Date _____ Period _____ Name _____

18 Study Guide

Use with Chapter 1

Mirrors and Lenses

Vocabulary Review

Write the term that correctly completes each statement. Use each term once.

~~achromatic lens~~ ~~chromatic aberration~~ ~~concave lens~~ ~~concave mirror~~ ~~convex lens~~ ~~convex mirror~~ ~~erect image~~ ~~focal length~~ ~~focal point~~ ~~lens/mirror equation~~ ~~magnification~~ ~~object~~ ~~principal axis~~ ~~real image~~ ~~spherical aberration~~ ~~virtual image~~

1. real image — An image at which light rays actually converge is a(n) _____.
2. concave mirror — A(n) _____ reflects light from its inwardly curving surface.
3. principal axis — The straight line perpendicular to the surface of a mirror at its center is the _____.
4. lens/mirror equation — The mathematical relationship between focal length, distance of object, and distance of image is expressed by the _____.
5. concave lens — A transparent refracting device that is thinner in the middle than at the edges is a(n) _____.
6. convex lens — A transparent refracting device that is thicker in the middle than at the edges is a(n) _____.
7. focal length — The distance between the focal point and the mirror or lens is the _____.
8. object — Any source of diverging light rays is a(n) _____.
9. virtual image — An image at which light rays do not actually converge is a(n) _____.
10. focal point — The place at which light rays parallel to the principal axis of a concave mirror converge is the _____.
11. chromatic aberration — An undesirable effect in which an object viewed through a lens appears to be ringed with color is _____.
12. erect image — An image that is not inverted is a(n) _____.
13. spherical aberration — An undesirable effect in which the parallel rays reflected in a concave mirror fail to meet at a point is _____.
14. convex mirror — A spherical mirror that reflects light from its outwardly curving surface is a(n) _____.
15. achromatic lens — A lens constructed so as to avoid undesirable color effects is a(n) _____.
16. magnification — The ratio of the size of an image to the size of the object that produces it is the _____.

18 Study Guide

Section 18.1: Mirrors

In your textbook, read about concave mirrors.
For each of the statements below, write true *or rewrite the italicized part to make the statement true.*

1. parallel — Rays *perpendicular* to the principal axis of a concave mirror converge at or near the focal point.
2. true — The focal length of a concave mirror is *half* the radius of curvature.
3. true — If the object is *farther out* than the center of curvature of a concave mirror, its image appears between the focus and the center of curvature.
4. real + virtual — Concave mirrors can produce *only virtual* images.
5. can — Concave mirrors *cannot* act as magnifiers.

In your textbook, read about real images formed by concave mirrors.
Circle the letter of the choice that best answers each question.

6. Which of the following correctly states the lens/mirror equation?
   - **a.** $f = d_i + d_o$
   - **b.** $1/f = d_i + d_o$
   - **c.** $f = 1/d_i + 1/d_o$
   - **d.** $1/f = 1/d_i + 1/d_o$

7. Which of the following is a correct relationship?
   - **a.** $m = h_i + h_o$
   - **b.** $m = h_i - h_o$
   - **c.** $m = h_i/h_o$
   - **d.** $m = h_o/h_i$

8. Which of the following indicates that an image produced by a concave mirror is upright?
   - **a.** a positive value for h_i
   - **b.** a negative value for h_i
   - **c.** a positive value for d_i
   - **d.** a negative value for d_i

9. To which of the following is m equal?
   - **a.** d_o/d_i
   - **b.** $-d_o/d_i$
   - **c.** d_i/d_o
   - **d.** $-d_i/d_o$

In your textbook, read about virtual images and image defects in concave mirrors.
Circle the letter of the choice that best answers each question.

10. Which of the following indicates that an image produced by a concave mirror is virtual?
    - **a.** a positive value for h_i
    - **b.** a negative value for h_i
    - **c.** a positive value for d_i
    - **d.** a negative value for d_i

11. If an object is placed at the focal point of a concave mirror, where will the image be?
    - **a.** also at the focal point
    - **b.** at the center of curvature
    - **c.** at infinity
    - **d.** at the surface of the mirror

