

AP[®] PHYSICS B (Form B) 2008 SCORING GUIDELINES

General Notes About 2008 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 1 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 an 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.

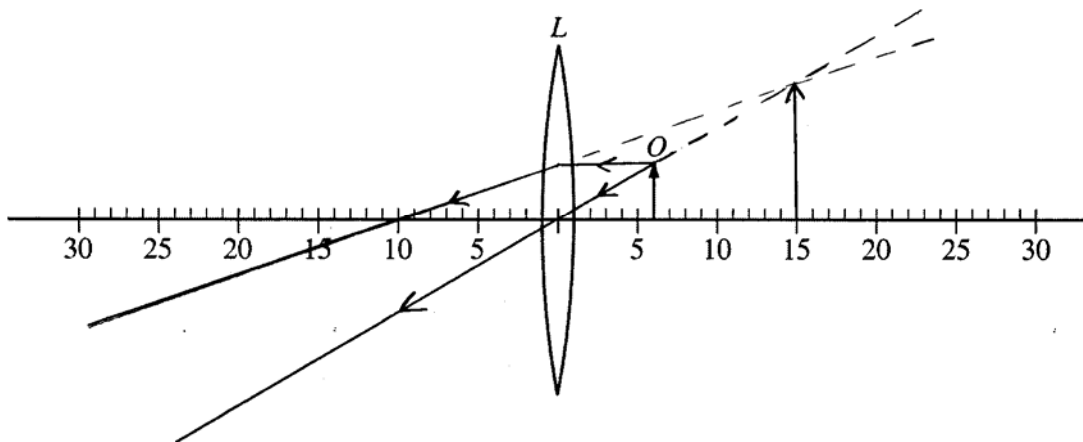
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Question 5

10 points total

**Distribution
of points**

- (a) 3 points
Example:



For each correct ray from the object used to locate the image, 1 point was awarded, to a maximum of 2 points 2 points
For the correct size and orientation of the image 1 point

- (b)
(i) 1 point

For an indication that the image is virtual 1 point

- (ii) 1 point

For a correct justification 1 point
Example: The rays emerging from the lens did not actually converge at the image but only appear to have done so.
This point was only awarded if the point for part (b)(i) was awarded.

- (c) 2 points

For correct use of the equation relating image distance to object distance and focal length, with correct substitutions 1 point

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

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

$$s_i = \frac{(10.0 \text{ cm})(6.0 \text{ cm})}{6.0 \text{ cm} - 10.0 \text{ cm}}$$

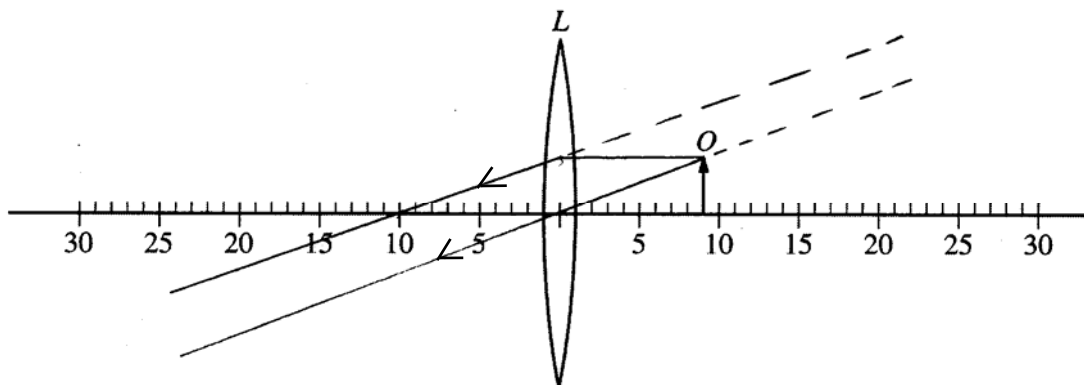
For the correct answer with the correct sign 1 point
 $s_i = -15 \text{ cm}$

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Question 5 (continued)

**Distribution
of points**

- (d) 3 points
Example:



For an indication that the height of the new image is larger 1 point
For a correct justification (only when the previous point has been awarded) 2 points

Justification approach 1: 2 points

The rays passing through the lens become less diverging from each other due to the geometry. Their extensions meet further away from the lens making the image larger.

