Mirror Equation Questions

Based on the geometry of the rays theoretically reflecting from a curved mirror, the mirror equation is derived to be:

\[
\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}
\]

- \(d_o\) = distance to object
- \(d_i\) = distance to image
- \(f\) = focal length

The conventions for this equation include:
- All distances are measured from the vertex of a curved mirror.
- Distances of real objects and images are positive.
- Object heights and image heights are positive when measured upward from the principal axis, and negative when measured downward.

The magnification equation:

\[
M = \frac{h_i}{h_o} = \frac{d_i}{d_o}
\]

Practice:

1. Determine the image distance in each of the following.
   a) A converging mirror has a focal length of 15 cm. An object is placed (i) 40 cm, and (ii) 10 cm from the mirror.
      \((-24 \text{ cm}, -30 \text{ cm})\)
   b) A diverging mirror has a focal length of -20 cm. An object is placed (i) 10 cm, and (ii) 30 cm from the mirror.
      \((-6.7 \text{ cm}, -12 \text{ cm})\)

2. A candle 3.0 cm high is placed 30 cm from a converging mirror with a focal length of 20 cm. Using the mirror and magnification equations, determine the image position and its height. From these results, provide the image characteristics (S.A.L.T).
   \((d_i = 60 \text{ cm}; h_i = -6.0 \text{ cm})\)

3. A converging mirror has a focal length of 20 cm. Where should an object be placed so that its virtual image will be twice as tall as the object?
   \((10 \text{ cm})\)

4. A woman looks at herself in a magnifying converging mirror whose focal length is 20 cm. If her face is 10 cm from the mirror,
   a) at what distance from the mirror is her image? \((-20 \text{ cm})\)
   b) what is the magnification of her face? \((-2)\)

5. A 2.0 cm high candle is placed 15 cm in front of a concave mirror with a focal length of 30 cm. How far "behind" the mirror does the candle appear, and how large is it? \((-30 \text{ cm}, 4 \text{ cm})\)

6. A trucker sees the image of a car passing her truck in her diverging rear-view mirror, whose focal length is -60 cm. If the car is 1.5 m high and 6.0 m away, what is the size and location of the image? \((-30 \text{ cm}, 13.5 \text{ cm})\)

7. A spherical, polished metallic ball is used as a diverging mirror \((f = -20 \text{ cm})\) over a birdbath. A bird, 25 cm tall, standing 50 cm away, looks directly at the mirror. What are the size and position of the bird's image? \((7.2 \text{ cm}, -14 \text{ cm})\)

8. When standing 2.0 m in front of an amusement park mirror, you notice that your image is three times taller. What is the radius of curvature of the mirror? \((6.0 \text{ m})\)

9. A child looks at his reflection in a spherical Christmas tree ornament 8.0 cm in diameter, and sees that the image of his face is reduced by one-half. How far is his face from the ornament? \((2.0 \text{ cm})\)

10. A converging mirror has a focal length of 15 cm. Where would you place an object in order to produce an erect virtual image twice as tall as the object? \((d_o = 7.5 \text{ cm})\)