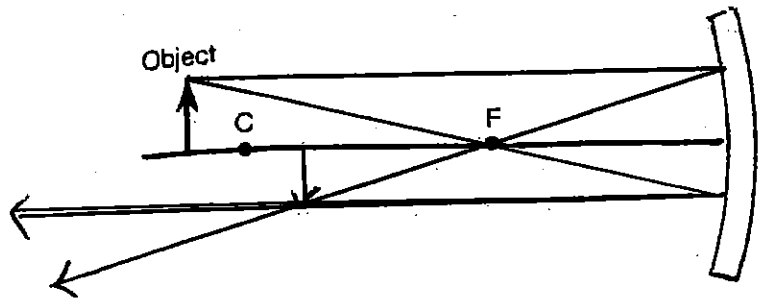
12. Which of the following posed a problem for the Hubble Space Telescope?
    - **a.** improperly ground lenses
    - **b.** chromatic aberration
    - **c.** spherical aberration
    - **d.** cracked spherical mirrors

13. Why don't parabolic mirrors have trouble with spherical aberration?
    - **a.** All parallel rays are reflected to a single spot.
    - **b.** All parallel rays focus on infinity.
    - **c.** They use a secondary mirror for correction.
    - **d.** They have a virtual focus point.

C=Center
r= 2f

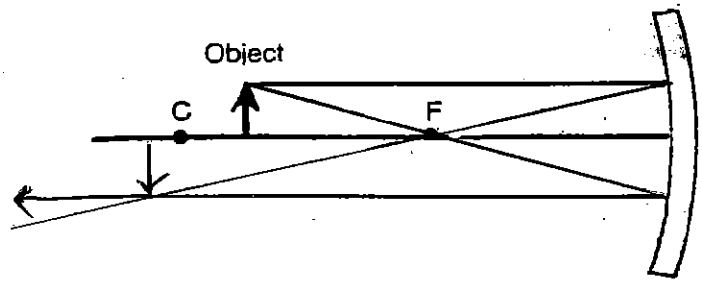
IMAGE FORMATION IN MIRRORS
RAY DIAGRAMS

CONCAVE (CONVERGING) MIRRORS



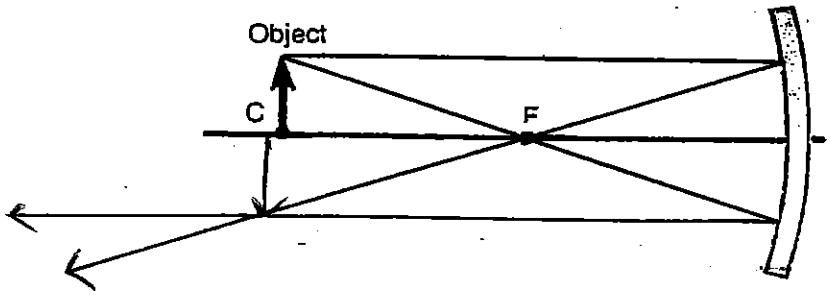
Object beyond C.

image: smaller real inverted between C+F



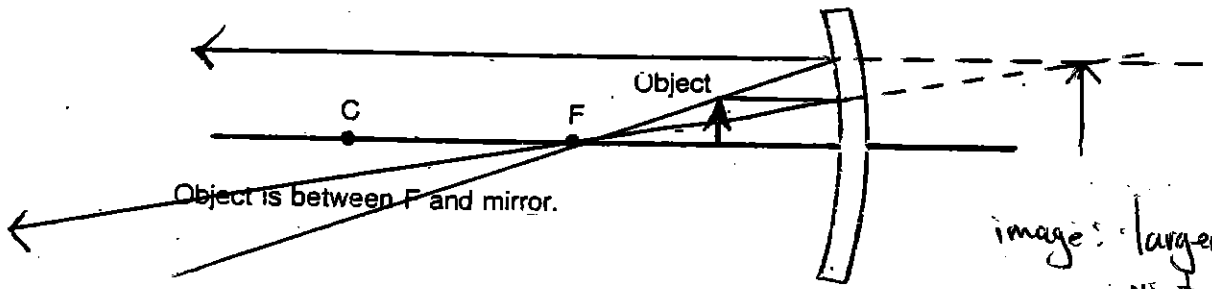
Object is between C and F.

image: larger real inverted beyond C



Object is at C.

image: same size real inverted at C



Object is between F and mirror.

