

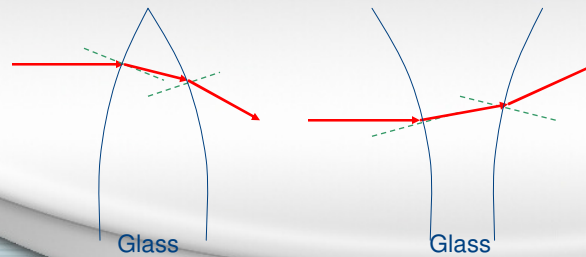
Curved Lens Characteristics and Equations

Objectives

- Describe characteristics of images formed from lenses
- Draw accurate scale diagrams for converging and diverging lenses
- Relate object distance and image distance to focal length, using the lens equation for converging and diverging lenses
- Apply the magnification equation to lenses

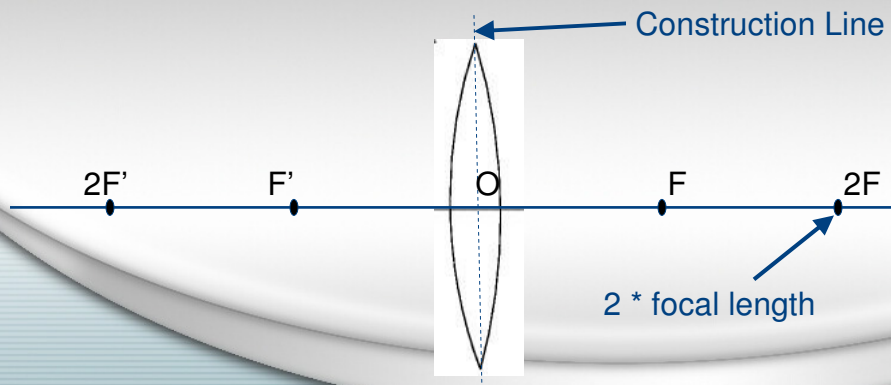
Drawing Lens Ray Diagrams

- Recall how rays of light travel through lenses?



