AP® PHYSICS 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.

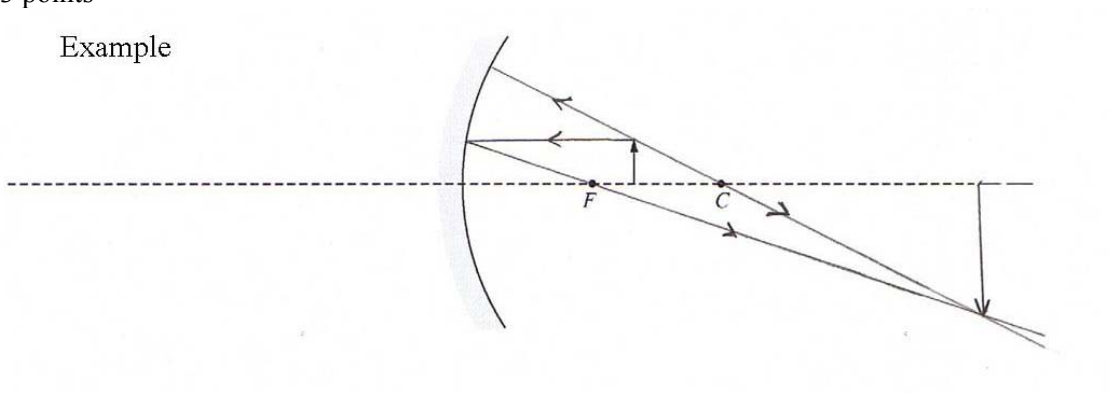
AP® PHYSICS B
2008 SCORING GUIDELINES

Question 6

10 points total **Distribution of points**

(a) 3 points

Example



For a correct ray, correctly drawn (must reflect off mirror and must extend below principal axis) 1 point

For a second correct ray, correctly drawn (must reflect off mirror and must extend below principal axis) 1 point

For an inverted image located to the right of C and at the location where the rays converge 1 point

(b) 2 points

For correctly indicating that the image is real 1 point

For a correct justification with no incorrect statements 1 point

Examples of correct responses include:

- Image is inverted.
- Image is on the same side of the mirror as the object $(s_i > 0)$.
- Light from the object passes through the image point.
- Rays converge at the image.
- Image could be projected on a screen.
- Object is placed beyond the focal point of a converging mirror.

(c) 2 points

For a correct mirror equation and at least one step toward a correct solution 1 point

$\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f}$, leading to $\frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o}$, for example

Substituting into the second equation above

$$\frac{1}{s_i} = \frac{1}{6.0\text{ cm}} - \frac{1}{8.0\text{ cm}} = \frac{8-6}{48}\frac{1}{\text{cm}} = \frac{2}{48}\frac{1}{\text{cm}}$$

For a correct calculation with correct units, consistent with substitutions made 1 point

$s_i = 24$ cm

Question 6 (continued)

Distribution of points

(d) 3 points

For correctly indicating that the image is smaller than the object 1 point
For a correct justification 2 points

Numerical justification:

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

$$\frac{1}{s_i} = \frac{1}{-6.0\text{ cm}} - \frac{1}{8.0\text{ cm}} = -\frac{8+6}{48}\frac{1}{\text{cm}} = \frac{14}{48}\frac{1}{\text{cm}}$$

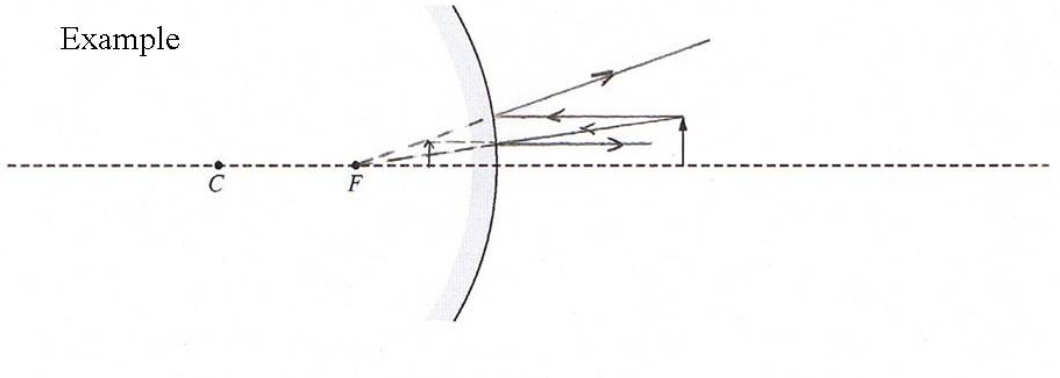
$$s_i = -3.4\text{ cm}$$

$$M = -\frac{s_i}{s_o} = -\frac{-3.4\text{ cm}}{8.0\text{ cm}} = 0.43$$

Qualitative justifications:

