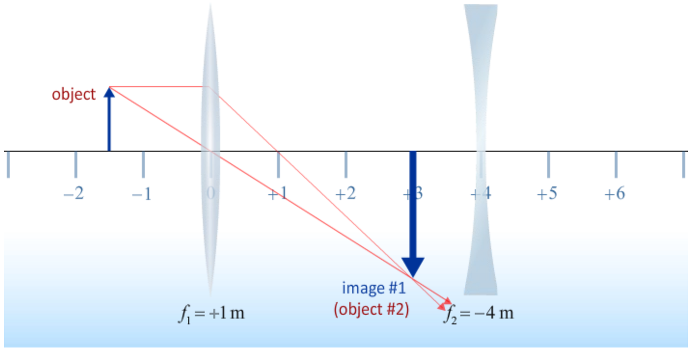
Physics 212
Lecture 28

Today's Concept:

A) Optical Devices



Your Comments

Hey! What would be the format of the final exam? Would it have an equal amount of stuff from each midterm and approximately how many questions would be on it? Thanks!

There's no time to be doing prelectures and checkpoints when you have your physics exam and a presentation in sign language you have no idea how to do (still) and then a math test at 8 in the morning the next day! Sorry. (>_<)

This whole prelectures due after an exam thing needs to stop...

Pep talk for the exam: Success is not measured by taking your achievements and weighing them against your setbacks. It is determined how many of your setbacks you turn into achievements. Study what you don't understand and feel confident in topics you do understand. PHYS 212 SP 13!!!!!!!!

We need to get eye of the tiger on to prep for this final exam!!! EYEEE OF THE TIIGEERR!

Could you talk about contact lenses? Are there contacts for both nearsighted and farsightedness?

Just take a step back...I mean this is so cool. Albeit slightly confusing, but dang lenses are so powerful. I'm really fortunate not to need glasses, so I miss out on the extra lens, but the eye...ITS LIKE MAGIC!

End of Semester Logistics

- Check your grade book scores
  - If anything is not correct email appropriate person

- Remaining Assignments
  - Prelecture 29 (Optional video of Tim solving problems)
  - CheckPoint 29 (Required: Survey please complete)
  - Homework (Mirrors)
- Final Exam
  - 50 questions uniformly distributed over semester
  - Conflict is Friday May 3rd 7:00 PM
  - Combined is Monday May 6th 1:30 PM

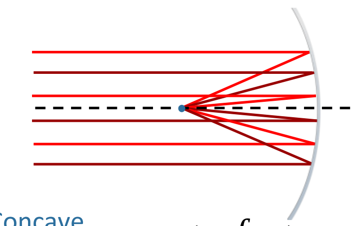
Executive Summary - Mirrors & Lenses:

$S > 2f$ — real, inverted, smaller

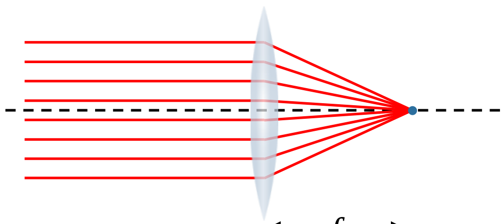
$2f > S > f$ — real, inverted, bigger

$f > S > 0$ — virtual, upright, bigger

$f > 0$



Concave (Converging) $\leftarrow f \rightarrow$

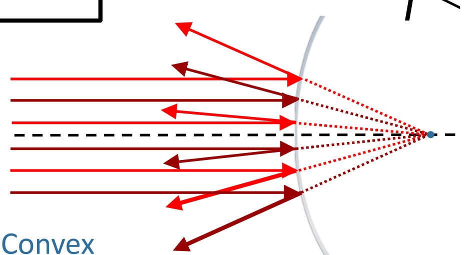


Converging $\leftarrow f \rightarrow$

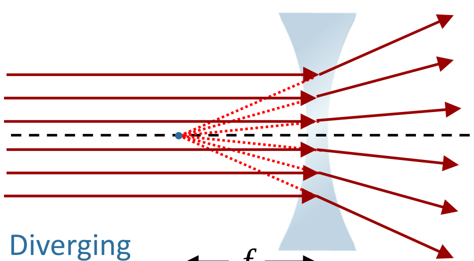
$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f} \qquad M = -\frac{S'}{S}$$

$S > 0$ — virtual, upright, smaller

$f < 0$



Convex (diverging) $\leftarrow f \rightarrow$



Diverging $\leftarrow f \rightarrow$

It's Always the Same:

$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f} \qquad M = -\frac{S'}{S}$$

You just have to keep the signs straight:

s' is positive for a real image

f is positive when it can produce a real image

Lens sign conventions

S: positive if object is "upstream" of lens

S' : positive if image is "downstream" of lens

f: positive if converging lens

Mirrors sign conventions

S: positive if object is "upstream" of mirror

S': positive if image is "upstream" of mirror

f: positive if converging mirror (concave)