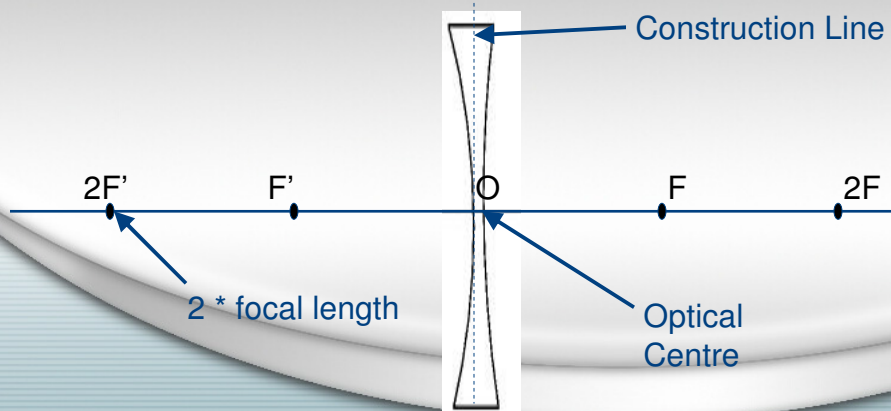
Drawing Lens Ray Diagrams

- Lets simplify the ray diagram



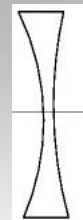
Drawing Lens Ray Diagrams

- Diverging lenses are the same



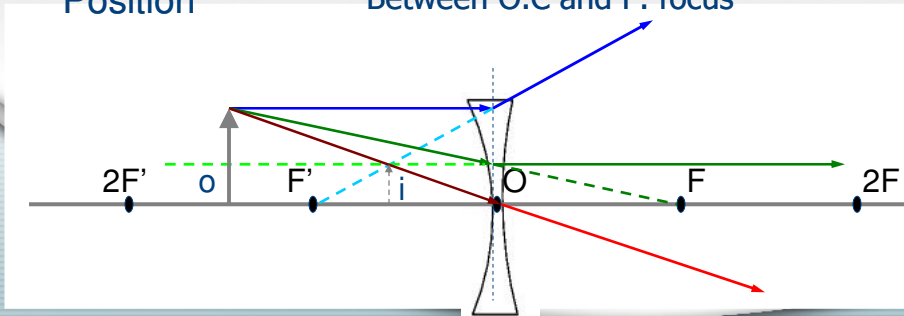
Diverging Lens Images

- What is the definition of a Diverging Lens?
- Where have we seen diverging lenses?



Diverging Lens Image Characteristics

Size Smaller
 Up/Down Erect
 Type Virtual
 Position Between O.C and P. focus

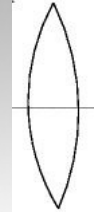


Lens Image Characteristics

#	Object Location	Size	Up/Down	Type	Image Location
<i>Diverging Lens</i>					
	Anywhere	Smaller	Erect	Virtual	Between OC & F

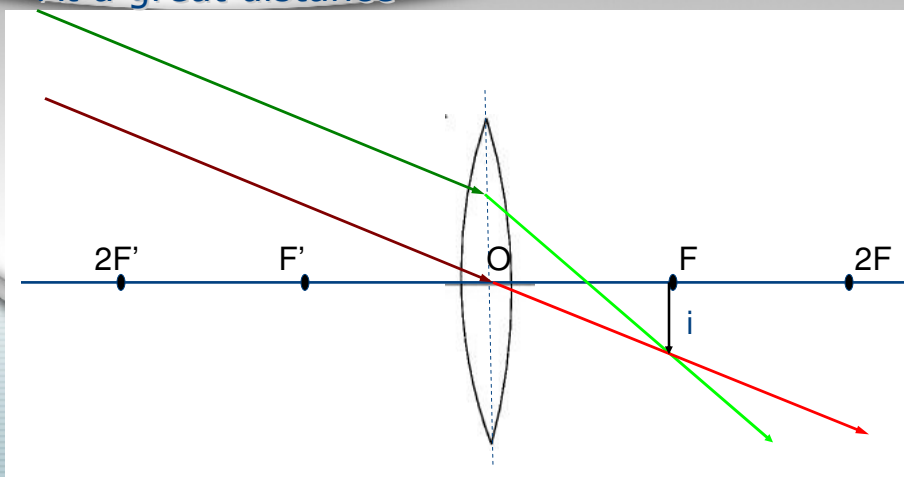
Converging Lens Images

- What is the definition of a Converging Lens?
- Not nearly so simple as diverging lenses
- Number of different conditions (6)
- Start far away from lens and work our way closer



