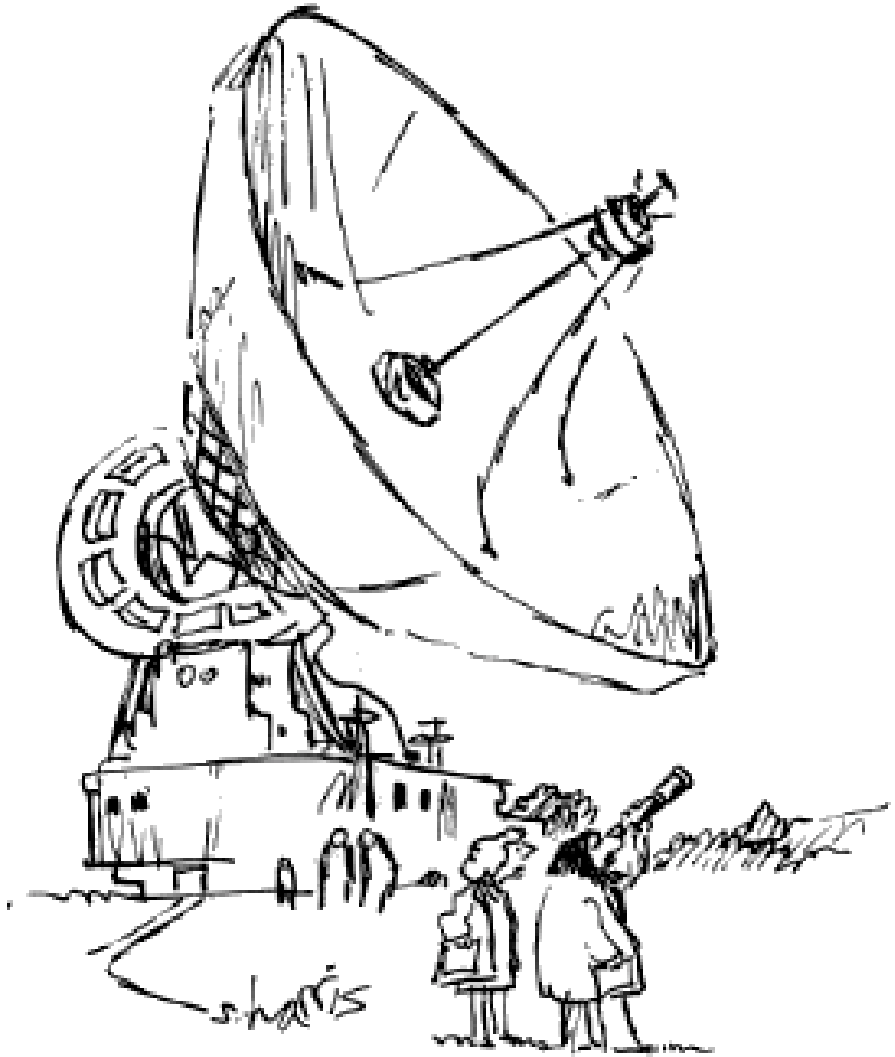


"Just checking."

