Rec 26, Nov. 19, 2009

34.19

\[ \frac{n_a + n_b}{s} = \frac{n_b - n_a}{R} \]

\[ n_a = 1.45 \text{ (oil)} \]

\[ n_b = 1.60 \text{ (glass)} \]

\[ R = +3 \text{ cm} \]

\[ s' = +1.2 \text{ m} \]

\[ f = +90 \text{ cm} \]

\[ \frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \]

\[ \frac{1}{s} + \frac{1}{1.41 s} = \frac{1}{f} \]

\[ f = +90 \text{ cm} \]

\[ \frac{2.41}{1.41 s} = \frac{1}{f} \]

\[ s = f (2.41)/1.41 \approx 154 \text{ cm} \]

\[ s' = 217 \text{ cm} > 0 \Rightarrow \text{image real} \]

[Diagram]

A.B.A.C.S.
The image contains handwritten notes related to optics, specifically focusing on the use of lenses and the calculation of image positions and magnifications. Here is the transcribed content in a more structured format:

**Lens Equation**

\[ \frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \]

**a)**

\[ f = \frac{ss'}{s + s'} = \frac{-24}{5} = -4.8 \text{ cm} \]

\( f < 0 \) ⇒ Diverging

**b)**

\[ m = -\frac{s'}{s} = -\frac{3}{8} \]

\[ h = \frac{3}{8} (6.5) = 2.44 \text{ mm} \]

\( s' < 0 \) ⇒ Virtual

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**Object 1:**

\( s = 1.3 \text{ m} \)

\[ f = 0.09 \text{ m} \ (f > 0 \text{ for real image}) \]

\[ \frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \]

\[ \frac{1}{s'} = \frac{1}{f} - \frac{1}{s} = \frac{s - f}{fs} \]

\[ s' = \frac{fs}{s - f} = 9.67 \text{ cm} \]

**Object 2:**

\( s = 6.5 \text{ m} \)

\[ s_0 \]

\[ s' = \frac{fs}{s - f} = 9.13 \text{ cm} \]

\( s'_1 - s'_2 = 0.54 \text{ cm} \) moved toward film
Physics 24  Special Homework Assignment #9

A lens forms an image of an object. The object is 20.0 cm from the lens. The image is formed 15.0 cm from the lens on the same side as the object.

(a) What is the focal length of the lens? Based on the results of your calculation, is it a converging or diverging lens?

Image on same side as real object $\Rightarrow s' > 0$ so image is virtual

$$S = 20 \text{ cm}, \quad s' = -15 \text{ cm}$$

$$\frac{1}{S} + \frac{1}{s'} = \frac{1}{f}$$

$$\frac{1}{20} + \frac{1}{-15} = \frac{1}{f} \Rightarrow f = -60 \text{ cm}$$

Diverging lens

(b) If the object is 8.0 mm tall, how tall is the image? Based on the results of your calculation, is it upright or inverted?

$$m = \frac{y'}{y} = -\frac{s'}{s} \Rightarrow y' = -\frac{s'}{s} y = -\frac{(-15)}{20} 8 = +6 \text{ mm}$$

Upright

(c) Verify your calculations by making a complete a ray diagram showing the formation of the image using the figure provided. Adjacent marks on the principal axis are separated by 10.0 cm.
1. Which of the glass lenses, when placed in air, will cause parallel rays of light to converge?
   [A] II, II, and III  [B] I, IV, and V  
   [C] II, III, and V  [D] I, III, and V

2. You have a thin diverging lens whose focal points are 30.0 cm from the lens.
   (a) You use the lens to form a virtual image of a light bulb. The distance between this image and the bulb is 60.0 cm. Calculate the distance from the light bulb to the lens.

   \[
   \frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \quad s > 0, \quad f < 0 \\
   \frac{1}{s'} = \frac{1}{f} - \frac{1}{s} = \frac{s - f}{fs} \\
   s' = \frac{s}{s - f} \\
   \frac{s}{f} < 0 \Rightarrow |s'| < |s| \\
   \frac{1}{s} + \frac{1}{60} = \frac{1}{f} \\
   \frac{f}{s} = \frac{60}{60 - s} \\
   60f = s^2 - 60s \\
   s^2 - 60s - 1800 = 0 \\
   s = \frac{1}{2} \left[ 30 \pm \sqrt{1089} \right] = 30 \pm 33 \Rightarrow s > 0 \text{ (real object)} \\
   s = \frac{3}{2} \left[ 30 \pm 10.49 \right] = 83 \text{ cm}
   \]

   (b) Your lens in part a has a double-concave shape, as shown. One of the surfaces has a radius of curvature with an absolute value of 20.0 cm. If the lens has a refractive index of 1.5 and is surrounded by air, calculate the radius of curvature of the other surface.

   \[
   \frac{1}{f} = (n-1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) \\
   \frac{1}{30} = (1.5-1) \left( \frac{1}{-20} - \frac{1}{R_2} \right) \\
   \frac{1}{30} = \frac{1}{2} \left( \frac{1}{20} - \frac{1}{R_2} \right) \Rightarrow \frac{1}{15} + \frac{1}{20} = \frac{1}{R_2} \\
   \frac{1}{R_2} = -\left( \frac{1}{15} + \frac{1}{20} \right) \Rightarrow R_2 = 60 \text{ cm}
   \]

   (c) Assume that the light bulb has been moved to 40.0 cm away from the lens. Draw a ray diagram for this new situation. (The spacing between the tick marks is 5.0 cm.) Use solid lines for actual light rays and dashed lines for reference lines.

   [Diagram of light rays refracted by a diverging lens]