FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: Physics 2C 3/10

NAME:

DATE: REVISION DATE:

① Lens makers Eq.
② Cameras
③ Human Vision : 2 problems

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② Cameras

f : focal length
D : apeture size / diameter

"Apeture" → ① apeture diameter D
"Apeture" → ② (f-number) = $\frac{f}{D}$

Facts:

"zoom" m ∝ f

exposure ("brightness") ∝ $\frac{D^2}{f^2} = \frac{1}{(\text{f-number})^2}$

Suppose a camera's exposure is correct when the lens has a focal length of 8.0 mm. Will the picture be overexposed or underexposed or still correct if the focal length is "zoomed" to 16.0 mm without changing the aperture or shutter speed?

"D" hole size

Δt

(A) Overexposed (too bright)
(B) Underexposed (too dark)
(C) Still correct

$$I \propto \frac{D^2}{f^2}$$

To fix the exposure, what could we do to either the aperture diameter D or the shutter time Δt?

(A) Increase D and/or increase Δt
(B) Increase D and/or decrease Δt
(C) Decrease D and/or increase Δt
(D) Decrease D and/or decrease Δt

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Lensmakers

Converging (wider in center)

(Double) - convex

Plano - Convex

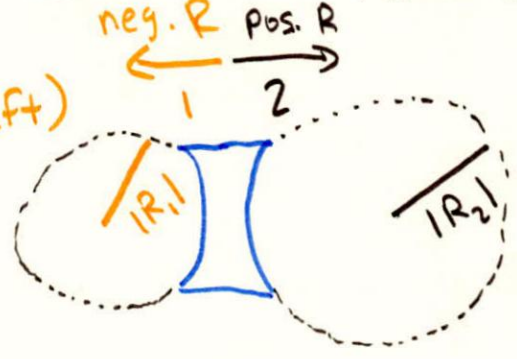
Convex - Meniscus

Diverging (narrower in center)

(Double) - Concave

Plano - Concave

Concave - Meniscus



1: left
2: right

side 2 (right)

for this example,
$R_1 < 0$
$R_2 > 0$

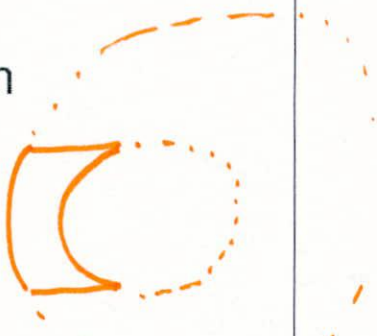
Lensmakers Eq.

$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

A meniscus lens, made of glass with n=1.5, is overall diverging. The radii of curvature have magnitudes 50 cm and 25 cm. What is the focal length of this lens?

(A) -400 cm < f < -200 cm
(B) -200 cm < f < 0 cm
(C) 0 cm < f < 200 cm
(D) 200 cm < f < 400 cm

$R_1 = -25\,cm$
$R_2 = -50\,cm$



$R_1 = +50\,cm$
$R_2 = +25\,cm$

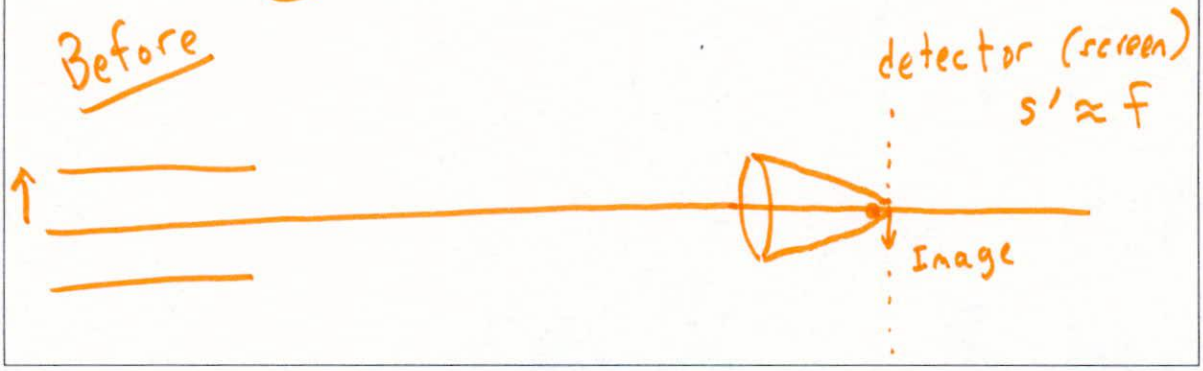
$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