November 18th

Images

Chapter 35

Schedule

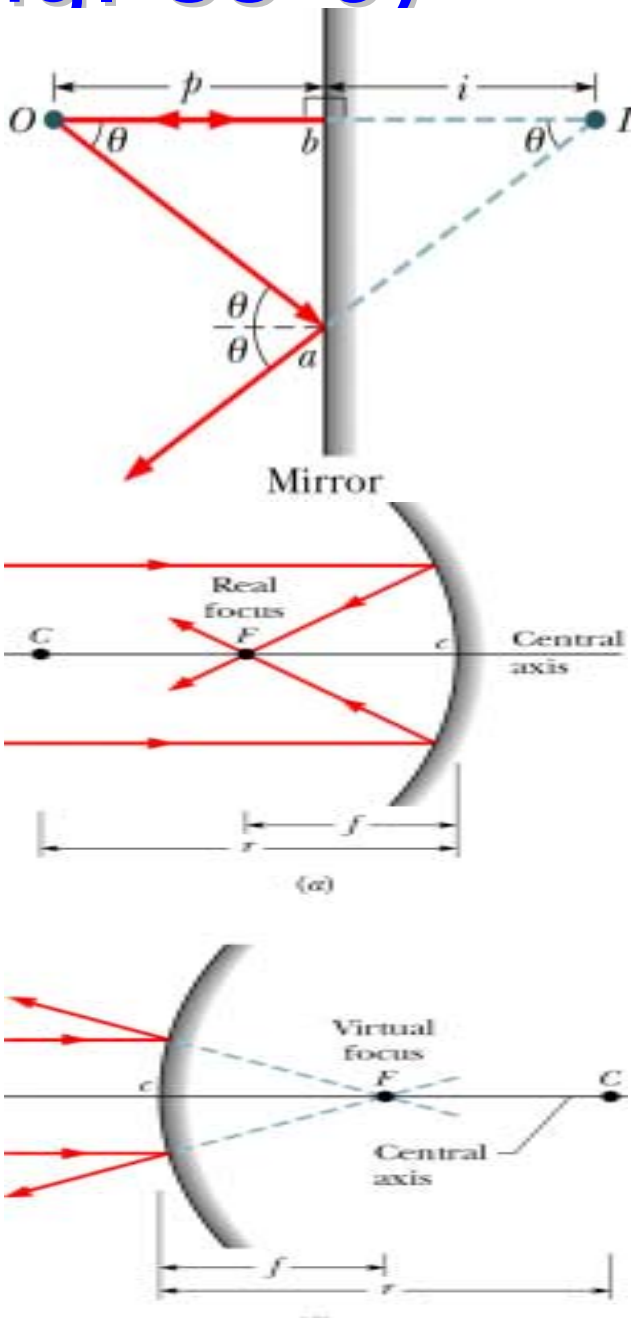
- HW set #11 will open Tues. Nov. 18th and is due on Tues. Nov. 25th at 7am.
  - Third mid-term is Nov. 25th at 6pm
- HW set #12 will open Wed. Nov. 26th and is due on Wed. Dec. 3rd at 7am.
- Corrections for the third exam will open Wed. Nov. 26th at 5pm and are due Mon. Dec. 8th at 7am.
  - Final exam is Dec. 8th at 5:45-7:45pm.

Midterm Exam #3

- Last mid-term is Tues. Nov. 25th at 6pm.
  - Section 1 in N100 BCC (Business College)
  - Section 2 in 158 NR (Natural Resources)
- Covers homework sets #9, 10 and 11!
  - Chapters 32-35 in textbook
- Allowed one page (both sides) of notes and calculator.
- Bring photo id.
- Email Prof. Tollefson (tollefson@pa.msu.edu) if need make-up exam and explain why.
  - Make-up exam will be Wed. Nov. 26th at 8am
- Review in class on Monday.

Review – Mirrors (Fig. 35-6)

- Plane – flat mirror
- Concave – caved in away from object
- Convex – flexed out toward object
- Real images on side where object is, virtual images on opposite side
- Plane and convex mirrors make only virtual images
- Concave mirrors can produce both real and virtual images



Review – mirrors (Fig. 35-7)