image: larger virtual upright behind mirror

CONVEX (DIVERGING) MIRRORS

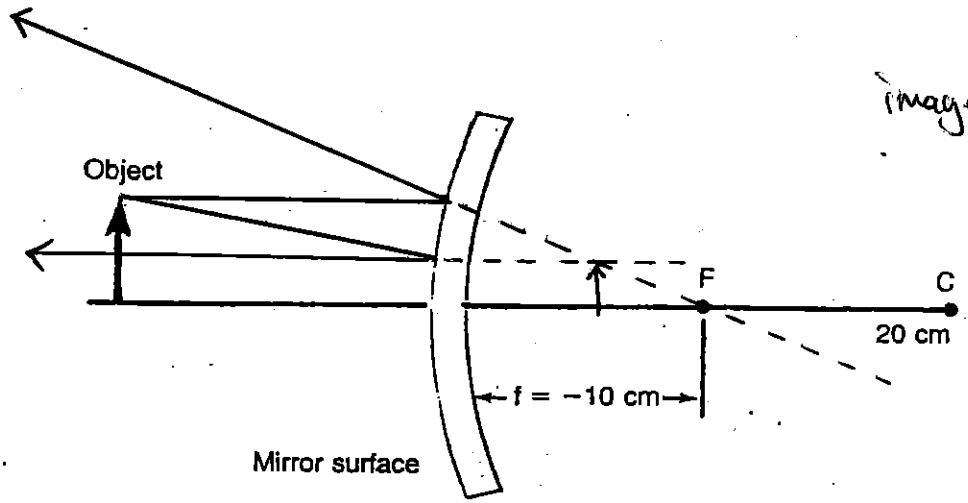


image: smaller upright virtual behind mirro

Convex spherical mirrors cause reflected light rays to diverge.

Images formed by diverging mirrors are always virtual, erect, and smaller than the object.

Diverging mirrors are used to show a large field of view.

In your textbook, read about convex mirrors.

For each of the statements below, write true *or rewrite the italicized part to make the statement true.*

26. true — The focal length of a convex mirror is *negative.*

27. diverge — Rays reflected from a convex mirror always *converge.*

28. true — Convex mirrors reflect an *enlarged* field of view.

29. virtual — The images produced by convex mirrors are *real* images.

30. inverted — When the magnification is negative, an image will be *erect.*

31. smaller — Compared to the size of the corresponding objects, the images produced by convex mirrors are always *the same size.*

Name:

Period:

Chapter 18.1- Mirror Problems

Use the following formulas to answer the following questions. These questions are taken from the chapter 18 review problems on pages 388-389.

Focal length: $f = \frac{1}{2}r$ f = focal point r = radius of curvature of lens

The Mirror Equation: $\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$ *Magnification:* $m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$

d_i = image distance to the mirror d_o = object distance to the mirror
h_i = image height h_o = object height m = magnification

1. A concave mirror has a focal length of 10.0 cm. What is its radius of curvature?

$f = \frac{1}{2}r =$ $r = 2f = 2(10) = 20$ cm

2. The sun falls on a concave mirror and forms an image at the focus point, which is 3.0 cm from the mirror. If an object 24 mm high is placed 12.0 cm from the mirror, where will its image be formed?

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

3. A jeweler inspects a watch with a diameter of 3.0 cm by placing it 8.0 cm in front of a concave mirror with a 12.0 cm focal length.
   a. Where will the image of the watch appear?

$d_i = \frac{f d_o}{d_o - f} = \frac{(12\text{ cm})(8)}{8 - 12} = -24$ cm - virtual image

   b. What will be the diameter of the image?

$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$ $h_i = \frac{-d_i h_o}{d_o} = \frac{-(-24\text{ cm})(3\text{ cm})}{8\text{ cm}} = 9$ cm

4. Shiny lawn spheres placed on pedestels are convex mirrors. One such sphere has a diameter of 40 cm. A 12 cm robin sits in a tree 1.5 m from the sphere.
   a. Where is the image of the robin?

$d = 40$, $r = 20$, $f = -10$ cm (convex)

$d_i = \frac{f d_o}{d_o - f} = \frac{(-10\text{ cm})(150\text{ cm})}{(150 - (-10)} = -9.375$ cm - virtual

   b. How tall is the robin's image?

