}{s_i}\right)$

$\frac{1}{f} = 1.5 + 1.85$

$\frac{1}{f} = 3.35$

$f = 0.299\ m$

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6. (10 points)

You are asked to experimentally determine the focal length of a converging lens.

(a) Your teacher first asks you to estimate the focal length by using a distant tree visible through the laboratory window. Explain how you will estimate the focal length.

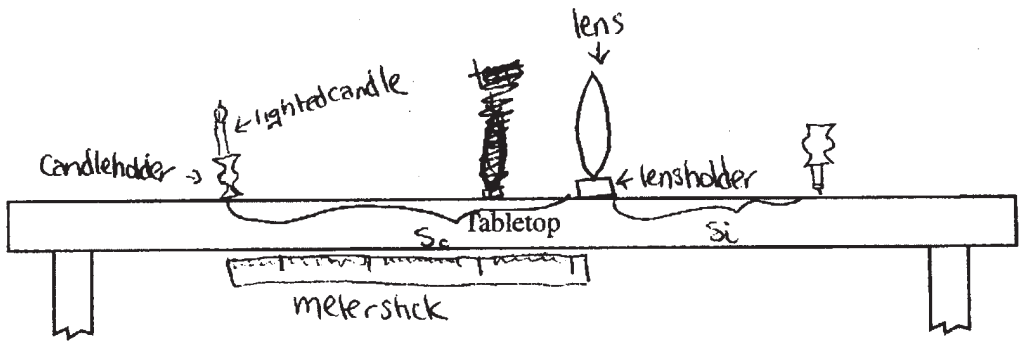
I know that $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$. I will measure the distance from the lens to the tree, and the distance from the lens to the image of the tree. With this information, I can estimate the focal length.

To verify the value of the focal length, you are to measure several object distances s_o and image distances s_i using equipment that can be set up on a tabletop in the laboratory.

(b) In addition to the lens, which of the following equipment would you use to obtain the data?

X Lighted candle	X Candleholder	___ Desk lamp	___ Plane mirror
___ Vernier caliper	X Meterstick	___ Ruler	X Lens holder
___ Stopwatch	___ Screen	___ Diffraction grating	

(c) On the tabletop below, sketch the setup used to obtain the data, labeling the lens, the distances s_o and s_i, and the equipment checked in part (b).



GO ON TO THE NEXT PAGE.

You are to determine the focal length using a linear graph of $1/s_i$ versus $1/s_o$. Assume that you obtain the following data for object distance s_o and image distance s_i.

Trial #	s_o (m)	s_i (m)	$1/s_o$ (m^{-1})	$1/s_i$ (m^{-1})
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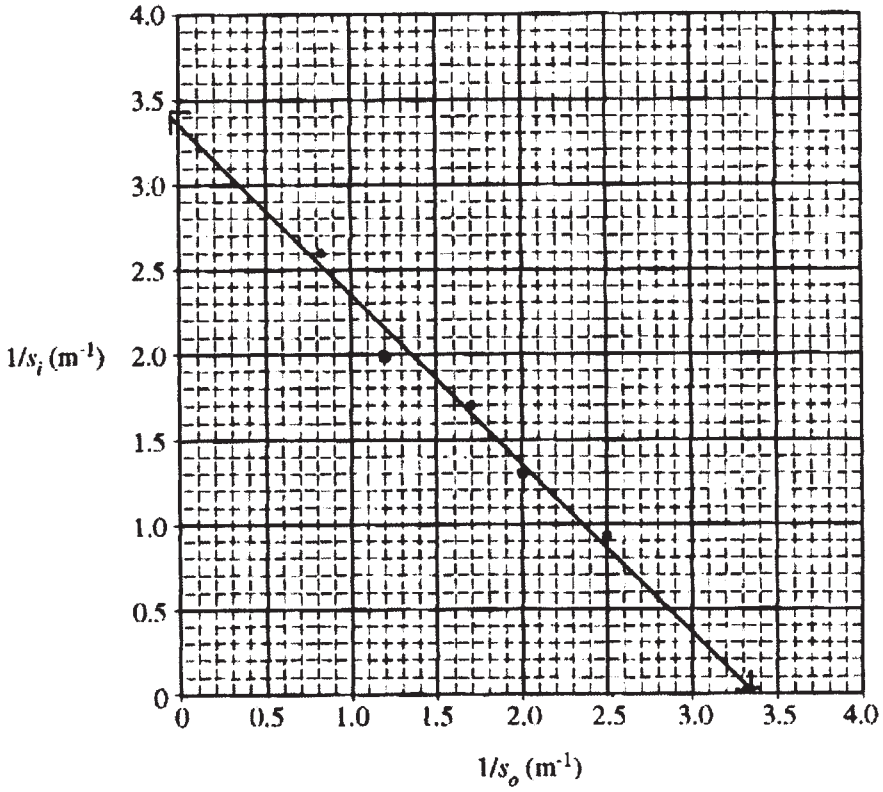
(d) On the grid below, plot the points in the last two columns of the table above and draw a best-fit line through the points.