Converging Lens Images

At a great distance

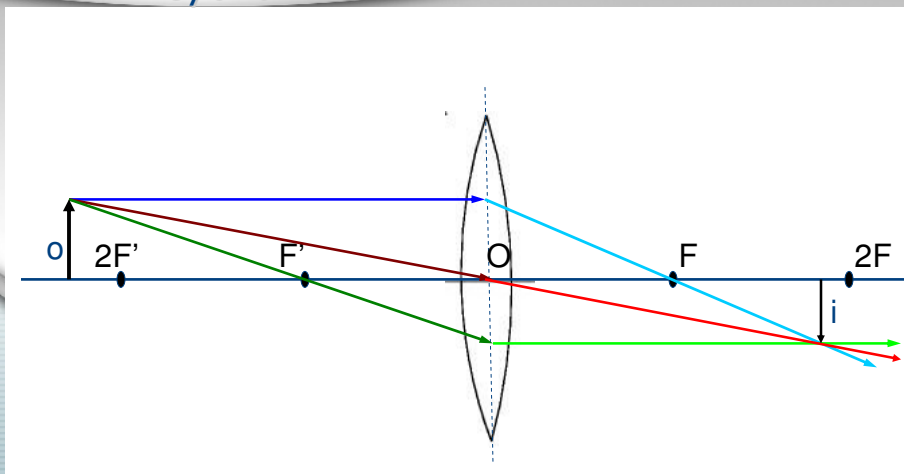


Lens Image Characteristics

#	Object Location	Size	Up/Down	Type	Image Location
<i>Diverging Lens</i>					
	Anywhere	Smaller	Erect	Virtual	Between OC & F
<i>Converging Lens</i>					
	At great distance	Smaller	Inverted	Real	At F

Converging Lens Images

#1 - Beyond $2F'$

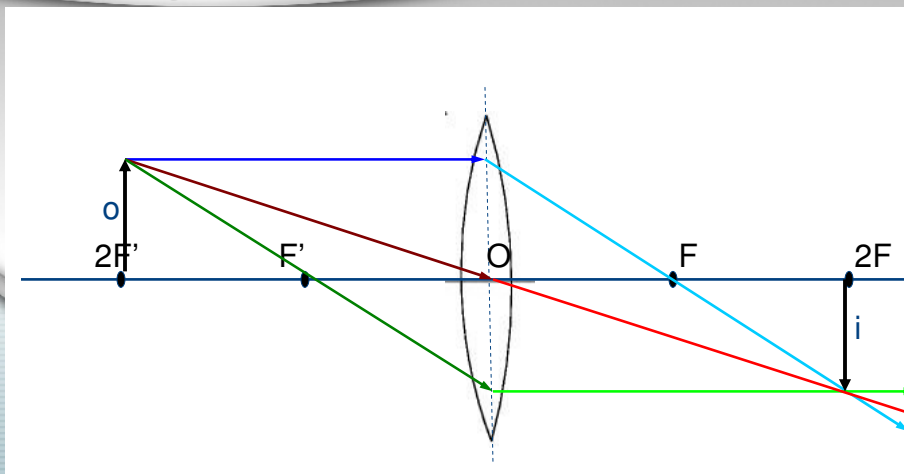


Lens Image Characteristics

#	Object Location	Size	Up/Down	Type	Image Location
<i>Diverging Lens</i>					
	Anywhere	Smaller	Erect	Virtual	Between OC & F
<i>Converging Lens</i>					
	At great distance	Smaller	Inverted	Real	At F
1	Beyond $2F'$	Smaller	Inverted	Real	Between F & $2F$

Converging Lens Images

#2 - At $2F'$

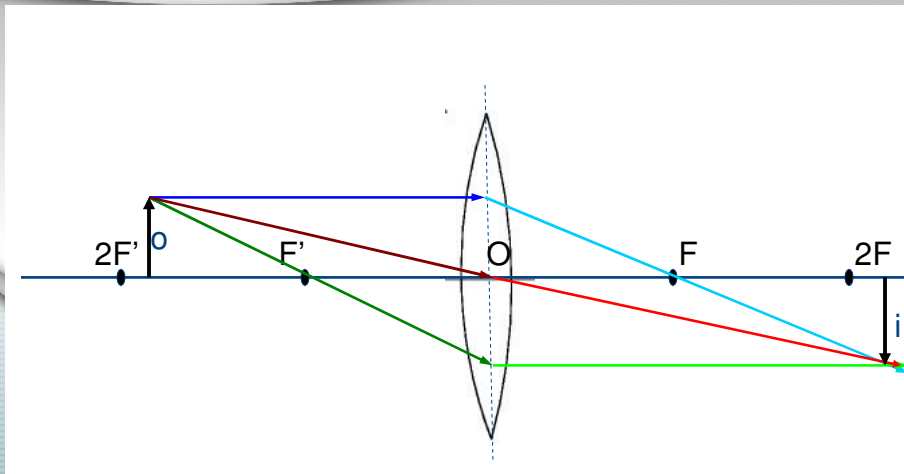


Lens Image Characteristics

#	Object Location	Size	Up/Down	Type	Image Location
<i>Diverging Lens</i>					
	Anywhere	Smaller	Erect	Virtual	Between OC & F
<i>Converging Lens</i>					
	At great distance	Smaller	Inverted	Real	At F
1	Beyond $2F'$	Smaller	Inverted	Real	Between F & $2F$
2	At $2F'$	Same	Inverted	Real	At $2F$