$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$ $h_i = \frac{-d_i h_o}{d_o} = \frac{-(-9.375\text{ cm})(12\text{ cm})}{150\text{ cm}} = 0.75$ cm

IMAGE FORMATION IN LENSES
RAY DIAGRAMS

DOUBLE CONVEX (CONVERGING) LENSES

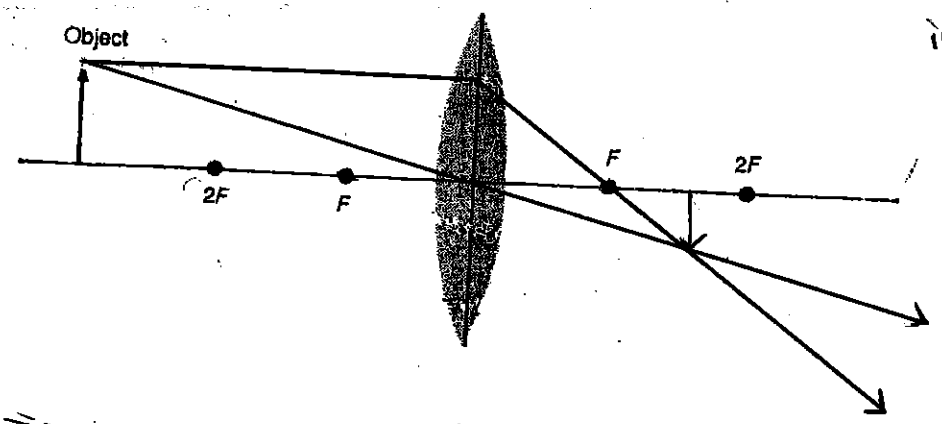


image: smaller
real
inverted
between F+2F

A converging lens is thick in the center and thin at the edges.

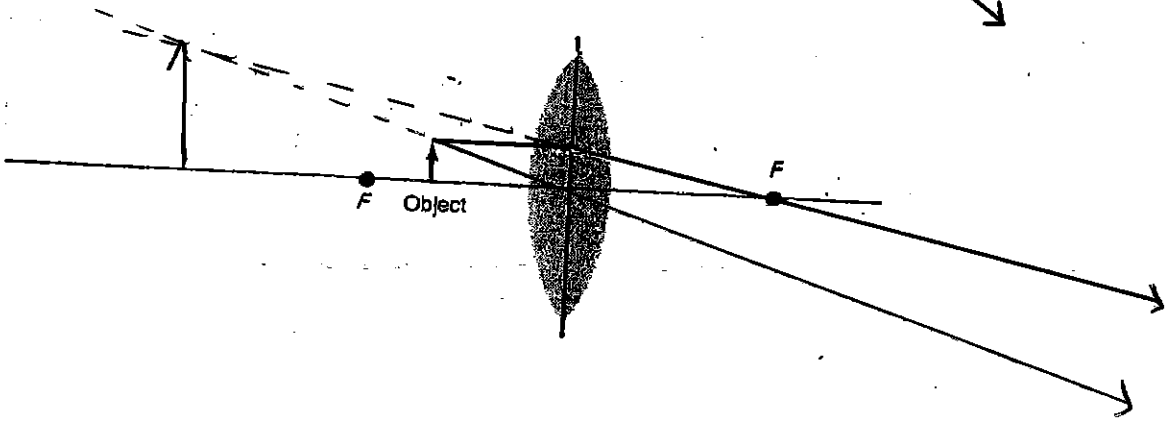
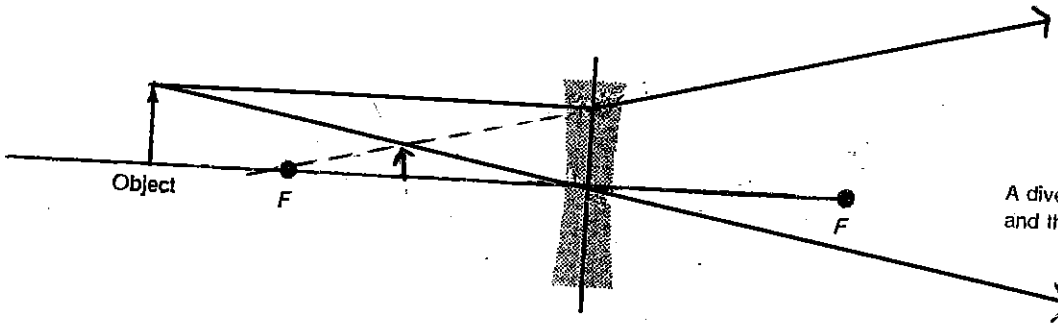


image: larger
virtual
upright
behind
object

DOUBLE CONCAVE (DIVERGING) LENSES



A diverging lens is thin in the center and thick at the edges.

image: smaller
virtual
upright
between F+lens in front of object

18 Study Guide

Name _____

Section 18.2: Lenses

In your textbook, read about real images formed by convex lenses.
Circle the letter of the choice that best completes the statement or answers the question.