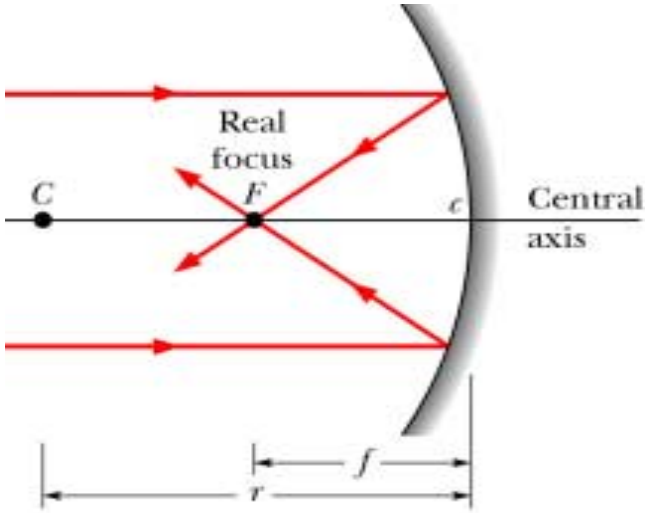
- Spherical mirrors have focal point, r is radius of curvature

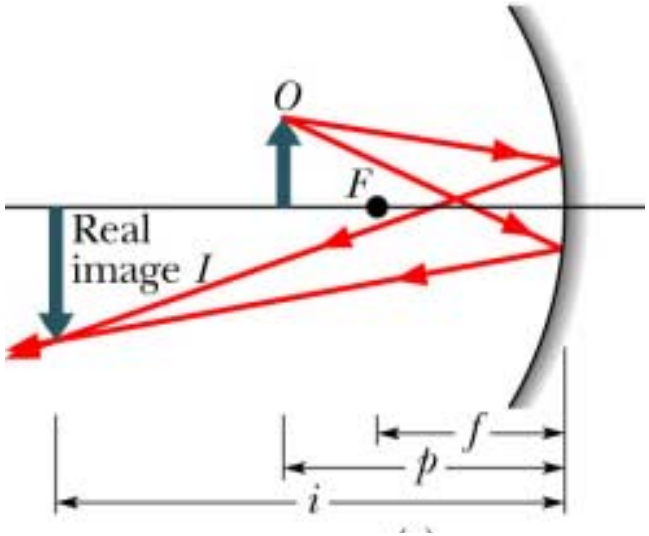
$$f = \tfrac{1}{2} r$$

- Find focal length, *f* from

$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$$

  - Object distance *p* is +
  - Image distance *i* is + for real images, - for virtual images
  - f is + for concave, - for convex





Review - mirrors

- Ratio of image's height h' to object's height h is called lateral magnification, m

$$|m| = \frac{h'}{h}$$

- Magnification also equal to

$$m = -\frac{i}{p}$$

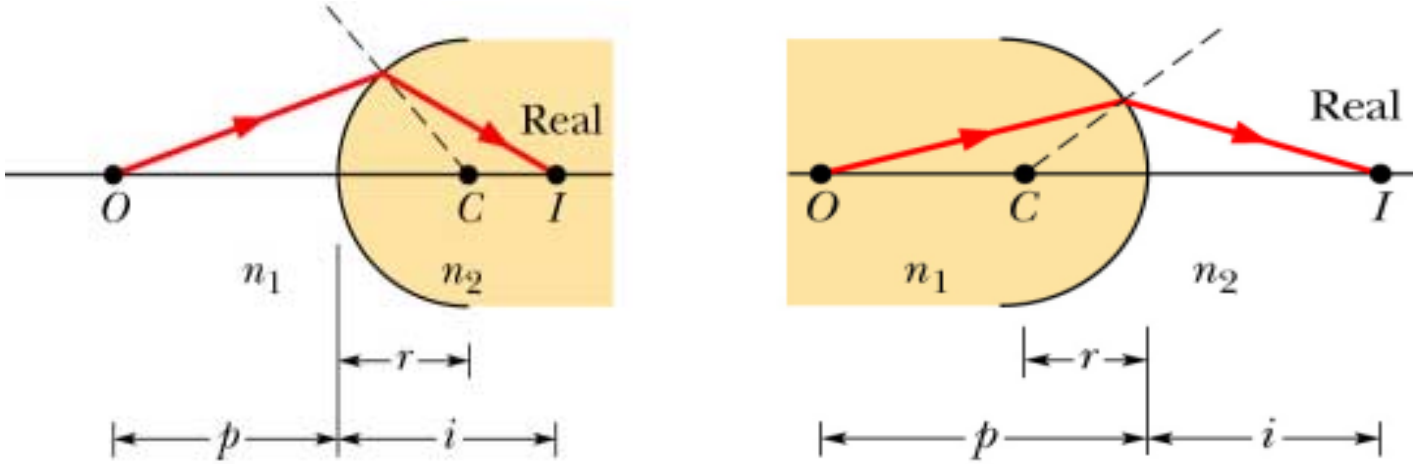
- m is + if image has same orientation as object
- m is – if image is inverted from object
- Plane mirror $m = +1$