System of Lenses

Trace rays through lenses, beginning with most upstream lens

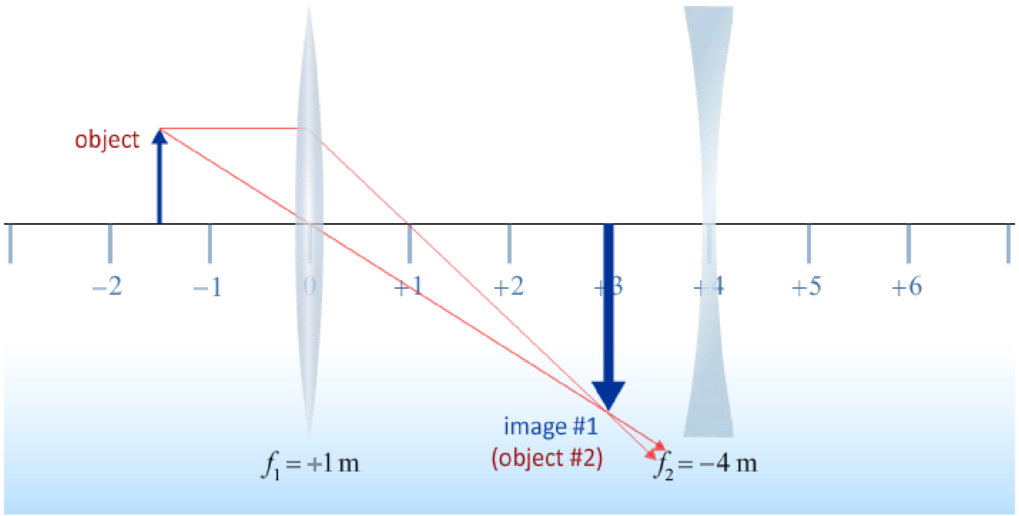
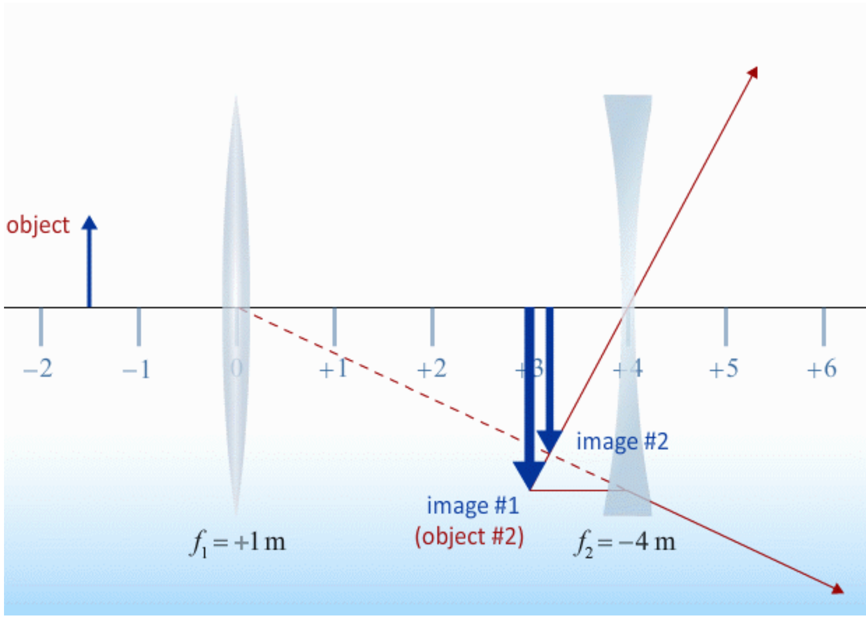
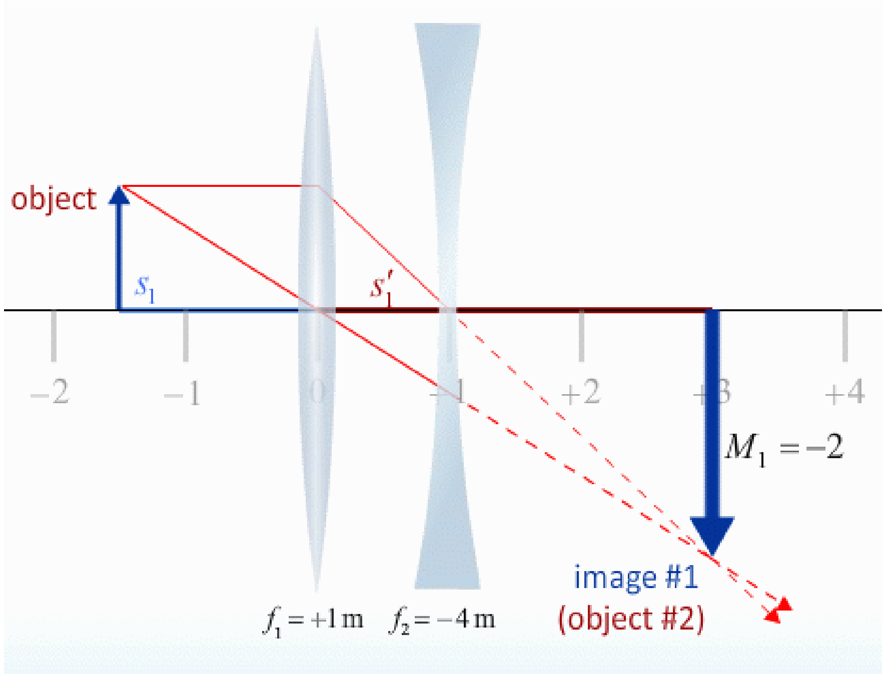