Justification approach 2: Construct a new ray diagram 2 points

For each correct ray from the object used to locate the image, 1 point was awarded, to a maximum of 2 points. The student must explicitly refer to the diagram as the justification for the larger height in order for the diagram to be considered.

Justification approach 3: Calculate the change in magnification 1 point
For a correct calculation of the image location after the object is moved

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

$$s_i = \frac{fs_o}{s_o - f} = \frac{(10.0 \text{ cm})(9.0 \text{ cm})}{9.0 \text{ cm} - 10.0 \text{ cm}} = -90 \text{ cm}$$

For a correct calculation of the magnification both prior to moving the object and after the object is moved, leading to the conclusion that the new image is larger 1 point

$$M_1 = -\frac{s_i}{s_o} = -\frac{-15 \text{ cm}}{6 \text{ cm}} = +2.5$$

$$M_2 = -\frac{s_i}{s_o} = -\frac{-90 \text{ cm}}{9 \text{ cm}} = +10$$

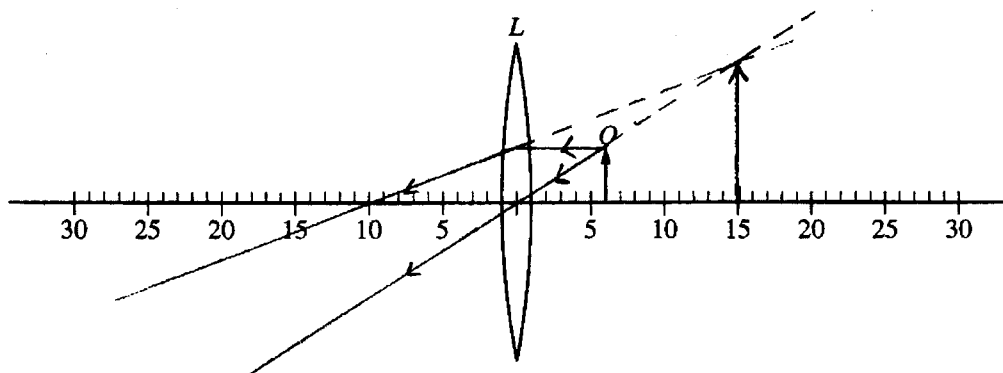
The magnification increases so the height of the new image is larger.

5. (10 points)

B5A₁

A thin converging lens L of focal length 10.0 cm is used as a simple magnifier to examine an object O that is placed 6.0 cm from the lens.

- (a) On the figure below, draw a ray diagram showing at least two incident rays and the position and size of the image formed.



- (b) i. Indicate whether the image is real or virtual.

Real Virtual

- ii. Justify your answer.

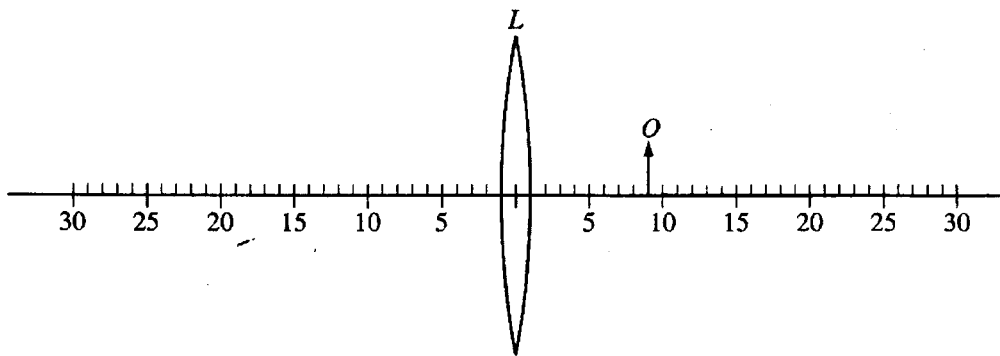
The image is virtual because the ~~lines~~ ~~are~~ light rays passing through the lens ~~are~~ do not converge ~~and~~ ~~one~~ but the image appears to ~~converge~~ be behind the object where the imaginary light rays converge.