Converging Lens Images

#3 - Between F' & $2F'$

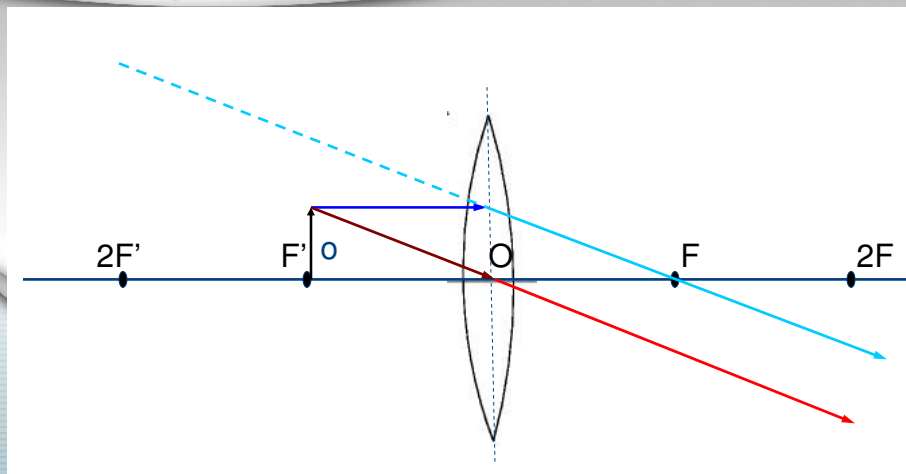


Lens Image Characteristics

#	Object Location	Size	Up/Down	Type	Image Location
<i>Diverging Lens</i>					
	Anywhere	Smaller	Erect	Virtual	Between OC & F
<i>Converging Lens</i>					
	At great distance	Smaller	Inverted	Real	At F
1	Beyond $2F'$	Smaller	Inverted	Real	Between F & $2F$
2	At $2F'$	Same	Inverted	Real	At $2F$
3	Between F' & $2F'$	Larger	Inverted	Real	Beyond $2F$

Converging Lens Images

#4 - At F

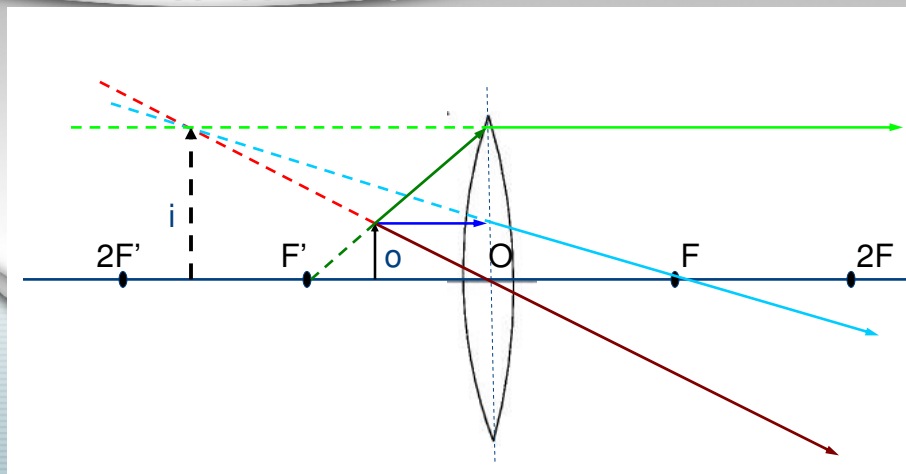


Lens Image Characteristics

#	Object Location	Size	Up/Down	Type	Image Location
<i>Diverging Lens</i>					
	Anywhere	Smaller	Erect	Virtual	Between OC & F
<i>Converging Lens</i>					
	At great distance	Smaller	Inverted	Real	At F
1	Beyond $2F'$	Smaller	Inverted	Real	Between F & $2F$
2	At $2F'$	Same	Inverted	Real	At $2F$
3	Between F' & $2F'$	Larger	Inverted	Real	Beyond $2F$
4	At F'			No Image Formed	

