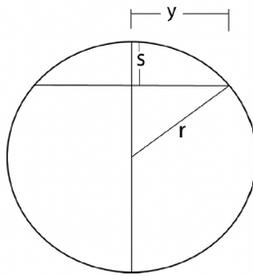


## Chapter 4: Single Refracting Surfaces

### Sagittal Depth & Radius of Curvature



Sagittal Depth (s)

### Approximate Sag Formula\*

$$s = \frac{y^2}{2r}$$

s = sagittal depth

y = ½ chord length

r = radius of curvature

\*use when s is very small compared to r

### Surface Power Calculation

$$F = \frac{n' - n}{r}$$

### Problems

Find sagittal depth given lens diameter and radius of curvature

Find center or edge thickness of a lens

Plano – convex lens

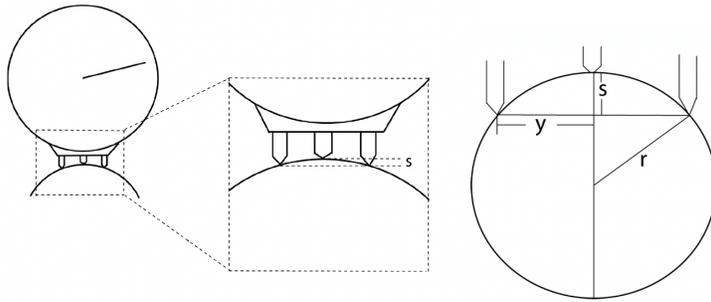
Plano – concave lens

Find surface power of a lens given index and radius

Find radius given surface power and index

Find index given surface power and radius

## Using a Lens Clock to Approximate Surface Power



Measuring  $s$  with Lens Clock

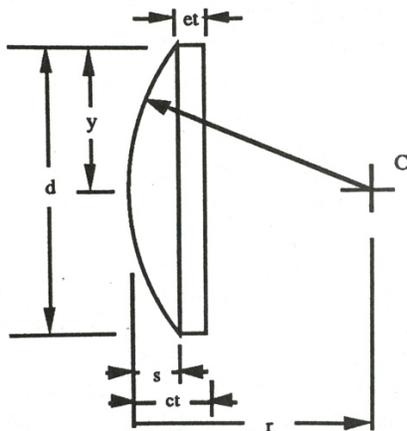
The lens clock can be used to measure surface power of a lens. The lens clock provides a direct measurement of sagittal depth. Lens clock is calibrated for an index of 1.53. For lenses with index other than 1.53, must convert clock power to true power.

$$F_{TRUE} = \frac{(n_{LENS} - 1)F_{CLOCK}}{0.53}$$

### Problems

Find the diameter of a ball using a lens clock.

Find surface power when lens clock is used on a surface where index is not 1.53.

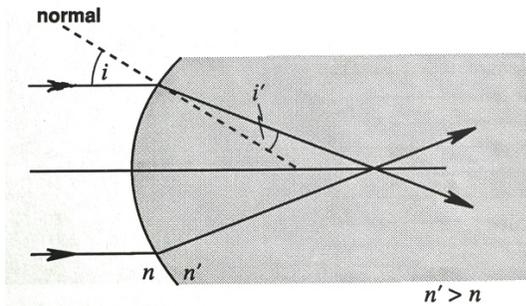


Loshin 1991

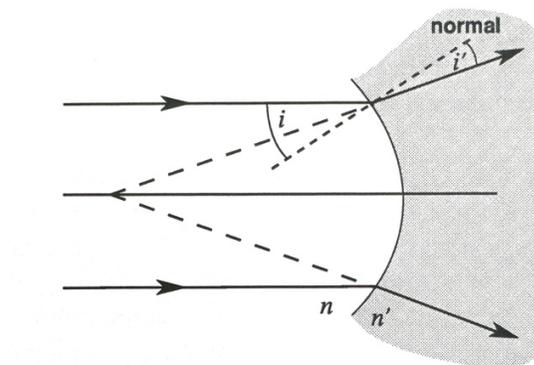
For a convex lens:  $ET + S = CT$

For a concave lens:  $CT + S = ET$

## Single Refracting Surfaces



Rays from an object at *infinity* create a real image



Rays from an object at *infinity* create a virtual image

## Object Types

### Real Object

- Formed to the right of the interface
- Divergent incident pencil
- Negative object distance
- L is negative

### Virtual Object

- Formed to the left of the interface
- Convergent incident pencil
- Positive object distance
- L is positive

$$F = L' - L$$

$$F = \frac{n' - n}{r} \quad L' = \frac{n'}{l'} \quad L = \frac{n}{l}$$

L = Incident Vergence

L' = Emergent Vergence

## Problems

Given object distance, radius, and index, find:

Surface power

Incident and emergent vergence

Image location

Type of image

## Focal Points of Single Refracting Surface

Secondary Focal Point (F')

When object is located at infinity

$$L = 0$$

Distance from surface to image is  $f'$  (secondary focal length)

$$l' = f' = \frac{n'}{L'} = \frac{n'}{F}$$

Primary Focal Point (F)

When object is at Primary Focal Point

Parallel emergent rays

Distance from surface to object is  $f$

$$l = f = \frac{n}{L} = -\frac{n}{F}$$

## Lateral Magnification

$$LM = \frac{\text{image size}}{\text{object size}} = \frac{h'}{h}$$

If LM is positive, image is erect

If LM is negative, image is inverted

## Extrafocal Distances

Object extrafocal distance ( $x$ ): distance from F to object

Image extrafocal distance ( $x'$ ): distance from F' to image

## Refractive Error

Myopia

Image of infinite object in front of the retina

Requires minus lens power to "correct"

Hyperopia

Image of infinite object behind the retina

Requires plus lens power to "correct"

Far Point

Point conjugate to the retina without accommodation (accommodation relaxed)

## Problems

Assume all lenses and interfaces are located in air

1. What is the refracting power of the surface of an interface with a center of rotation located 12.5cm to the right of the surface if the medium has an index of 1.58.
2. A convex-plano lens ( $n = 1.55$ ) with a front surface power of +5.00D has a diameter of 60mm. If the edge thickness of the lens is 1.5mm, what is the center thickness.
3. A 50mm plano-concave lens has a back surface power of -4.25D. If the edge thickness is 4.5mm and the radius of curvature is 12.5cm, what is the center thickness of the lens.
4. You measure a front surface power of +5.14D on lens made from CR-39 plastic ( $n = 1.49$ ). If the lens clock used is calibrated for 1.53, what is the actual power of the lens.
5. Where is the image formed when a pencil of light from an object located 50cm in front of a glass rod passes through the +8.00D surface of the rod ( $n = 1.53$ ).
6. Where is the primary focal point in problem 5.
7. Where is the secondary focal point in problem 5.
8. If a 2cm object is placed 20cm in front of a +10.00D SRS that separates air from a medium with an index of 1.55, how large is the image.
9. What is the lateral magnification in problem 8.
10. Where is the far point of an uncorrected -5.00D myope located.

## Answers

1. +4.64D
2. 5.6mm
3. 2.0mm
4. +4.75D
5. 25.5cm (behind the curved surface)
6. -12.5cm (in front of curved surface)
7. 19.1cm (behind the curved surface)
8. -3.1cm (inverted)
9. 1.55x
10. 20cm in front of the eye