- (c) Calculate the distance of the image from the center of the lens. (Do NOT simply measure your ray diagram.)

$$\begin{aligned}\frac{1}{s_i} + \frac{1}{s_o} &= \frac{1}{f} \\ \frac{1}{s_i} &= \frac{1}{f} - \frac{1}{s_o} = \frac{1}{10} - \frac{1}{6} \\ &= -\frac{1}{15} \\ s_i &= -15 \text{ cm.}\end{aligned}$$

The image is 15 cm from the centre of the lens.

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- (d) The object is now moved 3.0 cm to the right, as shown above. How does the height of the new image compare with that of the previous image?

It is larger. It is smaller. It is the same size.

Justify your answer.

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

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

$$= \frac{1}{10} - \frac{1}{(6+3)} = \frac{1}{90}$$

$$s_i = -90 \text{ cm}$$

New image:

$$M = -\frac{s_i}{s_o} = \frac{h_i}{h_o}$$

$$= -\frac{-90}{90} = +10$$

Old image

$$M = -\frac{s_i}{s_o}$$

$$= -\frac{-15}{6}$$

$$= 2.5$$

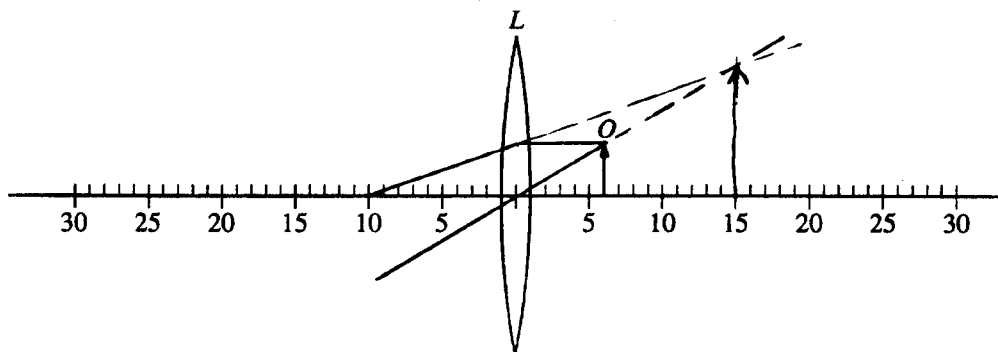
The image is now 10 times the size of object as compared to previous image that is 2.5 times the object's size.

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5. (10 points)

A thin converging lens L of focal length 10.0 cm is used as a simple magnifier to examine an object O that is placed 6.0 cm from the lens.

- (a) On the figure below, draw a ray diagram showing at least two incident rays and the position and size of the image formed.



(b)

- i. Indicate whether the image is real or virtual.

Real Virtual

- ii. Justify your answer.

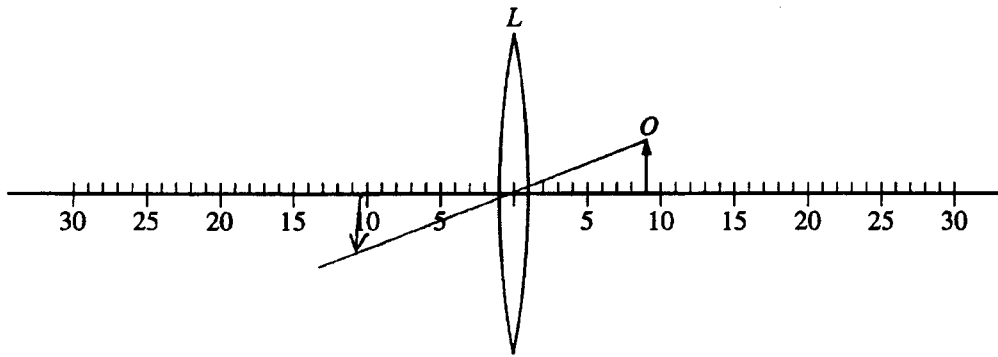
It is virtual because it is upright and can not be projected onto a screen as it is on the same side as the object. This is because the distance from object to lens is shorter than the focal length.

- (c) Calculate the distance of the image from the center of the lens. (Do NOT simply measure your ray diagram.)

$$\frac{1}{f} = \frac{1}{s_i} + \frac{1}{s_o} \quad \frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o} = \frac{1}{10} - \frac{1}{6} = -0.0667$$

$$s_i = -15 \text{ cm}$$

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- (d) The object is now moved 3.0 cm to the right, as shown above. How does the height of the new image compare with that of the previous image?

