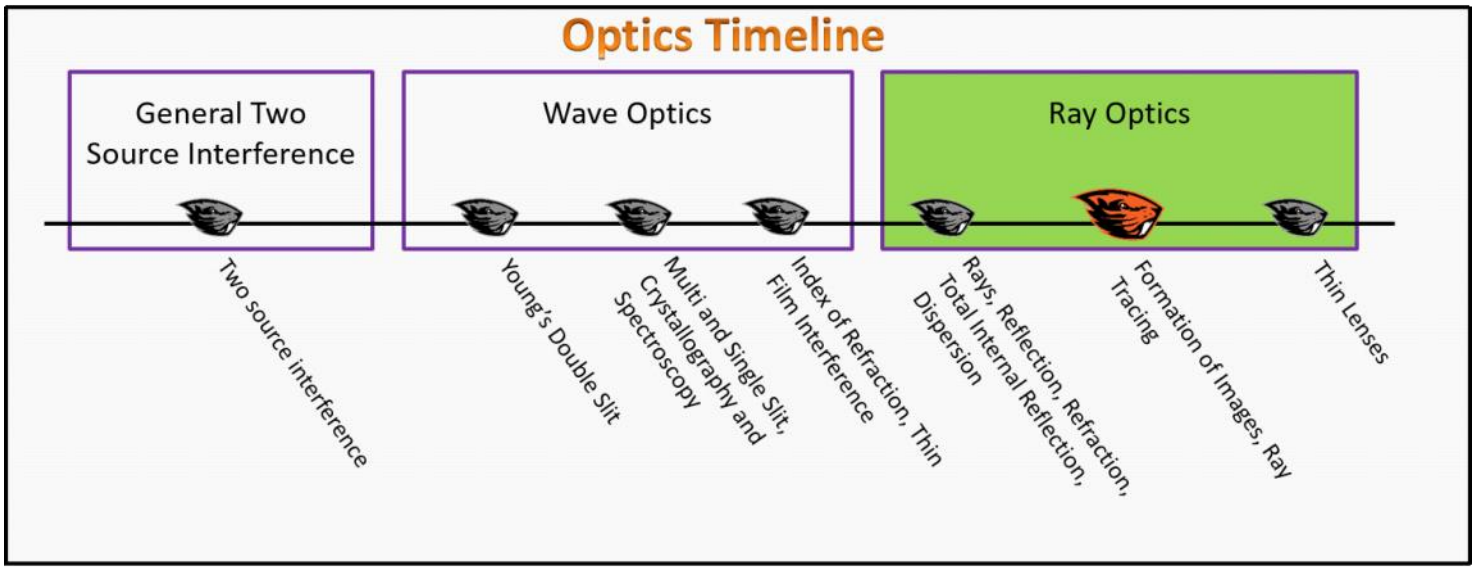
Wednesday, April 17, 2019 7:40 AM

Ray Optics
Foundation Stage (RO.2.L2)

Lecture 2
Formation of Images, Ray Tracing



Textbook Chapters (* Calculus version)

- **BoxSand** :: KC videos (Ray Tracing)
- **Knight** (College Physics : A strategic approach 3rd) :: 18.4 ; 18.5
- ***Knight** (Physics for Scientists and Engineers 4th) :: 34.4 ; 34.5
- **Giancoli** (Physics Principles with Applications 7th) :: 23-2 ; 23-5 ; 23-7

Warm up

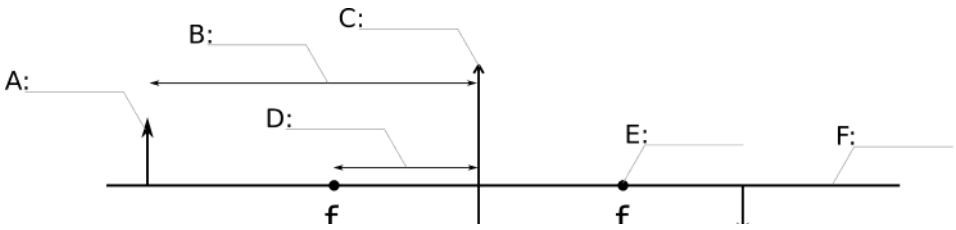
RO.2.L2-1:

Description: Definition question labeling quantities related to single lens thin film apparatus.

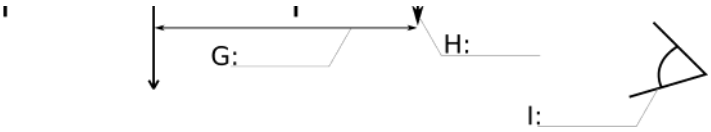
Learning Objectives: [?] - Can you identify the objectives from the previous lecture, and this lecture, that this question is relevant to?