Review - mirrors

Mirror Type	Object Location	Image Location	Image Size	Image Type	Image Orient-ation	Sign of *f*	Sign of *i*	Sign of *m*
Plane	Anywhere	i = **-** p	Equal	Virtual	Same	∞	**-**	**+1**
Concave	p < f	Anywhere	Bigger	Virtual	Same	**+**	**-**	**+**
Concave	f < p < 2f	i > 2f	Bigger	Real	Invert	**+**	**+**	**-**
Concave	p = 2f	i = 2f	Equal	Real	Invert	**+**	**+**	**-**
Concave	p > 2f	2f > i > f	Smaller	Real	Invert	**+**	**+**	**-**
Convex	Anywhere	|i| < |f|	Smaller	Virtual	Same	**-**	**-**	**+**

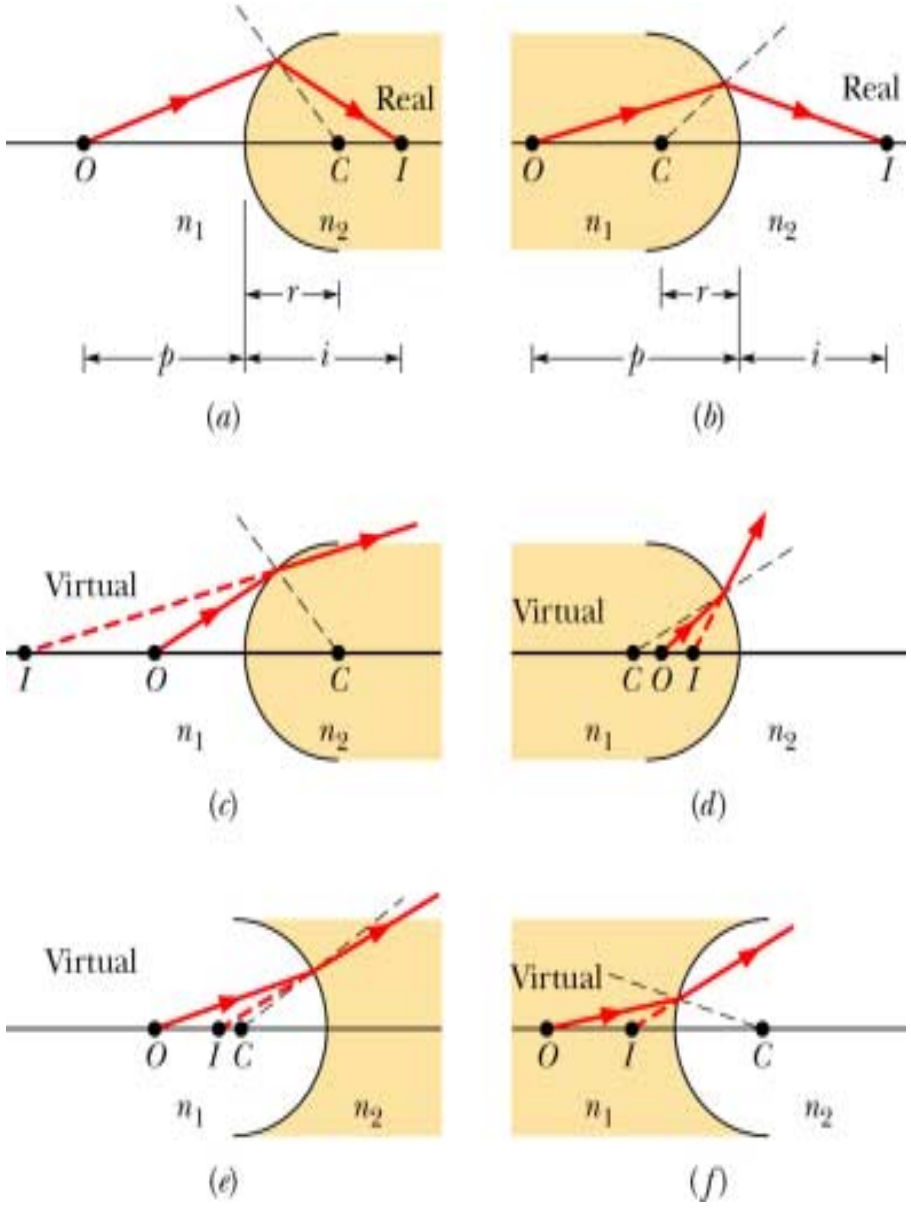
Refracting surfaces (Fig. 35-10)