1. Convex lenses typically have _____.
   - **a.** one focal point
   - **b.** two focal points
   - **c.** a virtual focal point
   - **d.** no focal point

2. For a convex lens, if an object is between f and $2f$, the image will be _____.
   - **a.** smaller than the object
   - **b.** larger than the object
   - **c.** the same size as the object
   - **d.** at infinity

3. For a lens, which of the following relationships is correct?
   - **a.** $m = h_o/h_i$
   - **b.** $m = d_i/d_o$
   - **c.** $m = -h_o/h_i$
   - **d.** $m = -d_i/d_o$

4. The relationship $1/f = 1/d_i + 1/d_o$ is _____.
   - **a.** valid for any lens
   - **b.** not valid for lenses
   - **c.** valid for convex lenses only
   - **d.** valid for concave lenses only

5. What kinds of images can convex lenses produce?
   - **a.** real only
   - **b.** virtual only
   - **c.** both real and virtual
   - **d.** neither real nor virtual

6. What is the principal advantage of using a large convex lens rather than a small one?
   - **a.** elimination of spherical aberration
   - **b.** elimination of chromatic aberration
   - **c.** increasing the size of the focal point
   - **d.** collection of more light rays

7. If an object is placed at the focal point of a convex lens, the refracted rays will _____.
   - **a.** emerge in a parallel beam
   - **b.** converge at the other focal point
   - **c.** converge at the lens surface
   - **d.** diverge

In your textbook, read about virtual images formed by convex lenses.
Answer the following questions, using complete sentences.

8. What type of lens can be used as a magnifying glass?
   Convex lens

9. When a lens is used as a magnifying glass, where is the object placed?
   between F + lens

10. When a lens is used as a magnifying glass, what sign(s) do d_i and h_i have?
    d_i = (−) h_i = (+)

18 Study Guide

Name _____

In your textbook, read about concave lenses and lens defects.
For each of the statements below, write true *or rewrite the italicized part to make the statement true.*

11. upright — The images produced by concave lenses are always *inverted.*
12. true — A concave lens is *thinner* in the center than at the edges.
13. diverge — Concave lenses refract light rays so that the rays *converge.*
14. true — The images produced by concave lenses are *virtual and enlarged.*
15. true — Lenses suffer from spherical aberration because the rays that pass through *do not* all pass through the focus.
16. true — The edges of a lens act like a *prism,* scattering light in a ring of color.
17. true — You can reduce *spherical aberration* by joining a concave lens with a convex lens.

In your textbook, read about microscopes and telescopes.
Circle the letter of the choice that best completes the statement or answers the question.

18. The objective lens of a microscope is used to produce an image located _____.
    - **a.** at the ocular lens
    - **b.** between the ocular lens and its focal point
    - **c.** at the focal point of the ocular lens
    - **d.** beyond the ocular lens and its focal point
19. What kind of image is a telescope designed to produce for the viewer?
    - **a.** real and inverted
    - **b.** real and erect
    - **c.** virtual and inverted
    - **d.** virtual and erect
20. An astronomical refracting telescope uses _____.
    - **a.** two concave lenses
    - **b.** a combination of concave and convex lenses
    - **c.** two convex lenses
    - **d.** a variety of lenses and mirrors

PROBLEMS: The Lens Equations

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ $\frac{h_i}{h_o} = \frac{-d_i}{d_o}$

p. 389

Equations to be used: The equations for lenses are the same as those used for mirrors.

13. The convex lens of a copy machine has a focal length of 25.0 cm. A letter to be copied is placed 40.0 cm from the lens.

a. How far from the lens is the copy paper located? $d_i = ?$

b. The machine was adjusted to give an enlarged copy of the letter. How much larger will the copy be?

a) $d_i = \frac{f d_o}{d_o - f} = \frac{(25)(40)}{(40-25)} = 66.7\text{ cm}$

b) $m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$ $m = \frac{-66.7\text{ cm}}{40\text{ cm}} = 1.67\times$

14. Camera lenses are described in terms of their focal length. A 50.0-mm lens has a focal length of 50.0 mm.

a. A camera is focused on an object 3.0 m away using a 50.0 mm lens. Locate the position of the image.