Image from first lens
Becomes object for second lens



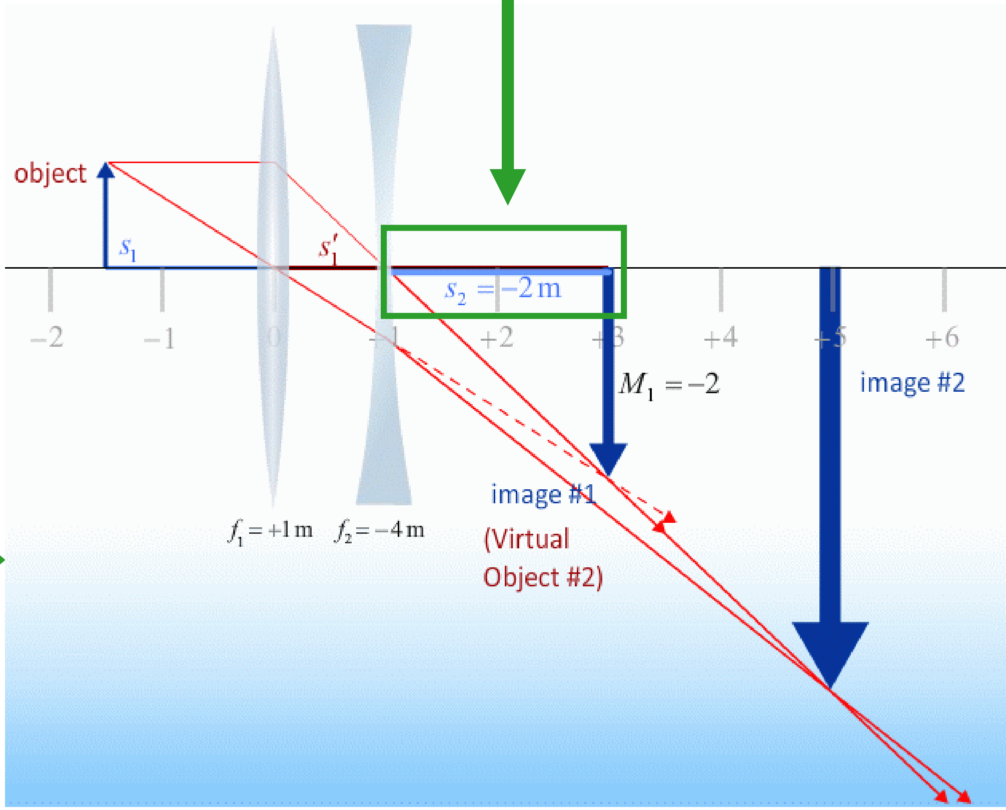
System of Lenses

Virtual Objects are Possible !!

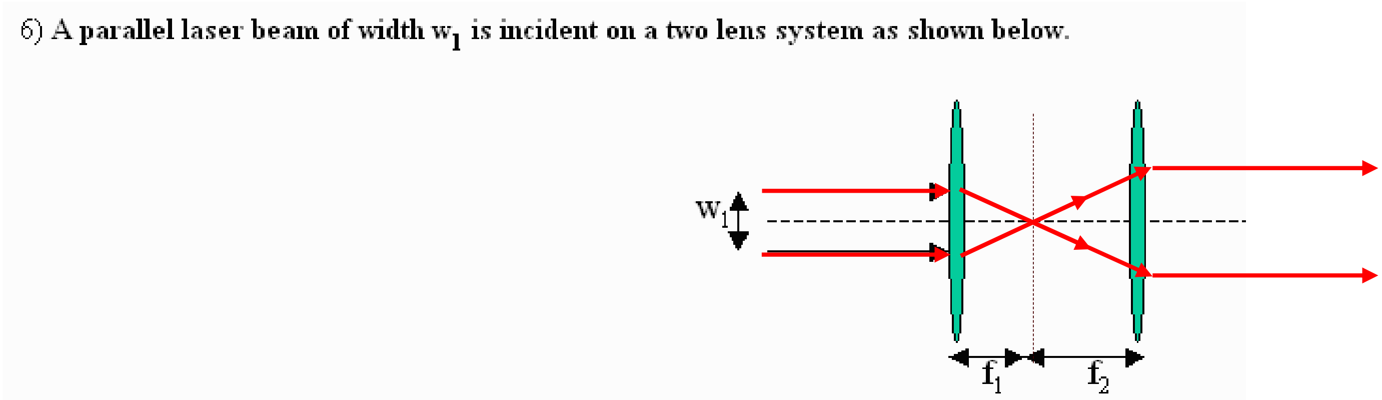


Object Distance is Negative!

Image from first lens
Becomes object for second lens



CheckPoint 3



Each lens is converging. The second lens has a larger focal length than the first ($f_2 > f_1$). What does the beam look like when it emerges from the second lens?