(e) Calculate the focal length from the best-fit line.

The focal length is the inverse of the y intercept of the best fit line. The y intercept is about $3.35\ m^{-1}$ so the focal length is 0.299 m.

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6. (10 points)

You are asked to experimentally determine the focal length of a converging lens.

(a) Your teacher first asks you to estimate the focal length by using a distant tree visible through the laboratory window. Explain how you will estimate the focal length.

look at the image created by the lens and measure its height. Estimate the height of the tree. by $\frac{1}{S_i} + \frac{1}{S_o} = \frac{1}{f}$ One could calculate the focal length.

To verify the value of the focal length, you are to measure several object distances s_o and image distances s_i using equipment that can be set up on a tabletop in the laboratory.

(b) In addition to the lens, which of the following equipment would you use to obtain the data?

✓ Lighted candle	✓ Candleholder	___ Desk lamp	___ Plane mirror
___ Vernier caliper	___ Meterstick	✓ Ruler	✓ Lens holder
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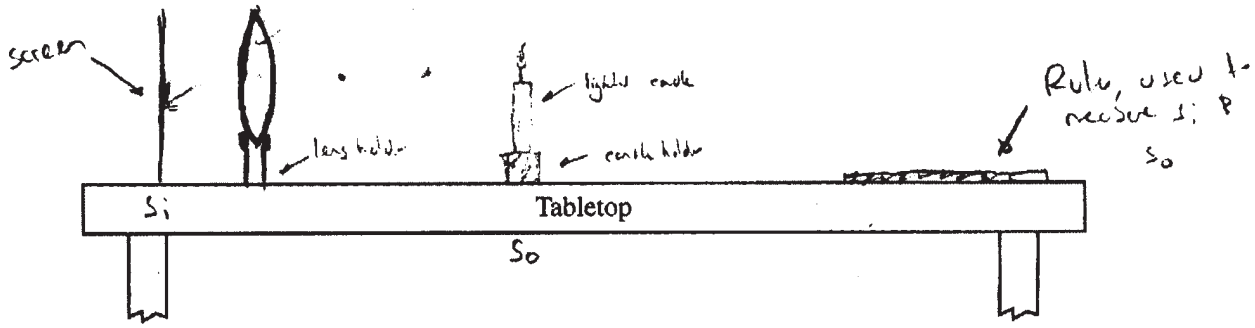
(c) On the tabletop below, sketch the setup used to obtain the data, labeling the lens, the distances s_o and s_i, and the equipment checked in part (b).



You are to determine the focal length using a linear graph of $1/s_i$ versus $1/s_o$. Assume that you obtain the following data for object distance s_o and image distance s_i.