- Images can be formed by refraction through transparent material
- Object O on left in medium with n_1
- Normal to refracting surface is radial line through center of curvature C
  - Ray bends toward normal if $n_2 > n_1$
  - Ray bends away from normal if $n_2 < n_1$



Refracting surfaces (Fig. 35-10)

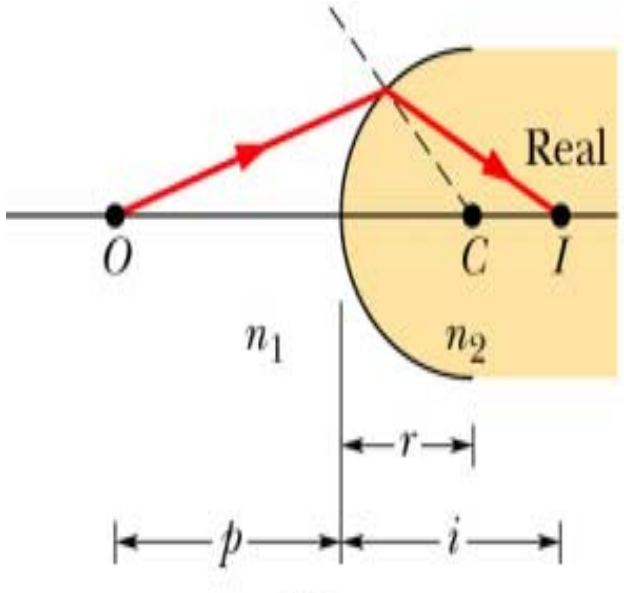
- Real images – when refraction directs ray towards central axis
- Virtual images – when refraction directs ray away from central axis
- Real images on side of refracting surface that is opposite the object, virtual images on same side as object



Refracting surfaces (Fig. 35-10)

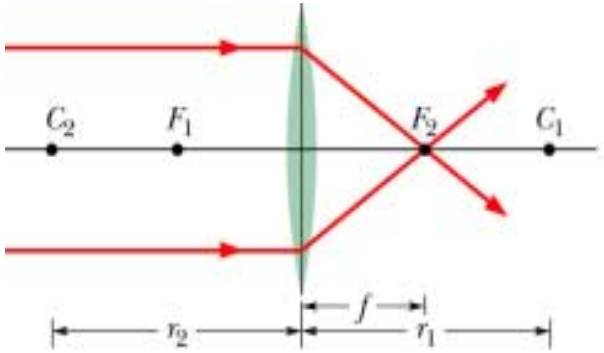
- Relation for radius of curvature of refracting surface
- Object is in medium of n_1
- Object distance p is +
- Image distance i is + for real image, - for virtual image
- If object faces convex refracting surface radius r is +, faces concave surface r is –
  - Reverse of sign convention for mirrors