A. The beam is converging

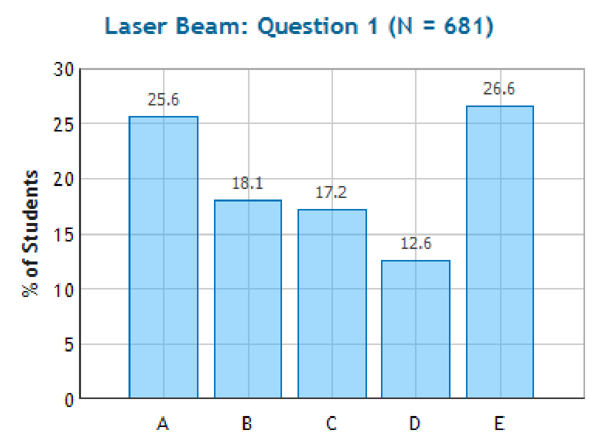
B. The beam is diverging

C. The beam is parallel to the axis with a width < w_1

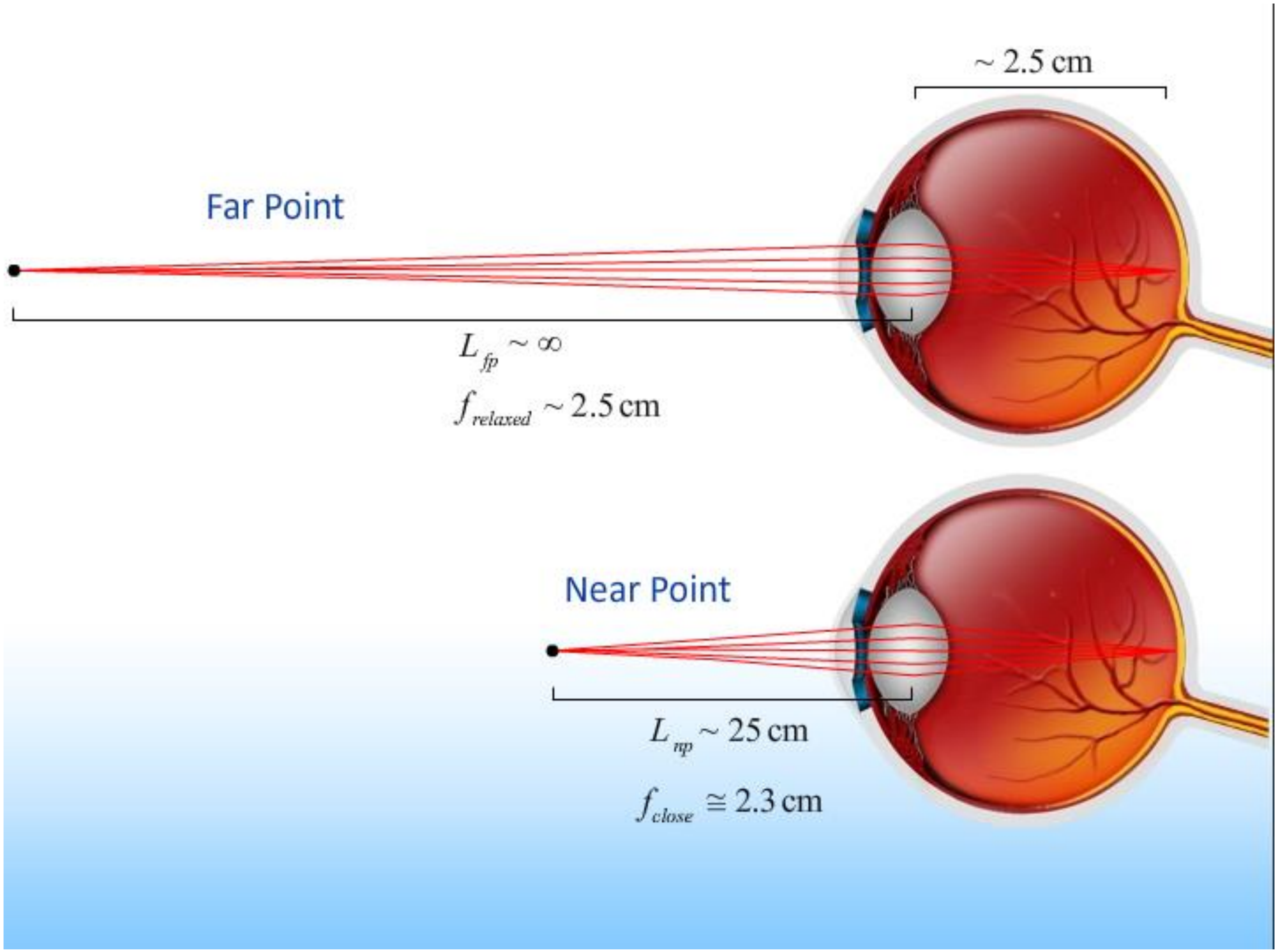
D. The beam is parallel to the axis with a width = w_1

E. The beam is parallel to the axis with a width > w_1

1. Parallel rays are transmitted and pass through focal point (f_1)
2. Those rays also pass through focal point of second lens (f_2) and therefore are transmitted parallel to the axis.
3. $f_2 > f_1$ implies that the width $> w_1$



Normal Eye

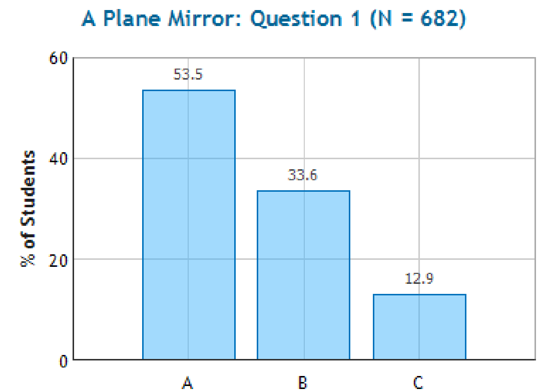


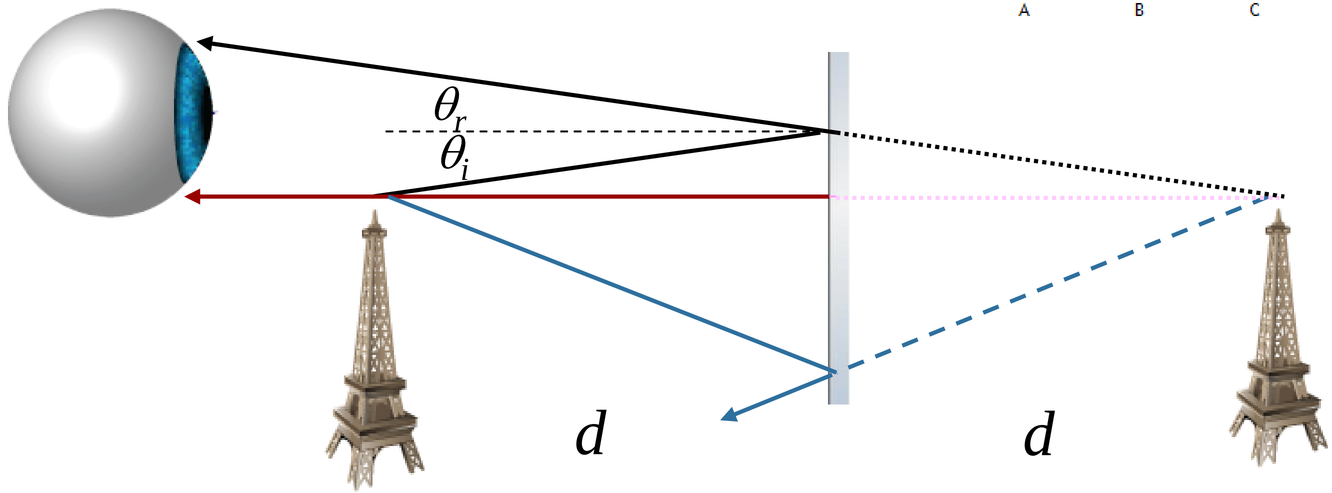
~ 2.5 cm
Far Point
$L_{fp} \sim \infty$
$f_{relaxed} \sim 2.5\,\text{cm}$
Near Point
$L_{np} \sim 25\,\text{cm}$
$f_{close} \cong 2.3\,\text{cm}$

CheckPoint 2

A person with normal vision (near point 28 cm) is standing in front of a plane mirror. What is the closest distance to the mirror the person can stand and still see herself in focus?