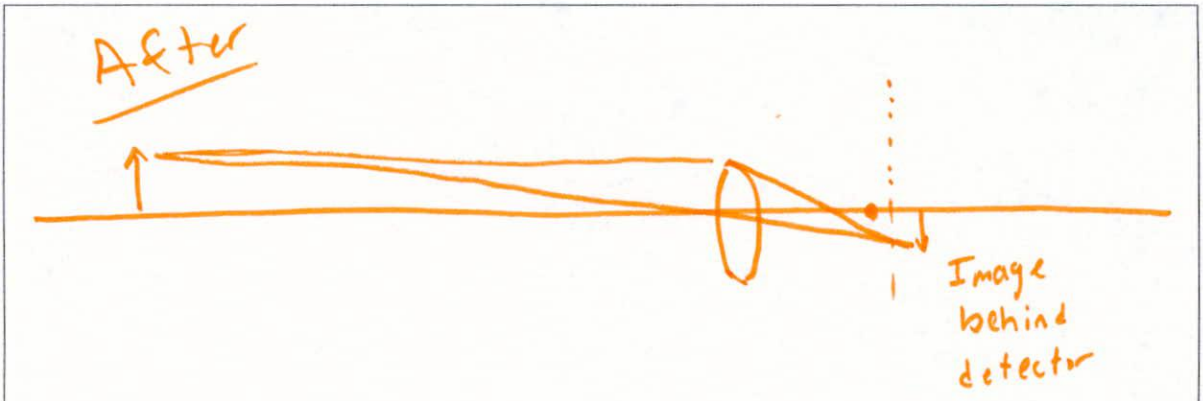
$$\frac{1}{f_1} = 0.5\left(\frac{1}{-25\,cm} + \frac{1}{50\,cm}\right) = -\frac{1}{100\,cm}$$

$$f_1 = -100\,cm$$

A photographer focuses their camera on an object. Suppose the object moves closer to the camera. To refocus, should the camera lens move closer to or farther from the detector?

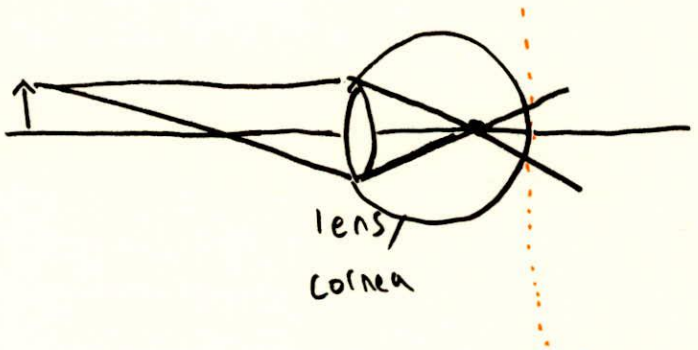
(A) Closer to the detector
(B) Farther from the detector





③ Human Vision: 2 problems

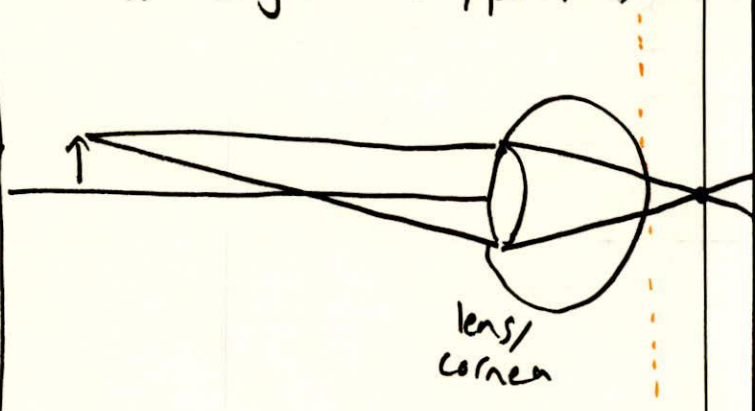
Near-sighted (myopia)



- focus before retina
- Need diverging lens to "spread out" light

"Presbyopia": age-related

Far-sighted (hyperopia)



- focus after the retina
- Need converging lens

- People with good vision can see any object between

$s = \infty$ and $s = 25\,cm$

far point — near point

(far point) $< \infty$ (myopic)

(near point) $> 25\,cm$ (hyperopic)

Goal: Take an obj. @ ∞ and have its image be at far point.