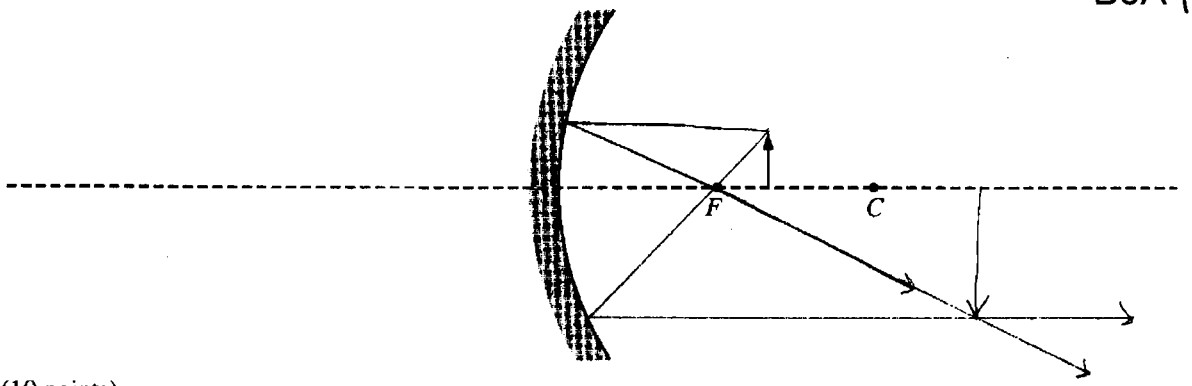
- Diverging mirrors always form an image that is smaller than the object.
- $s_i < s_o$ and so $h_i < h_o$. The student must prove the inequality with calculations or a diagram.

Ray diagram justification:



The ray diagram must contain at least two correct rays that show reflection and correctly show the image upright and smaller than the object, between the focal point and the mirror. The student must specifically indicate that his/her ray diagram is the justification to earn any points for it.

An incomplete but not incorrect justification earns 1 point.



6. (10 points)

The figure above shows a converging mirror, its focal point F, its center of curvature C, and an object represented by the solid arrow.

(a) On the figure above, draw a ray diagram showing at least two incident rays and the image formed by them.

(b) Is the image real or virtual?

X Real ____ Virtual

Justify your answer.

The light rays reflect off the mirror and converge, there are real light rays at that point so it is a real image. Your mind would not trace anything to behind the mirror. Also real images are usually inverted.

(c) The focal length of this mirror is 6.0 cm, and the object is located 8.0 cm away from the mirror. Calculate the position of the image formed by the mirror. (Do NOT simply measure your ray diagram.)

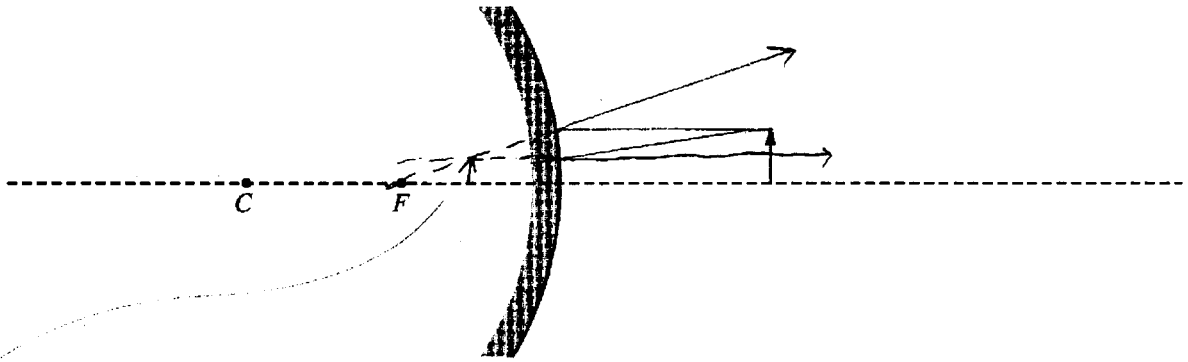
$$\frac{1}{.08} + \frac{1}{q} = \frac{1}{.06}$$

$q = 24$ cm

in front of the mirror

GO ON TO THE NEXT PAGE.

(d) Suppose that the converging mirror is replaced by a diverging mirror with the same radius of curvature that is the same distance from the object, as shown below.



For this mirror, how does the size of the image compare with that of the object?