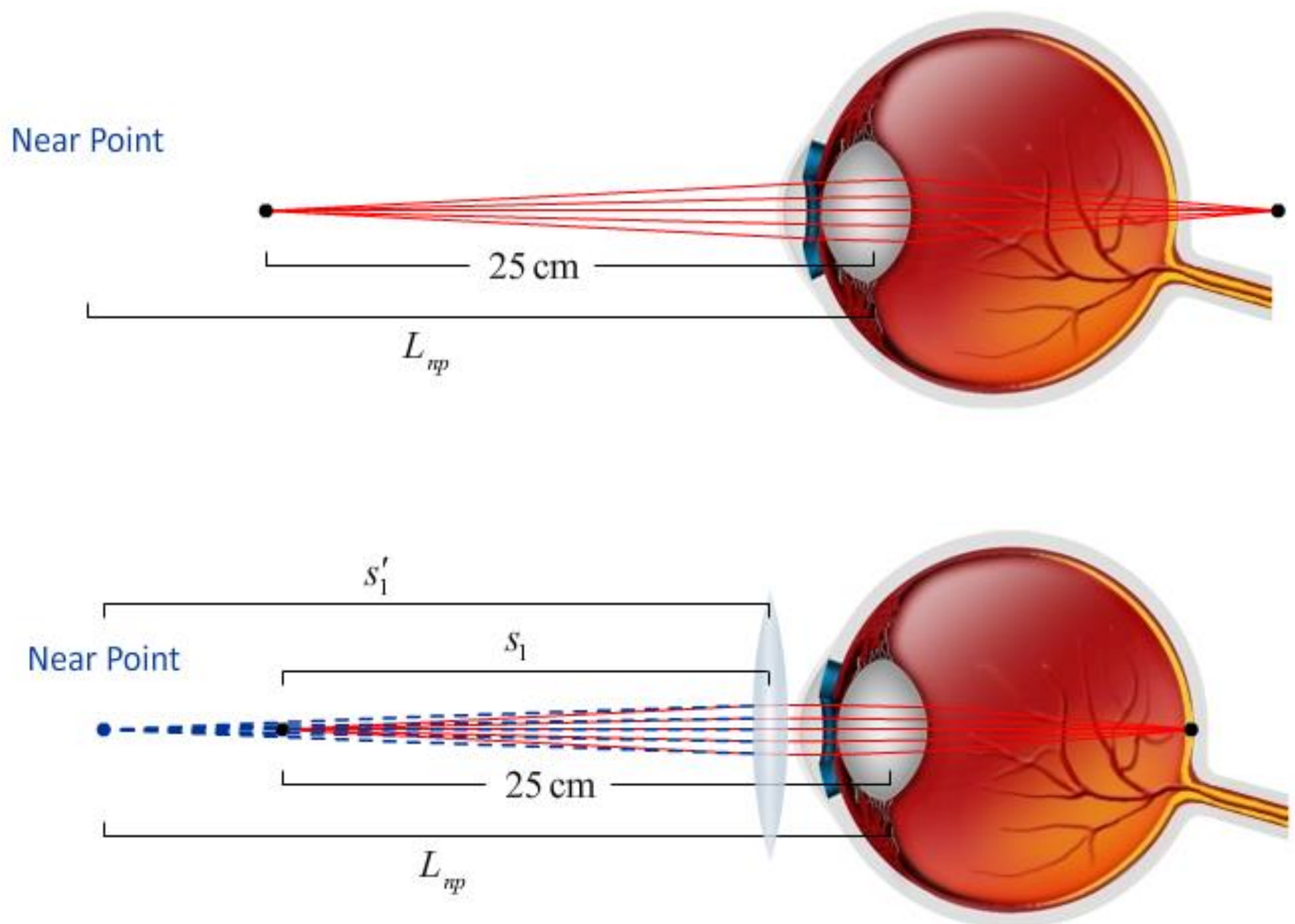
A. 14 cm **B.** 28 cm **C.** 56 cm





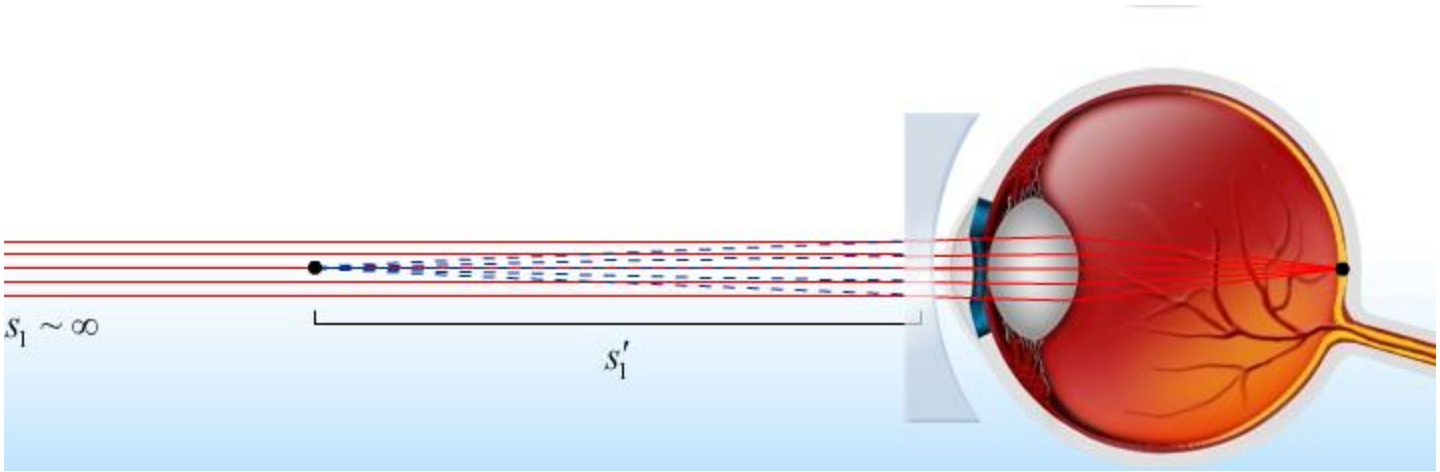
The image is formed an equal distance behind the mirror
Therefore, if you stand a distance = ½ of your near point, the distance to the image will be the near point distance.