Converging Lens Images

#5 - Between OC & F'

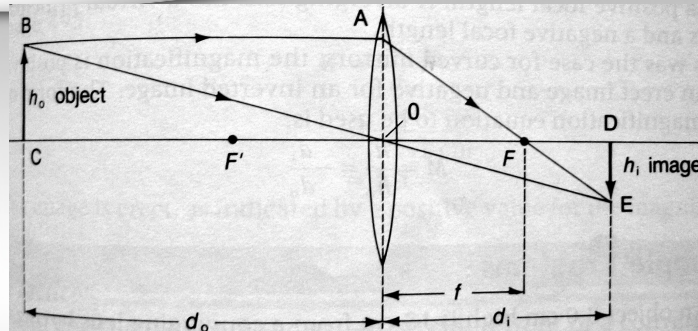


Lens Image Characteristics

#	Object Location	Size	Up/Down	Type	Image Location
<i>Diverging Lens</i>					
	Anywhere	Smaller	Erect	Virtual	Between OC & F
<i>Converging Lens</i>					
	At great distance	Smaller	Inverted	Real	At F
1	Beyond 2F'	Smaller	Inverted	Real	Between F & 2F
2	At 2F'	Same	Inverted	Real	At 2F
3	Between F' & 2F'	Larger	Inverted	Real	Beyond 2F
4	At F'	No Image Formed			
5	Between OC & F'	Larger	Erect	Virtual	Beyond F'

Curved Lens Equations

Magnification



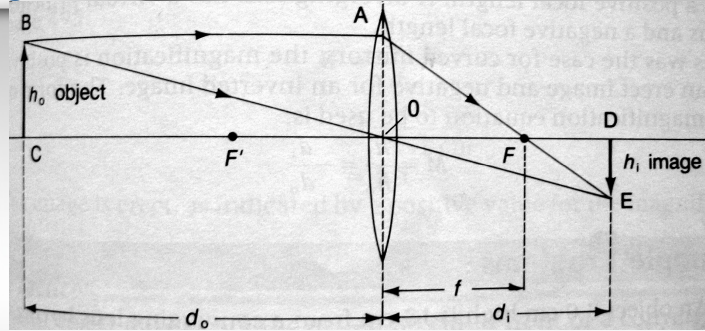
$$M = \frac{h_i}{h_o}$$

$$M = -\frac{d_i}{d_o}$$

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

Curved Lens Equations

Focal Length



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

$$C = 2F'$$

Curved Lens Equations

Sign Conventions:

- All distances are measured from the optical centre
 - Real distances are positive
 - Virtual distances are negative
- All heights are measured from the principal axis
 - Erect image heights are positive
 - Inverted image heights are negative

Practice Question

- Heath page 500 #5 (a-c)

Summary

- To locate a point on an image formed by a curved lens, at least two rays or their extensions must intersect
- For converging lenses:
 - Objects located beyond the focal length create images that are inverted/real
 - Objects located within the focal length create images that are larger/erect/virtual
- Diverging lenses create Smaller/Erect/Virtual images that are located between the optical centre and principal focus
- Sign Convention
 - Real distances, above principal axis: +ve
 - Virtual distances, below principal axis: -ve

Homework

- Heath: p.482 (#9, 13, 30, 32, 34, 36)
- Heath: p.511 #15, 18-21, 25, 27, 28