Problem Statement: A source of light is placed on the left hand side of a thin converging lens as seen in the physical representation below. The physical representation below has labeled quantities A-?. Match each label with the description of what the quantity is called.

(1) Optical axis
(2) Object (a.k.a. source)
(3) Image
(4) Object distance
(5) Image distance
(6) Focal point
(7) Focal length



(8) Thin lens
(9) Observer



Selected Learning Objectives

1. Coming soon to a lecture template near you.

Key Terms

- Source of light
- Image
- Optical axis
- Focal point
- Object distance
- Image distance
- Real image
- Virtual image
- Magnification
- Ray tracing
- Thin lens
- Converging lens
- Diverging lens

Key Equations

Key Concepts

- Coming soon to a lecture template near you.

Questions

Act I: Formation of Images | Reflection and Refraction

RO.2.L2-2:

Description: Conceptual question about sources of light. (2 minutes)

Learning Objectives: [?]

Problem Statement: Which of the following are sources of light in the room right now?

(1) Flashlight.
(2) Laser.
(3) Sun.
(4) Pencil.
(5) Cat.

(6) Your friend's nose.

RO.2.L2-3:

Description: Conceptual question about rays emitting from a source and eyes. (3 minutes)

Learning Objectives: [?]

Problem Statement: The figure below shows a pencil and an eye that is observing the pencil. Sketch all of the rays coming of the light of the pencil.

RO.2.L2-4:

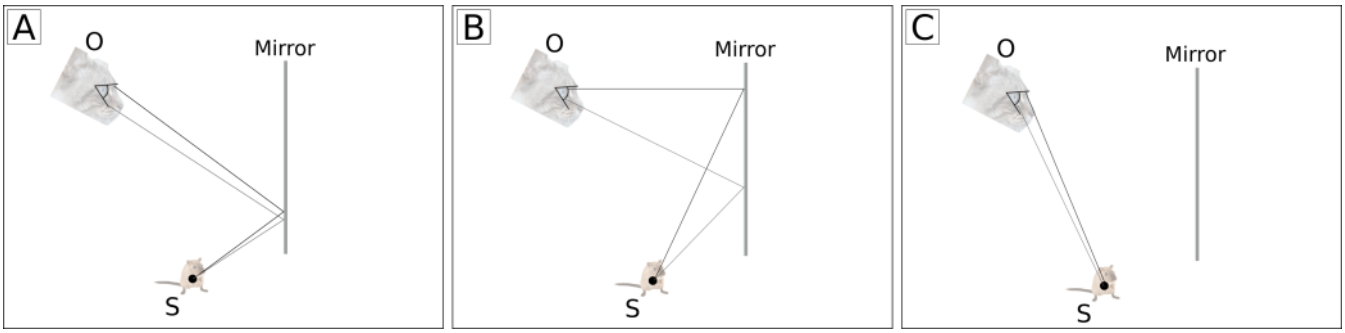
Description: Ray trace image formation from plane mirror. (3 minutes + 3 minutes)

Learning Objectives: [?]

Problem Statement: An observer **O**, facing a mirror, observes a source **S** of light via the mirror. We eventually wish to estimate where

the image of the source is located.

(a) Which physical representation correctly models this system?



(b) Trace back the rays from the mirror to find the location of the image produced by the mirror.

RO.2.L2-5:

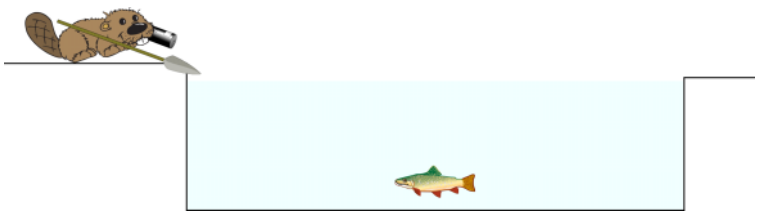
Description: Conceptual question and ray tracing for image formation from refraction. (3 minutes + 3 minutes + 2 minutes)

Learning Objectives: [?]

