Practice Problems: Lenses:

Lens problems are solved using the same equations as we used to solve mirror problems. The main difference is that real rays go through lenses instead of reflecting back like they do with mirrors. That means that real images are on the opposite side of the lens as compared to the object. d_o is positive wherever it is placed. When the image is on the opposite side of the lens it is real and it has a positive d_i. When the di is negative, it means the image is on the same side of the lens as the object.

Equations: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ $\quad M = -\frac{d_i}{d_o} = \frac{h_i}{h_o}$

1) Joe burns a hole in his shoe using a lens and sunlight. His shoe is 15 cm from the lens.
   a) What is the 'object'? b) What is d_o(nearly)? c) What is d_I? d) What is f? e) Is the lens concave or convex?

2) A slide projector projects images on a screen.
   a) If the slide is 15.5 cm from the lens and the lens has a focal length of 15 cm, how far away is the screen?
   b) If the slide is 2.0 cm high, how big is the image on the screen?
   c) Is the image real or virtual?
   d) Should the slide be placed in the projector right-side-up or upside-down?

3) A camera has a focal length of 50 mm. You are taking a picture of a person who is 2 meters tall and stands 3 meters away from the lens.
   a) How far from the lens should the film be located?
   b) How tall is the person's image on the film?

4) A lens forms an image that is upright 12 cm on the same side of the lens as the object. The image is 3.0 cm high. If the object is 4.0 cm high, find:
   a) do = ? b) di = ? c) is the image real or virtual? d) is the lens concave or convex?

29. A converging lens has a focal length of 20.0 cm. Locate the images for object distances of (a) 40.0 cm, (b) 20.0 cm, and (c) 10.0 cm. For each case, state whether the image is real or virtual and upright or inverted, and find the magnification.

30. Where must an object be placed to have unit magnification ($|M| = 1.00$) (a) for a converging lens of focal length 12.0 cm? (b) for a diverging lens of focal length 12.0 cm?

31. A diverging lens has a focal length of 20.0 cm. Locate the images for object distances of (a) 40.0 cm, (b) 20.0 cm, and (c) 10.0 cm. For each case, state whether the image is real or virtual and upright or inverted, and find the magnification.

32. A convex lens of focal length 15.0 cm is used as a magnifying glass. At what distance from a postage stamp should you hold this lens to get a magnification of +2.00?

33. (extra credit type problem) A transparent photographic slide is placed in front of a converging lens with a focal length of 2.44 cm. The lens forms an image of the slide 12.9 cm from the slide. How far is the lens from the slide if the image is (a) real? (b) virtual?

34. The nickel's image has twice the diameter of the nickel when the lens is 2.84 cm from the nickel. Determine the focal length of the lens.

35. (extra credit type problem) A certain LCD projector contains a single thin lens. An object 24.0 mm high is to be projected so that its image fills a screen 1.80 m high. The object-to-screen distance is 3.00 m. (a) Determine the focal length of the projection lens. (b) How far from the object should the lens of the projector be placed in order to form the image on the screen?

36. An object's distance from a converging lens is ten times the focal length. How far is the image from the focal point? Express the answer as a fraction of the focal length.

37. A diverging lens is to be used to produce a virtual image one-third as tall as the object. Where should the object be placed?

38. (extra credit type problem) An object is 5.00 m to the left of a flat screen. A converging lens for which the focal length is $f = 0.800$ m is placed between object and screen. (a) Show that there are two lens positions that form an image on the screen, and determine how far these positions are from the object. (b) How do the two images differ from each other?

Answers:

1) a) the sun b) infinity c) 15 cm d) 15 cm e) convex **2)** a) di = 465 cm b) 60 cm c) real d) upside down
3) a) 50.8 mm b) 33.9 mm **4)** a) 16 cm b) -12 cm c) virtual d) concave

23.29 (a) $\boxed{-1.00}$ $\boxed{\text{real, inverted, and 40.0 cm beyond the lens}}$

(b) $\boxed{\text{No image formed. Parallel rays leave the lens.}}$

(c) $\boxed{+2.00}$ $\boxed{\text{virtual, upright, and 20.0 cm in front of the lens}}$

23.30 (a) $\boxed{p = +24.0 \text{ cm}}$ $\boxed{p = 0 \ \text{(object is against the lens)}}$

(b) $\boxed{p = -24.0 \text{ cm}}$ $\boxed{p = 0 \ \text{(object is against the lens)}}$

23.31 (a) $\boxed{+1/3}$ $\boxed{\text{virtual, upright, and 13.3 cm in front of the lens}}$

(b) $\boxed{+1/2}$ $\boxed{\text{virtual, upright, and 10.0 cm in front of the lens}}$

(c) $+2/3$ $\boxed{\text{virtual, upright, and 6.67 cm in front of the lens}}$

23.32 $\boxed{\text{7.50 cm in front of the lens}}$

23.33 (a) $\boxed{p = 9.63 \text{ cm or } p = 3.27 \text{ cm}}$ Both are valid solutions for the real image case.

(b) $\boxed{p = 2.10 \text{ cm}}$.

23.34 $\boxed{5.68 \text{ cm}}$

23.35 (a) $\boxed{39.0 \text{ mm}}$ (b) $\boxed{39.5 \text{ mm}}$

23.36 $\boxed{f/9 \text{ outside the focal point}}$

23.37 $\boxed{2|f| \text{ in front of the lens}}$

23.38 (a) $\boxed{p = 4.00 \text{ m and } p = 1.00 \text{ m}}$

(b) $\boxed{\text{real, inverted, and four times the size of the object}}$