$$\frac{n_1}{p} + \frac{n_2}{i} = \frac{n_2 - n_1}{r}$$

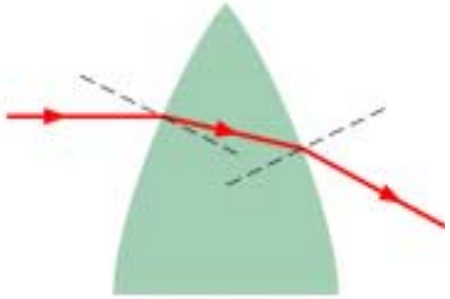


Thin Lenses (Figs 35-12)

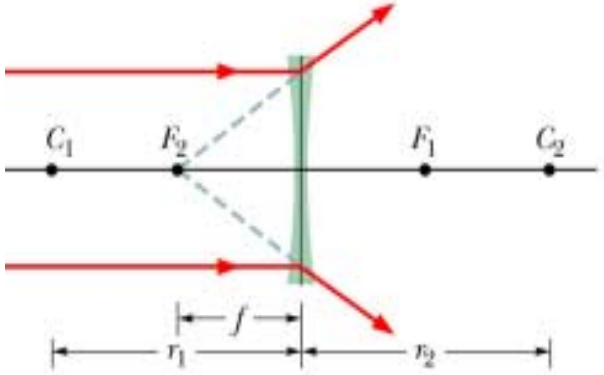
- Light rays bent by refraction form an image
- Converging – lens with convex refracting sides
- Diverging – lens with concave sides



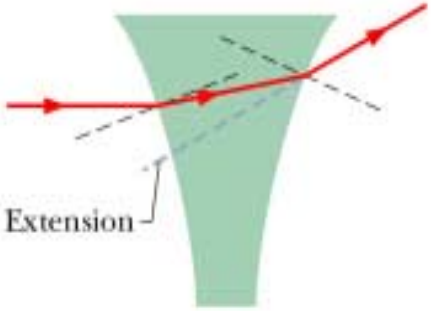
(a)



(b)



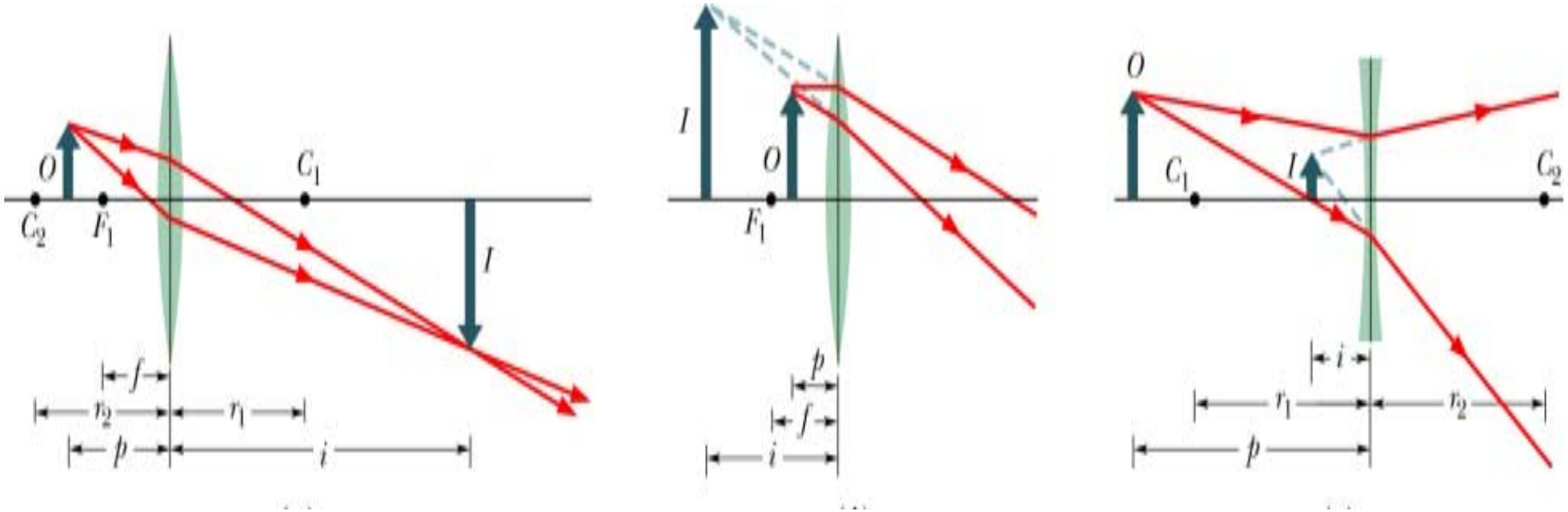
(c)