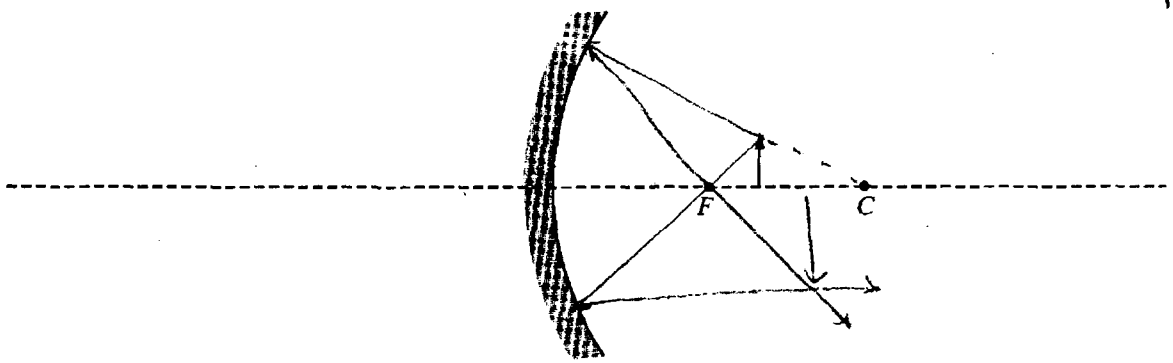
____ Larger than the object ✓ Smaller than the object ____ The same size as the object

Justify your answer.

virtual

Since the light rays diverge, you would trace them back to where they converge behind the mirror, this leads to an object that is smaller.

Diverging mirrors always produce smaller, upright and virtual images.



6. (10 points)

The figure above shows a converging mirror, its focal point F, its center of curvature C, and an object represented by the solid arrow.

(a) On the figure above, draw a ray diagram showing at least two incident rays and the image formed by them.

(b) Is the image real or virtual?

X Real ____ Virtual

Justify your answer.

The image does not appear behind the mirror, thus making the image real

(c) The focal length of this mirror is 6.0 cm, and the object is located 8.0 cm away from the mirror. Calculate the position of the image formed by the mirror. (*Do NOT simply measure your ray diagram.*)

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

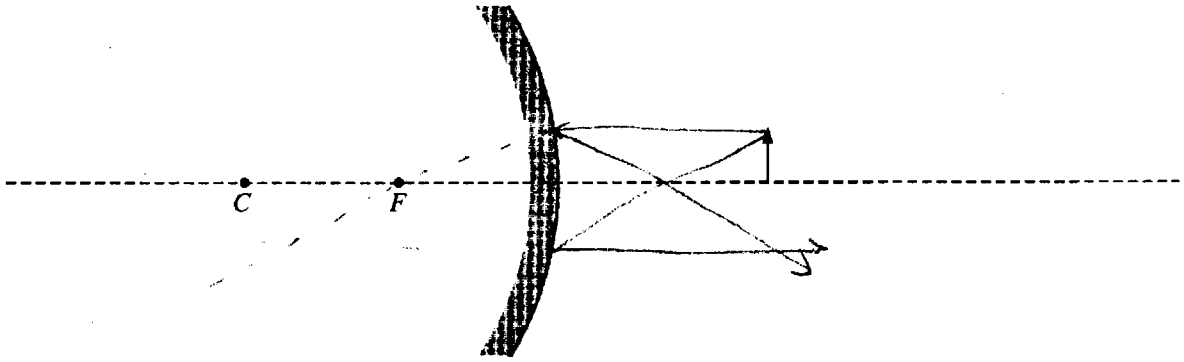
$$\frac{1}{8} + \frac{1}{d_i} = \frac{1}{6}$$

$$\frac{1}{d_i} = \frac{1}{24}$$

$$d_i = 24 \text{ cm}$$

GO ON TO THE NEXT PAGE.

(d) Suppose that the converging mirror is replaced by a diverging mirror with the same radius of curvature that is the same distance from the object, as shown below.

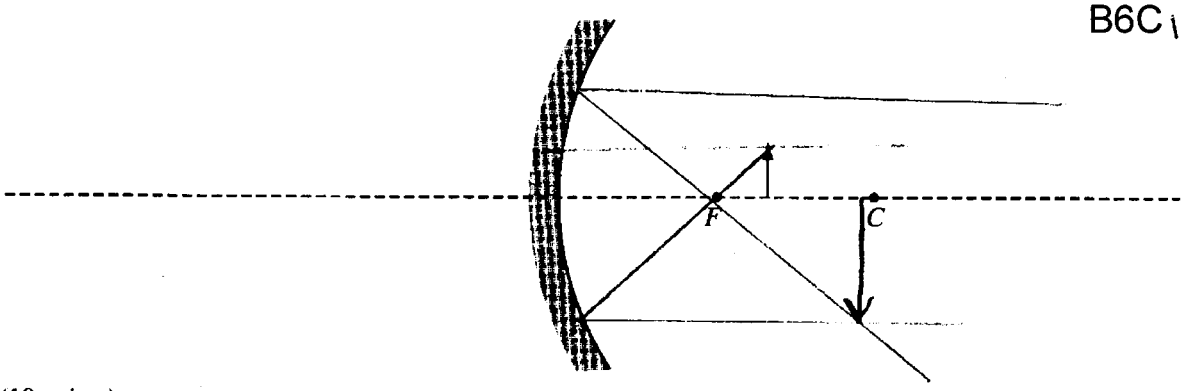


For this mirror, how does the size of the image compare with that of the object?