Far-Sighted



Converging Lens creates virtual image at person's near point

Near-Sighted



Fix with diverging lens that creates virtual image at far point.

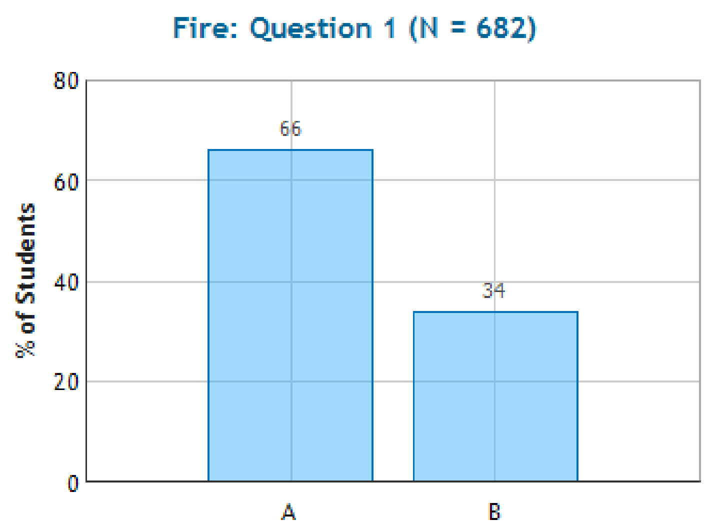
CheckPoint 1

Two people who wear glasses are camping. One of them is nearsighted and the other is farsighted. Which person's glasses will be useful in starting a fire with the sun's rays?

A. The farsighted person's glasses

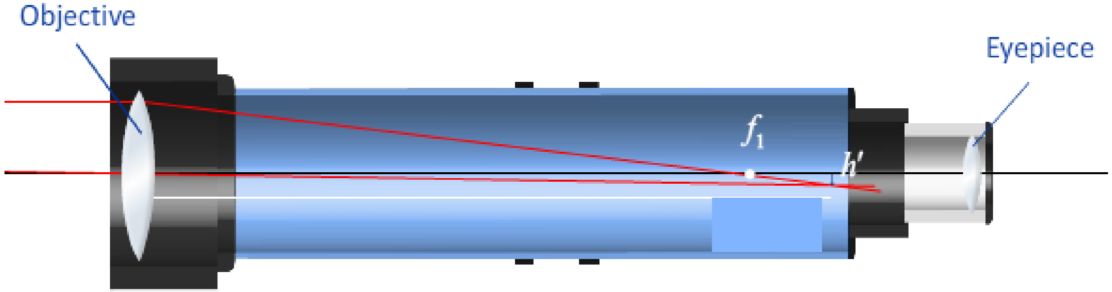
B. The nearsighted person's glasses

Farsighted = Converging Lens
Only Converging Lens can produce a real image!



Angular Magnification: Telescope

How does this apply to things far away? E.g. the moon



- Your eye can focus rays that are parallel or slightly diverging
  - Assume for simplicity that the rays from the eyepiece are parallel

The math:

First, what is the approximate image distance for the objective, s_1'?

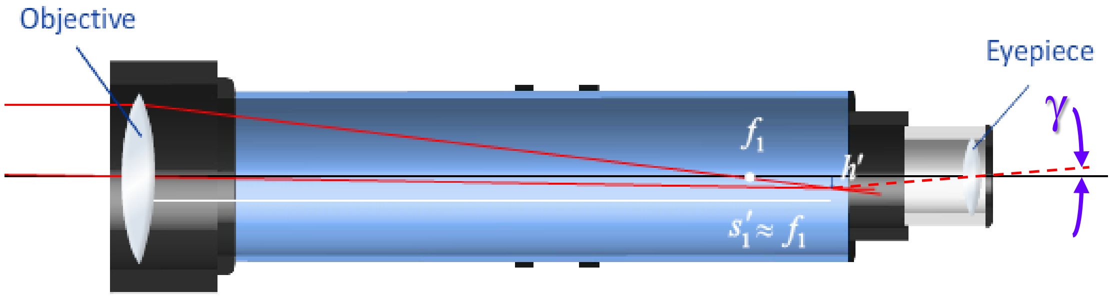
A) $s_1' \approx s_1$

B) $s_1' \approx f_1$

C) $s_1' = \dfrac{f_1 s_1}{s_1 - f_1}\ (no\ approximation)$

Angular Magnification: Telescope

How does this apply to things far away? E.g. the moon



- Your eye can focus rays that are parallel or slightly diverging
  - Assume for simplicity that the rays from the eyepiece are parallel

The math:

Objective: "1"

$$s_1' \approx f_1$$

Eyepiece: "2"