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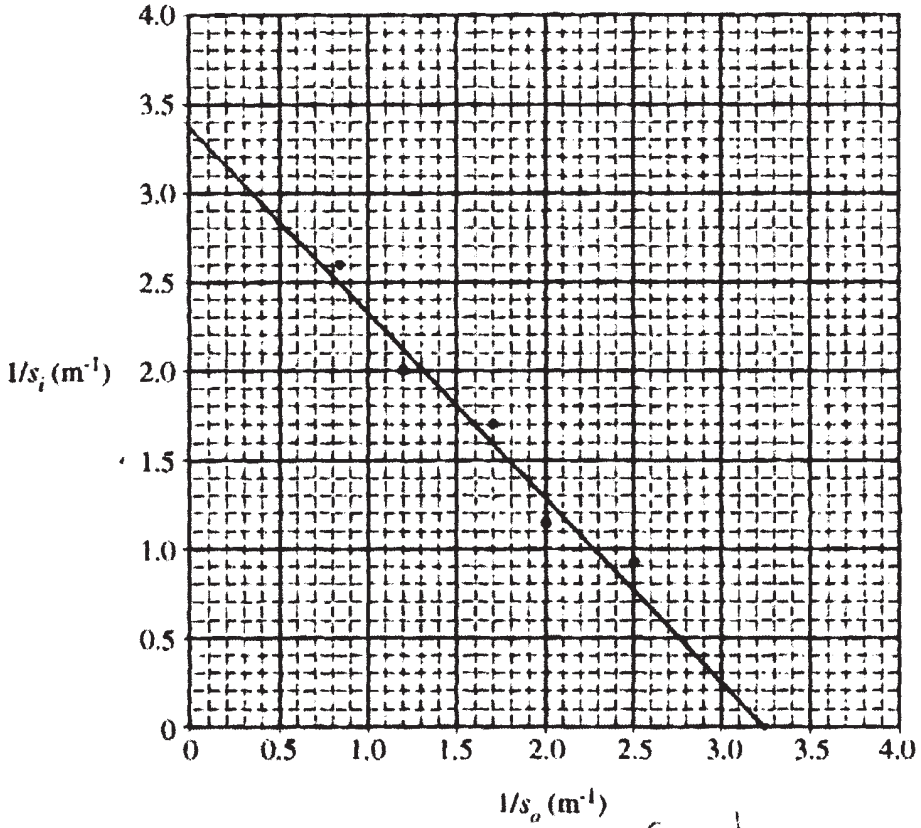

(e) Calculate the focal length from the best-fit line.

$$\frac{1}{f} = \frac{1}{s_i} + \frac{1}{s_o}$$

$$f = \left(\frac{1}{s_i} + \frac{1}{s_o} \right)^{-1}$$

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AP® PHYSICS B
2007 SCORING COMMENTARY

Question 6

Overview

This 10-point question was intended to assess basic understanding of geometric optics and students' facility with explaining an experimental procedure and utilizing data. Part (a) asked students to explain how to determine the focal length of a lens using a distant object, and part (b) directed them to select equipment to be used in making several "optical bench" measurements. In part (c) students were expected to sketch and label their planned experimental setup. Part (d) asked them to plot a set of data and draw a best-fit line on a grid for which both the scales and the variables to be plotted had already been provided. In part (e) they had to use the best-fit line to calculate the focal length of the lens.

Sample: 6A
Score: 10

The response does not explicitly mention using a screen, but from the description (that includes an explanation using the lens equation) it is clear that the student has a correct method.

Sample: 6B
Score: 7

In part (a) 1 point was earned for using object and image distances in the lens equation. Parts (b) and (c) do not show use of a screen to locate the image and only earned the point for labeling s_o and s_i. Parts (d) and (e) earned full credit. Part (e) uses the intercept method.

Sample: 6C
Score: 4

Part (a) earned nothing. In parts (b) and (c) s_o and s_i are not labeled, so only 2 points were earned. Part (d) earned full credit, and part (e) earned nothing.