X Larger than the object ____ Smaller than the object ____ The same size as the object

Justify your answer.

The image appears behind the mirror making the image appear larger than the object.



6. (10 points)

The figure above shows a converging mirror, its focal point F, its center of curvature C, and an object represented by the solid arrow.

(a) On the figure above, draw a ray diagram showing at least two incident rays and the image formed by them.

(b) Is the image real or virtual?

____ Real ✓ Virtual

Justify your answer.

The image is inverted so it is virtual

(c) The focal length of this mirror is 6.0 cm, and the object is located 8.0 cm away from the mirror. Calculate the position of the image formed by the mirror. (Do NOT simply measure your ray diagram.)

$f = .06$

$S_o = .08$

$$\frac{1}{S_i} + \frac{1}{S_o} = \frac{1}{f}$$

$$\frac{1}{S_i} + \frac{1}{.08} = \frac{1}{.06}$$

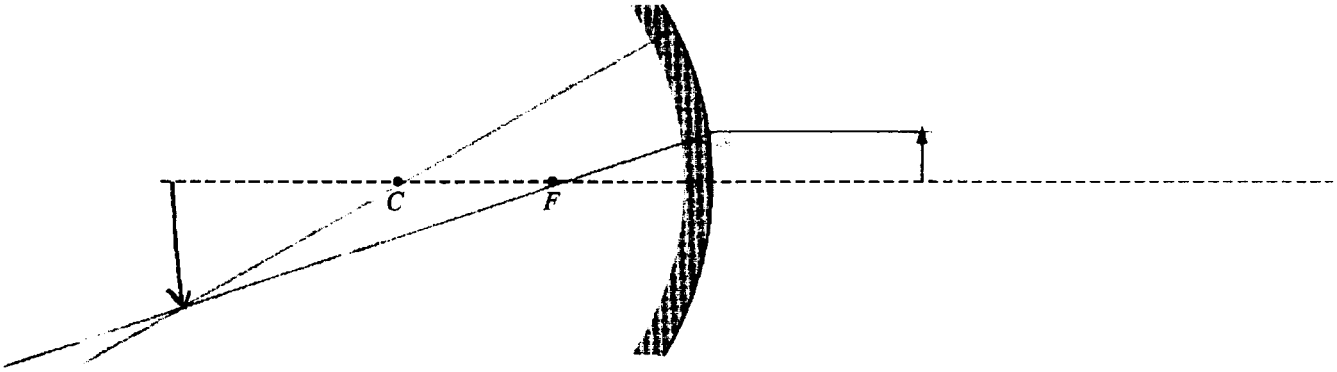
$$\frac{1}{S_i} = \frac{25}{6}$$

$S_i = .24$m away

GO ON TO THE NEXT PAGE.

B6C 2✓

(d) Suppose that the converging mirror is replaced by a diverging mirror with the same radius of curvature that is the same distance from the object, as shown below.



For this mirror, how does the size of the image compare with that of the object?

__✓__ Larger than the object ____ Smaller than the object ____ The same size as the object

Justify your answer.

By doing ray tracing, the image is definately larger

GO ON TO THE NEXT PAGE.

AP® PHYSICS B
2008 SCORING COMMENTARY

Question 6

Overview

The intent of this question was to test student understanding of the properties of reflection by asking them to draw a diagram. The question examined whether students know the difference between a real and a virtual image, and whether they know how images are formed. It also tested whether students are able to calculate the position of an image.

Sample: B6A
Score: 10

Full credit was awarded for part (a), which shows two correctly drawn rays and a correctly drawn image. Full credit was also awarded for parts (b) and (c). The correct choice is selected in part (d) and is justified both in words and through reference to the ray diagram, so full credit was awarded.

Sample: B6B
Score: 5

Only 1 point was awarded for part (a), for the correctly drawn ray that passes through F and reflects parallel to the principal axis. Full credit was awarded for the correct choice and valid justification in part (b). Full credit was also awarded for a correct calculation in part (c). The choice selected for part (d) is incorrect, so no credit was given for this part.

Sample: B6C
Score: 3

Only 1 point was awarded for part (a), for the ray that passes through F and is reflected parallel to the principal axis. An incorrect choice is selected in part (b), so no credit was awarded. Part (c) received full credit. The choice selected in part (d) is incorrect, so no credit was given for that part.