Object-Image Relationships
Two physics students are conducting an investigation on how the characteristics of the images formed by a concave mirror depend upon the object’s distance from the mirror. They acquire a small concave mirror with a 20.0-cm focal length (f) and mount it on a lab bench. They place a 4.0-cm high light bulb at varying distances from the mirror and project the image of the light bulb onto a note card. They measure the object distance (d₀) to the mirror, the image distance (dᵢ) to the mirror, and the image height (hᵢ). Figure 1 and Figure 2 show a representation of their data.

Figure 1

<table>
<thead>
<tr>
<th>Image Distance (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>40</td>
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<tr>
<td>20</td>
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<td>0</td>
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</tbody>
</table>

Object Distance (cm)

Figure 2

<table>
<thead>
<tr>
<th>Image Height (cm)</th>
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</thead>
<tbody>
<tr>
<td>20</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>0</td>
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</tbody>
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Object Distance (cm)
Questions:
1. Which statement describes the relationship between image height and object distance?
   a. They are directly related.  
   b. They are inversely related.  
   c. They do not affect one another.  
   d. There is no predictable relationship.

2. Which two changes are observed in the image as the object is moved closer to the surface of the mirror?
   a. Both the image height and the image distance increase.  
   b. Both the image height and the image distance decrease.  
   c. The image height increases and the image distance decreases.  
   d. The image height decreases and the image distance increases.

3. How does the size of the image compare to the size of the object when the object is placed a distance of three focal lengths (3\(\cdot\)f) from the mirror?
   a. The image is larger than the object.  
   b. The image is smaller than the object.  
   c. They are the same size.  
   d. No such prediction can be made with this info.

4. Where is the image located when it is the largest?
   a. The image is equally large at all locations.  
   b. The image is largest when it is positioned closest to the mirror.  
   c. The image is largest when it is positioned furthest from the mirror.  
   d. There is no way to predict since there is no relationship between image size and location.

5. At what object distance is the image the same size as the object?
   a. The object and the image are never the same size.  
   b. The object and image are the same size when the object distance is 20 cm.  
   c. The object and image are the same size when the object distance is 40 cm.  
   d. The object and image are the same size when the object distance is 90 cm.

6. At what position must the object be located in order for the image to be one-half the size of the object?
   a. The image is never one-half the size of the object.  
   b. The image is one-half the object’s size when the object distance is approximately 30 cm.  
   c. The image is one-half the object’s size when the object distance is approximately 40 cm.  
   d. The image is one-half the object’s size when the object distance is approximately 60 cm.

7. Based on the trend observed for the largest object distances, what might be expected if the object distance is increased beyond 100 cm?
   a. The image distance would not decrease below 20 cm.  
   b. The image distance would approach a very large value.  
   c. The image distance would be equal to the object distance.  
   d. The image distance would begin to increase again.
8. How does the size of the image compare to the size of the object when the image is a distance of 100 cm from the mirror?
   a. The image is two times larger than the object.
   b. The image is four times larger than the object.
   c. The image is 16 times larger than the object.
   d. The image size cannot be compared to the object size using the given information.

9. How tall is the image when it is located 25.0 cm from the mirror?
   a. Approximately 1.0-cm tall.
   b. Approximately 4.0-cm tall.
   c. Approximately 9.0-cm tall.
   d. Approximately 16.0-cm tall.

10. Use Figure 1 and Figure 2 to estimate the image height when the image is located a distance of 80.0 cm from the mirror.
    a. Approximately 1 cm
    b. Approximately 12 cm
    c. Approximately 27 cm
    d. Approximately 32 cm