Chapter 6 Summary

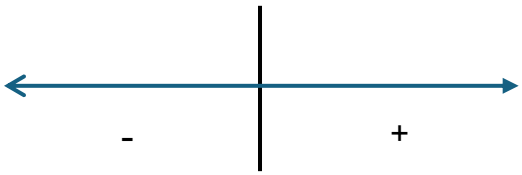
Thin Lenses
Definition
Lens Form (shape)
Power Formula
Primary & Secondary Focal Points & Lengths
Lateral Magnification & Image Size
Image-Object Relationship
Prismatic Effect of Lenses

Thin Lens Definition

A lens of uniform transparent material with two surfaces that are spherical or plane.
Surface Powers are a function of Radius & Index.
Total Power is the sum of the surface powers (F1 + F2).
For a thin lens: lens center thickness has negligible effect on lens power.

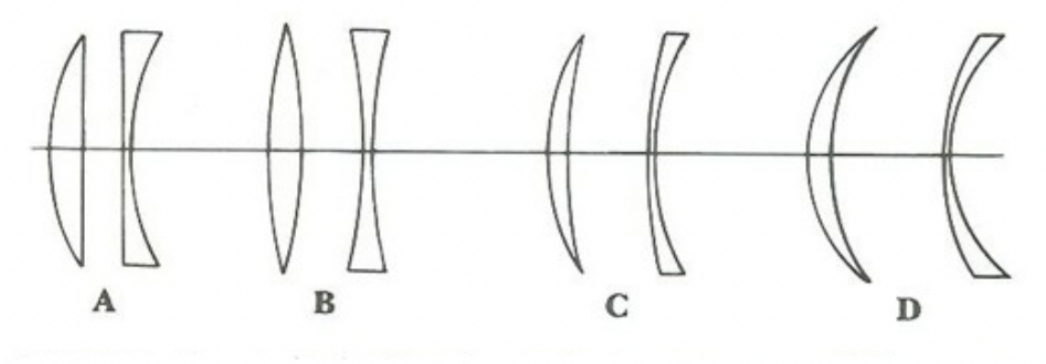
Lens Surface

Each surface has a center of curvature (C) and a radius of curvature (r).
Use sign convention for radius measurements:



Center of Curvature to the Left means negative radius of curvature.
Center of Curvature to the Right means positive radius of curvature.

Lens Form (shape)



Positive Lenses

A. Plano Convex
B. Biconvex
C. Positive Meniscus (periscopic)
D. Positive Meniscus (corrected curve)

Negative Lenses

A. Plano Concave
B. Biconcave
C. Negative Meniscus (periscopic)
D. Negative Meniscus (corrected curve)

Lens Power

Total Power = F1 + F2

F = (n' – n) / r for each surface

Example: what is power of a thin lens with a front surface radius of 50cm and a back surface radius of -20cm if the index of the lens is 1.50?

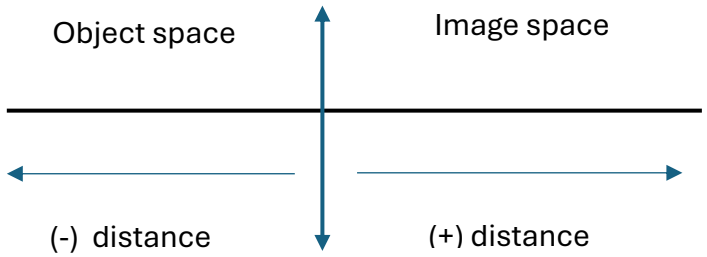
F1 = (1.50 -1.00) / 0.50 = +1.00D
F2 = (1.00 – 1.50) / -0.20 = +2.50D
F = F1 + F2
F = +1.00D + +2.50D = +3.50D

What is the form of this lens?
(Biconvex)

Optical (Optic) Axis

A line connecting the two radii of curvatures.
Some definitions:
Vertex: point where lens surface and optic axis intersect.
Chief Ray: ray that passes through center of lens without deviation.
Optical Center: point where chief ray intersects optic axis.
Geometric Center: physical center of the lens.