(d)

Thin lenses images (Figs 35-13)

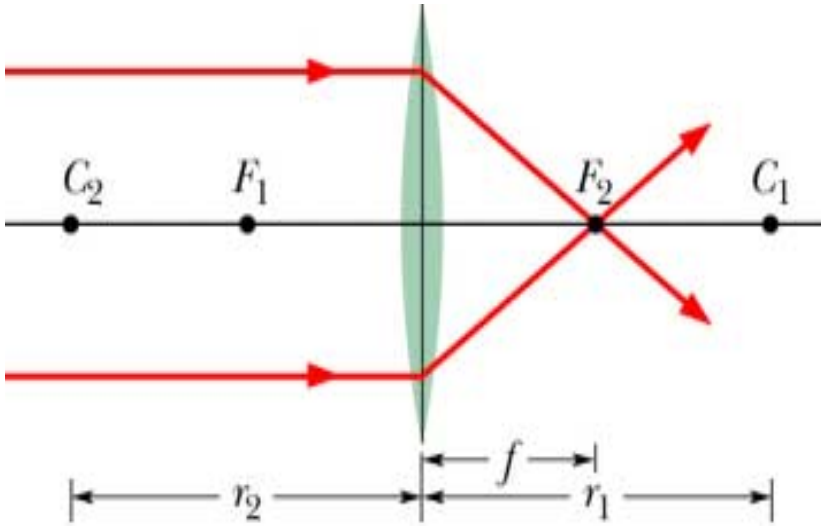
- Real images form on opposite side of lens from object, virtual images on same side
- Diverging lens only produces smaller, same orientation, virtual images (like convex mirror)
- Converging lens (like concave mirror) can produce both real and virtual images depending on where the object is in relation to the lens' focal point



Thin lenses images (Figs 35-12)

- Thin lenses have a focal point on each side of lens
- Focal length, f same as mirror

$$\frac{1}{p}+\frac{1}{i}=\frac{1}{f}$$



- Lens maker's equation – for lens in air, r_1 is radius of lens surface nearest the object, r_2 is other surface
  - r is + for convex surface, - for concave surface

$$\frac{1}{f}=(n-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$$

Thin lenses images (Figs 35-15)