Goal: See Clicker

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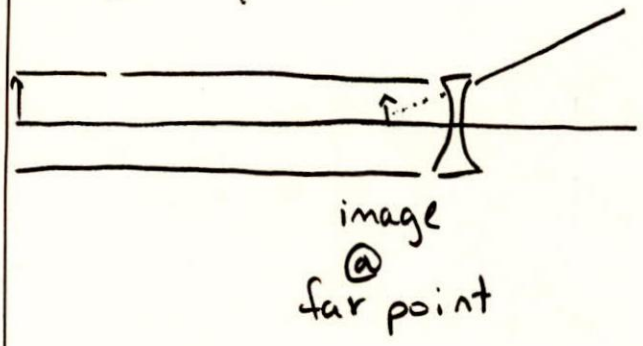
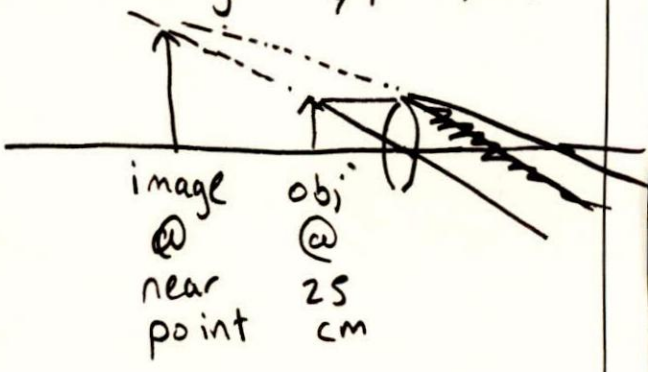
correcting myopia



correcting hyperopia



Lens: Power $P = \frac{1}{f}$ SI units Diopter (D)

$1\,D = \frac{1}{1\,m}$

eg. I have contact prescription $-4.00\,D$

$\Rightarrow f = \frac{1}{-4.00\,D} = -0.25\,m$

What is my far point?

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} = \frac{1}{-0.25\,m}$

Take obj @ $s = \infty$ and place image @ far point

solve for $\boxed{s' = -0.25\,m}$

hyperopia / presbyopia

Grandma's near point is at 100 cm. She buys glasses so that she can take an object _____ and instead have its image at _____.

(A) At infinity, 25 cm
(B) At her near point, 25 cm
(C) At 25 cm, infinity
(D) At 25 cm, her near point

near point: 100 cm
(Note signs!)
is this converging or diverging?

Which of the following is the best option for Grandma?

Take obj. @ 25 cm
and creat img @ FP: 100 cm

(A) +1.50 D
(B) +2.00 D
(C) +2.50 D
(D) +3.00 D

$\frac{1}{s} + \frac{1}{s'} = \boxed{\frac{1}{f}}$ Diopters

$\frac{1}{25\text{cm}} - \frac{1}{100\text{cm}} = \frac{4-1}{100\text{cm}} = \frac{3}{100\text{cm}}$

$= \boxed{+3.00\ \text{D}}$

STOP TO THINK 35.3 You need to improvise a magnifying glass to read some very tiny print. Should you borrow the eyeglasses from your hyperopic friend or from your myopic friend?

far-sighted

near-sighted

a. The hyperopic friend
b. The myopic friend
c. Either will do.
d. Neither will work.

for vertical

for horizontal

A certain eyeglass lens is thin at its center, even thinner at its top and bottom edges, and relatively thick at its left and right edges. What defects of vision is this lens intended to correct?

(A) hyperopia for objects oriented both vertically and horizontally
(B) myopia for objects oriented both vertically and horizontally
(C) hyperopia for objects oriented vertically and myopia for objects oriented horizontally
(D) hyperopia for objects oriented horizontally and myopia for objects oriented vertically