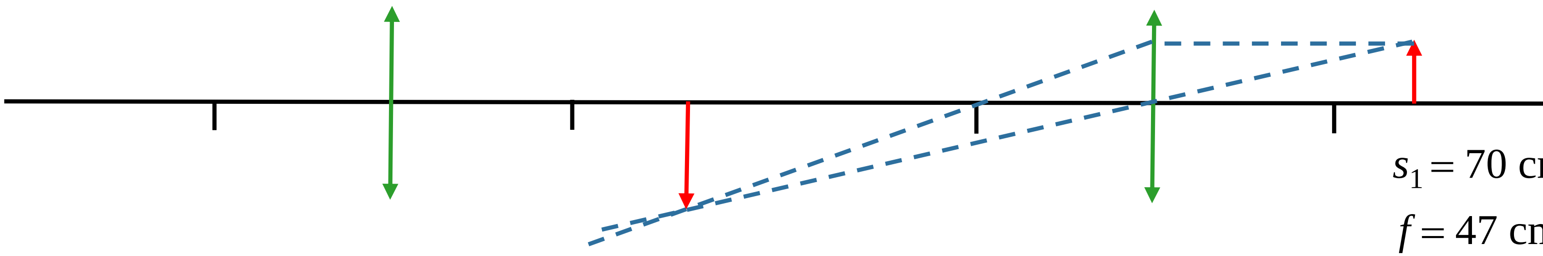
$$s_2 \approx f_2 \Rightarrow s_2' \rightarrow -\infty$$

Geometry

$$\alpha \approx \frac{h_1}{f_1}; \quad \gamma \approx \frac{h_1}{f_2}; \quad M = \frac{\gamma}{\alpha} \approx \frac{f_1}{f_2}$$

Multiple Lenses Exercises

Two converging lenses are set up as shown. The focal length of each lens is 47 cm. The object is a light bulb located 70 cm in front of the first lens.



$s_1 = 70$ cm

$f = 47$ cm

What is the nature of the image from the first lens alone?

A) REAL UPRIGHT

B) REAL INVERTED

C) VIRTUAL UPRIGHT

D) VIRTUAL INVERTED

EQUATIONS

$$\frac{1}{S'} = \frac{1}{f} - \frac{1}{S} \rightarrow S' = \frac{fS}{S-f}$$

$s > f \rightarrow s' > 0 \rightarrow$ real image

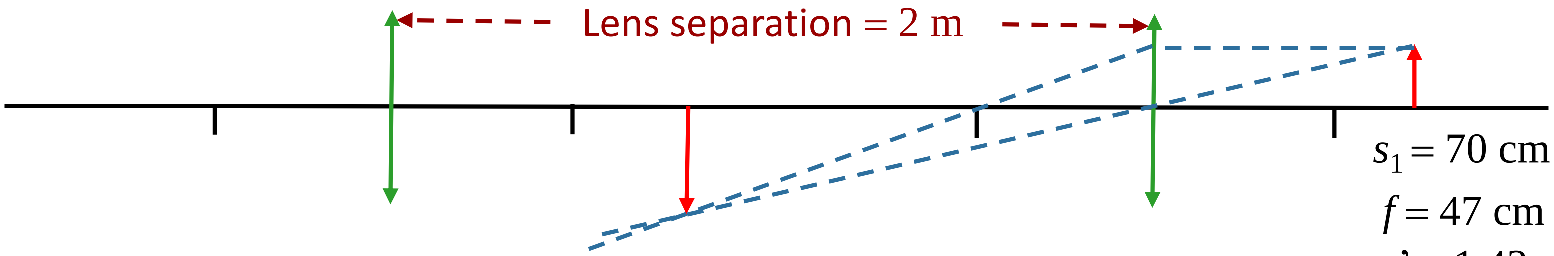
$$M = -\frac{S'}{S} \rightarrow M < 0 \rightarrow \text{inverted image}$$

PICTURES

Draw Rays as above.

Multiple Lenses Exercises

Two converging lenses are set up as shown. The focal length of each lens is 47 cm. The object is a light bulb located 70 cm in front of the first lens.



$s_1 = 70$ cm

$f = 47$ cm

$s_1' = 1.43$ m

What is the object distance s_2 for lens 2?

A) $s_2 = -1.43$ m B) $s_2 = +1.43$ m C) $s_2 = -0.57$ m D) $s_2 = +0.57$ m E) $s_2 = +2.7$ m

THE OBJECT FOR THE SECOND LENS IS THE IMAGE OF THE FIRST LENS

~~$s_2 = -0.57$~~

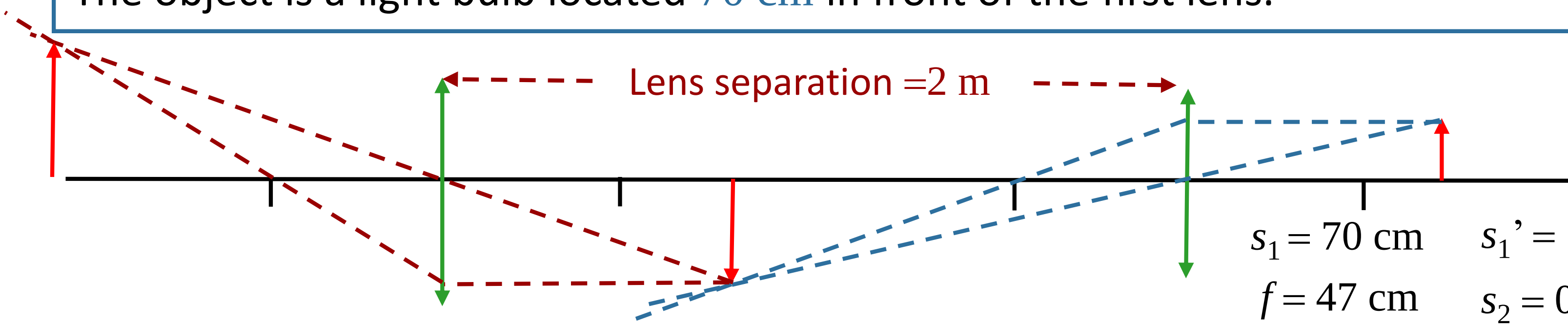
OR

$s_2 = +0.57$

Image of first lens is a REAL object for the second lens

Multiple Lenses Exercises

Two converging lenses are set up as shown. The focal length of each lens is 47 cm. The object is a light bulb located 70 cm in front of the first lens.