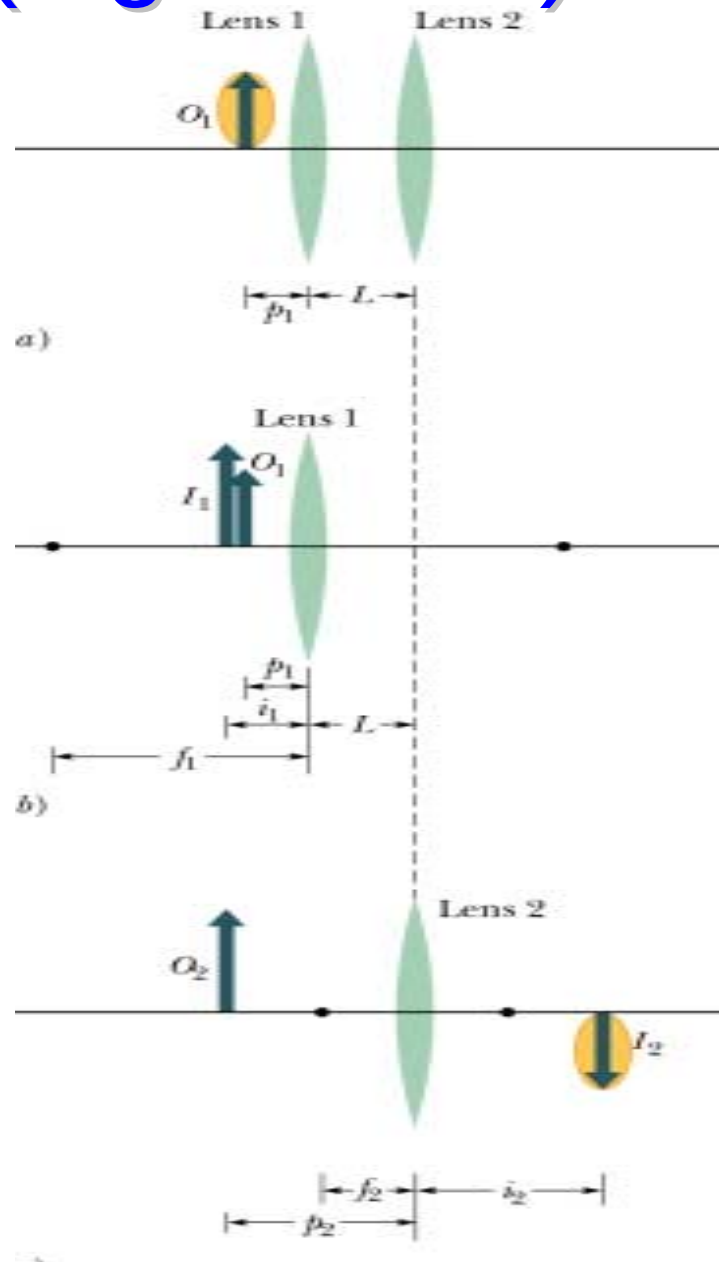
- Lateral magnification m same as for mirror

$$m = -\frac{i}{p}$$

- For a system of lenses or mirrors the total magnification M is product of each m

$$M = m_1 m_2 m_3 \ldots$$

- Work through system of lenses one by one – use image from one lens as object for next lens



Thin Lenses

Converging lens = concave mirror

Diverging lens = convex mirror

Thin Lens Type	Object Location	Image Location	Image Size	Image Type	Image Orient-ation	Sign of *f*	Sign of *i*	Sign of *m*
Converging	p < f	Anywhere	Bigger	Virtual	Same	+	-	+
Converging	f < p < 2f	i > 2f	Bigger	Real	Invert	+	+	-
Converging	p = 2f	i = 2f	Equal	Real	Invert	+	+	-
Converging	p > 2f	2f > i > f	Smaller	Real	Invert	+	+	-
Diverging	Anywhere	|i| < |f|	Smaller	Virtual	Same	-	-	+

Human Eye

- Has a converging lens which makes real, inverted images at the retina
- Near point is the closest distance which our lens can focus light on the retina
  - Distance increases with age
  - Typically at age 10 is 18cm, at 20 is 25cm, at 40 is 50cm, at 60 is 500cm or more
  - For problems will use 25cm for human eye
- Nearsighted – correct with a diverging lens
- Farsighted – correct with converging lens