b. A 1.00×10^3 mm lens is focused on an object 125 m away. Locate the position of the image.

a) $d_i = \frac{f d_o}{d_o - f} = \frac{(50\text{ mm})(3000\text{ mm})}{3000 - 50} = \boxed{50.8\text{ mm}}$

b) $d_i = \frac{(125\text{ m})(1\text{ m})}{(125 - 1)} = 1.008\text{ m} = \boxed{1008\text{ mm}}$

Name:

18 Mirrors and Lenses

$m = \frac{-d_i}{d_o} = \frac{h_i}{h_o}$ $\quad \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

1.a) A flower is placed in front of a concave, spherical mirror at a distance of 0.350 m from the center of the mirror. A real image of the flower is observed at a distance of 0.288 m from the center of the mirror. Calculate the focal length of the mirror.

$f = ?$
$d_i = .288\,m$
$d_o = .350\,m$

$f = \frac{d_i d_o}{d_i + d_o} = \frac{(.288\,m)(.350)}{.288 + .350}$

$\boxed{f = .158\,cm}$

b.) If the flower in problem 1a is 8.7 cm tall, how tall is the image of the flower?

$h_i =$ $\quad \frac{h_i}{h_o} = \frac{-d_i}{d_o}$

$h_i = \frac{-d_i h_o}{d_o} = \frac{-(.288)(8.7\,cm)}{(.350)}$

$\boxed{h_i = -7.16\,cm}$

inverted

2.) A convex lens with a focal length of 16.6 cm is used to form a real image of an object placed 35.0 cm from the lens. The height of the object is 4.5 cm. Calculate the size and distance of the real image that is formed.

$f = 16.6\,cm$
$d_o = 35.0\,cm$
$h_o = 4.5\,cm$
$h_i = ?$
$d_i = ?$

$d_i = \frac{f d_o}{d_o - f} = \frac{(16.6\,cm)(35)}{35 - 16.6}$

$\boxed{d_i = +31.6\,cm}$ real

$h_i = \frac{-d_i h_o}{d_o} = \frac{-(31.6\,cm)(4.5\,cm)}{35.0\,cm}$

$\boxed{h_i = -4.06\,cm}$

3.) The lens of a certain movie projector has a focal length of 22.50 cm. When a frame of film is in place, it is 23.25 cm from the lens. At what distance from the lens would you place a screen in order to receive a focused image? If the image on the film is 28 mm high, how tall is the image formed on the screen?

$f = 22.5\,cm$
$d_o = 23.25\,cm$
$h_o = 28\,mm$

$d_i = \frac{f d_o}{d_o - f} = \frac{(22.5\,cm)(23.25\,cm)}{23.25 - 22.5}$

$\boxed{d_i = 697.5\,cm}$

$h_i = \frac{-d_i h_o}{d_o} = \frac{-(697.5)(28\,mm)}{23.25}$ $\boxed{-84}$

$$m = \frac{h_i}{h_o} = \frac{d_i}{d_o}$$

7.) The lens of a magnifying loupe forms a 30.0-mm image of a 2.2 mm insect when the insect is placed 25 mm from the lens. What is the focal length of this lens?

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

$h_i = 30\text{ mm}$

$h_o = 2.2\text{ mm}$

$d_o = 25\text{ mm}$

$f = ?$

$$d_i = \frac{-h_i d_o}{h_o} = \frac{-(30\text{mm})(25\text{mm})}{(2.2\text{mm})} = -340.9\text{ mm}$$

virtual

$$f = \frac{d_i d_o}{d_i + d_o} = \frac{(-340.9\text{mm})(25\text{mm})}{(-340.9\text{mm} + 25\text{mm})} = \boxed{27.0\text{mm}}$$

5.) A student views a tree that is 27.5 m tall through a concave lens that has a focal length of −70.0 cm. If the tree is 34.0 m away, how tall is the virtual image of the tree?

$h_o = 27.5\text{m}$

$f = -70\text{cm} = -.7\text{m}$

$d_o = 34.0\text{m}$

$h_i = ?$

$$h_i = \frac{-d_i h_o}{d_o}$$

$$d_i = \frac{f d_o}{d_o - f} = \frac{(-.7\text{m})(34.0)}{(34.0 - (-.7))} = \boxed{-.686\text{ m}}$$

virtual

$$h_i = -\frac{(-.686)(27.5\text{m})}{34.0\text{cm}} = \boxed{.555\text{m}}$$