It is larger. It is smaller. It is the same size.

Justify your answer.

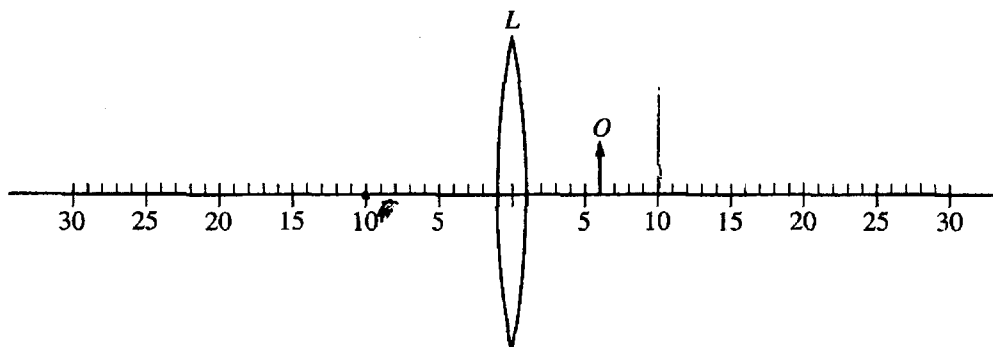
The distance from object to lens is larger than focal length, thereby creating an upside down real image that is smaller than before.

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5. (10 points)

A thin converging lens L of focal length 10.0 cm is used as a simple magnifier to examine an object O that is placed 6.0 cm from the lens.

(a) On the figure below, draw a ray diagram showing at least two incident rays and the position and size of the image formed.



(b)

i. Indicate whether the image is real or virtual.

___ Real ___ Virtual

ii. Justify your answer.

(c) Calculate the distance of the image from the center of the lens. (Do NOT simply measure your ray diagram.)

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

$$\frac{1}{s_i} + \frac{1}{6} = \frac{1}{10}$$

$$\frac{1}{s_i} = \frac{1}{10} - \frac{1}{6}$$

$$\frac{1}{s_i} = \frac{6}{60} - \frac{10}{60}$$

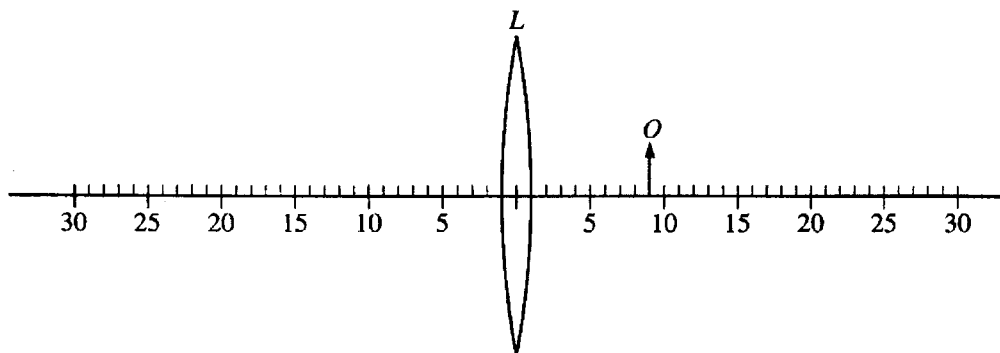
$$\frac{1}{s_i} = \frac{-4}{60}$$

$$-4s_i = 60$$

$$s_i = \frac{60}{-4}$$

$$s_i = \underline{\underline{-15 \text{ cm}}}$$

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- (d) The object is now moved 3.0 cm to the right, as shown above. How does the height of the new image compare with that of the previous image?

It is larger. It is smaller. It is the same size.

Justify your answer.

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AP[®] PHYSICS B
2008 SCORING COMMENTARY (Form B)

Question 5

Sample: B5A

Score: 10

All parts of this question are correct, so full credit was given. The choice in part (d) is justified by explicitly calculating the magnifications for the old and new images.

Sample: B5B

Score: 7

Parts (a), (b), and (c) earned full credit. The choice in part (d) is wrong, so no credit was earned there.

Sample: B5C

Score: 3

No work is shown for parts (a) or (b). The image distance is correctly calculated in part (c), so full credit was given for that part. One point was awarded for a correct choice in part (d), but no attempt is made at justifying the selection.