$s_1 = 70$ cm $\quad s_1' = 1.43$ m

$f = 47$ cm $\quad s_2 = 0.57$ m

What is the nature of the FINAL image in terms of the ORIGINAL object?

A) REAL UPRIGHT

B) REAL INVERTED

C) VIRTUAL UPRIGHT

D) VIRTUAL INVERTED

EQUATIONS

$$S_2' = \frac{fs_2}{s_2 - f}$$

$s_2 > f$ → $s_2' > 0$ → real image

$$M_2 = -\frac{S_2'}{S_2}$$

→ $M_2 < 0$ → $M = M_1 M_2 > 0$

→ upright image

PICTURES

Draw Rays as above.

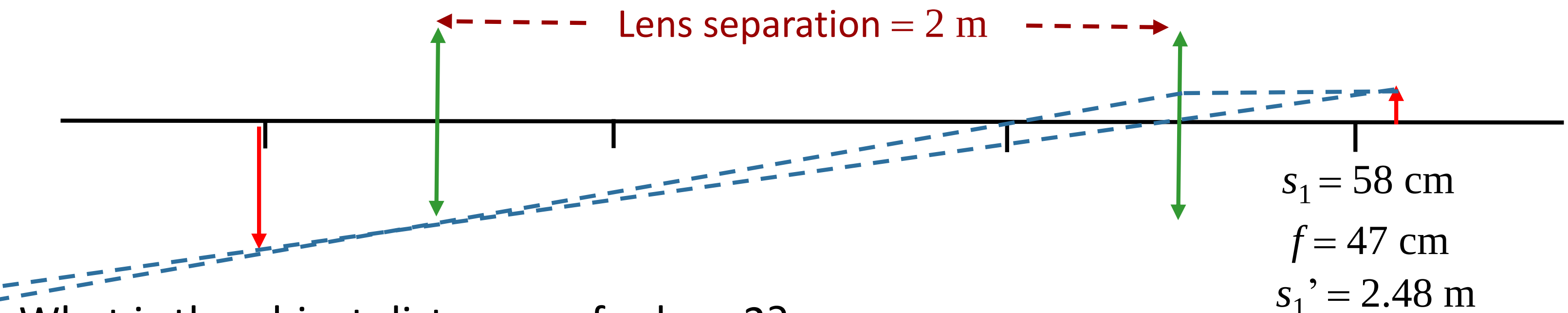
RESULTS

$s_2' = 2.69$ m

$M = 9.6$

Multiple Lenses Exercises

Suppose we now decrease the initial object distance to 58 cm. Applying the lens equation, we find $s_1' = 2.48\text{m}$



What is the object distance s_2 for lens 2?

A) $s_2 = -0.48$ m B) $s_2 = +0.48$ m C) $s_2 = -2.48$ m D) $s_2 = +2.48$ m E) $s_2 = +2.58$ m

THE OBJECT FOR THE SECOND LENS IS THE IMAGE OF THE FIRST LENS

$s_2 = -0.48$

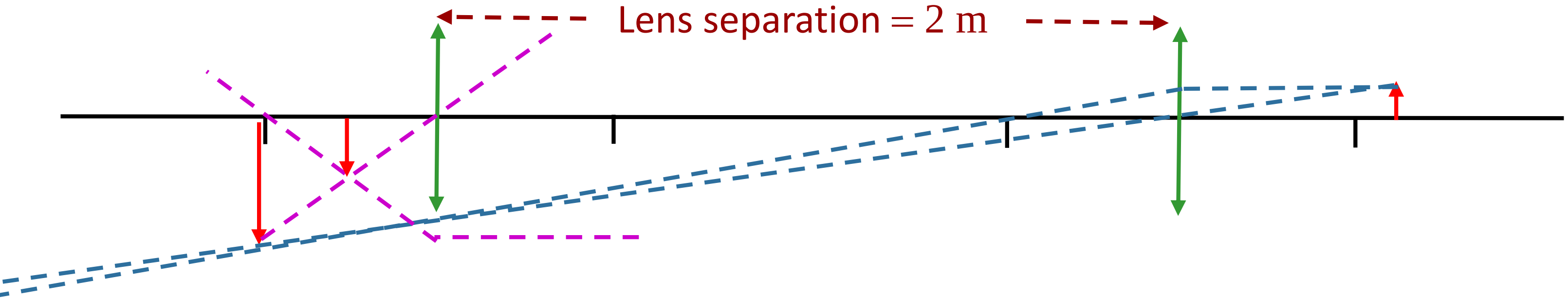
OR

~~$s_2 = +0.48$~~

Image of first lens is a VIRTUAL object for the second lens

Multiple Lenses Exercises

Suppose we now decrease the initial object distance to 58 cm. Applying the lens equation, we find $s_1' = 2.48\text{m}$



$s_1 = 58$ cm

$f = 47$ cm

$s_1' = 2.48$ m

$s_2 = -0.48$ m

What is the nature of the final image in terms of the original object?

A) REAL UPRIGHT

B) REAL INVERTED

C) VIRTUAL UPRIGHT

D) VIRTUAL INVERTED

EQUATIONS

$$S_2' = \frac{fs_2}{s_2 - f}$$

$s_2 < 0$ → $s_2' > 0$ → real image

$$M_2 = -\frac{S_2'}{S_2}$$

→ $M_2 > 0$ → $M = M_1 M_2 < 0$

→ inverted image

PICTURES

Draw Rays as above.

RESULTS

$s_2' = 0.24$ m

$M = -2.1$

Study hard for your finals!

Thanks for a fantastic semester!