Review of Object & Image Space



Lens Power

$$F1 = \frac{n_L - n_S}{r_1} \qquad F2 = \frac{n_s - n_L}{r_2}$$

n_s = index of surrounding space
n_L = index of lens material

Primary & Secondary Focal Lengths

$$F = -\frac{n}{f} = \frac{n'}{f'} \qquad f' = -f \qquad f + f' = 0$$

Focal lengths have the same magnitude but opposite signs.
F and F' are on opposite sides of the lens.

Thin Lens Imaging

Positive Lens Image Object Relationship

Object Location	Object Type	Image Location	Image Type	Orientation	LM
$\ell = -\infty$	RO	$\ell' = f'$	RI	Inverted (-)	?
$-\infty < \ell < f$	RO	$\ell' > f'$	RI	Inverted (-)	?
$\ell = f$	RO	$\ell' = \infty$	RI	Inverted (-)	Mag
$f < \ell <$ surface	RO	$\infty < \ell' <$ surface	VI	Erect (+)	Mag
surface $< \ell < +\infty$	VO	surface $< \ell' < \ell$	RI	Erect (+)	Min

Negative Lens Image Object Relationship

Object Location	Object Type	Image Location	Image Type	Orientation	LM
$\ell = -\infty$	RO	$\ell' = f'$	VI	Erect (+)	Min
$-\infty < \ell <$ surface	RO	$\ell < \ell' <$ surface	VI	Erect (+)	Min
surface $< \ell < f$	VO	$\ell' > \ell$	RI	Erect (+)	Mag
$\ell = f$	vO	$\ell' = \infty$	RI	Erect (+)	Mag
$f < \ell < +\infty$	VO	$-\infty < \ell' <$ surface	VI	Inverted (+)	?

Lateral Magnification

$$LM = \frac{h'}{h}$$

$$LM = \frac{n\ell'}{n'\ell} = \frac{n_s\ell'}{n_s\ell} = \frac{\ell'}{\ell}$$

$$LM = -\frac{f}{x} = -\frac{x'}{f'}$$

Determining lateral magnification depends on what information has been provided.

Newtonian Formula for Thin Lenses

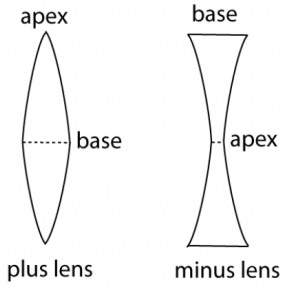
$$xx' = -(f')^2$$

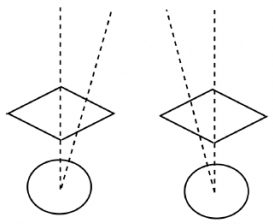
Prismatic Effects of Lenses

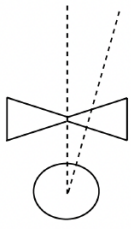
Prism power induced (deviation) depends on distance from center of the lens.

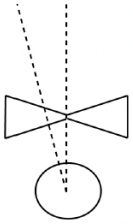
Prentice's Rule

Prism power (Δ) (Prism Diopters) = distance from OC (cm) x Lens Power (F)









Thin Lens Problem Solving

Math Problems

1 Determine the radius of a surface given its curvature (C).
2 Determine the surface power of a lens given the radius (r) and index.
3 Determine the lens power given two radii of curvature and index.
4 Determine index of lens given Power and radii.
5 Find primary and secondary focal points of a thin lens.
6 Find primary and secondary focal lengths of a thin lens.
7 Find image location given object location and lens power.
8 Find lateral magnification when object and image heights are attainable.
9 Find lateral magnification using object and image distances.
10 Determine extra focal lengths for a thin lens.
11 Apply Prentice's Rule to determine prism power at a point on a lens.

Concept Questions

1 Determine form of thin lens given radii.
2 Distinguish between optical axis and optical center.
3 Define the term vertex.
4 Describe the significance of primary or secondary focal points.
5 Define extra focal distance.
6 What type of prism is induced when a myope looks temporally from OC of lenses.
7 What type of prism is induced when a hyperope looks below OC of lenses.