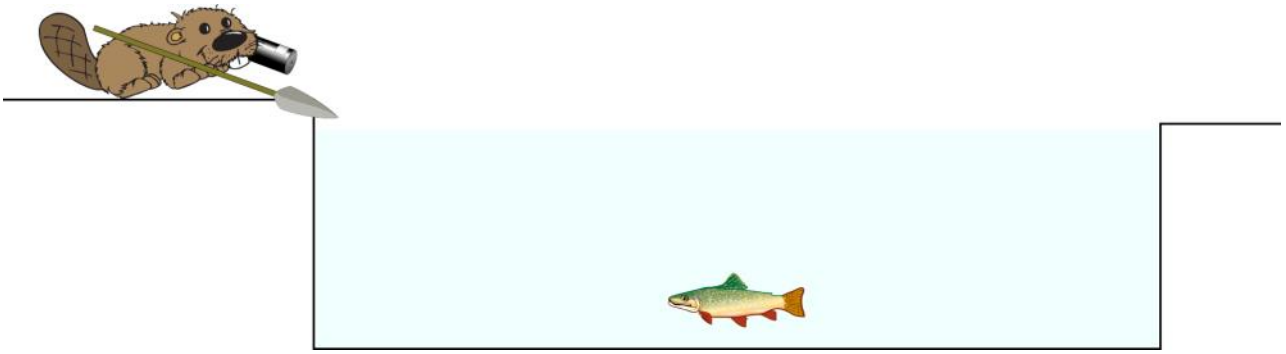
Problem Statement: Benny the beaver is on a fishing trip to escape from the hard life of dam building. Since Benny is a beaver, he does not bring a fishing rod, rather a laser and a spear.

(a) If Benny is trying to cook the fish with a high power laser, while the fish is still in the water and Benny is on the shore, where should Benny aim the laser?

(1) Directly at the fish Benny sees.
(2) In front of the fish Benny sees (closer to Benny).
(3) Beyond the fish Benny sees (farther from Benny).



(b) Estimate the location of the image of the fish that Benny sees.



(c) If Benny were to use the spear to catch the fish, where should he aim the spear when he throws it?

(1) Directly at the fish Benny sees.
(2) In front of the fish Benny sees (closer to Benny).
(3) Beyond the fish Benny sees (farther from Benny).

Act II: Thin Lens Ray Tracing

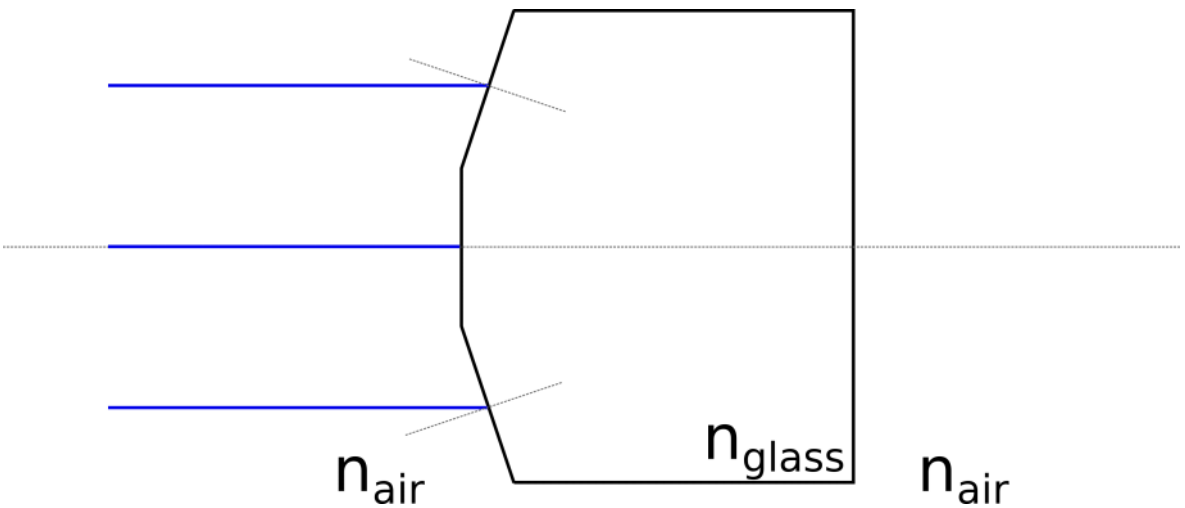
RO.2.L2-6:

Description: Sketch rays through thick piece of glass with air on both sides using law of refraction. (5 minutes + 3 minutes)

Learning Objectives: [?]

Problem Statement: Three parallel rays of light travel to the faceted thick piece of glass shown below.

(a) Sketch the path of each ray as they travel through the glass back into the air on the other side.



(b) If the frequency of the light is decreased, what happens to the point where the rays converge?

(1) Moves to the left.
(2) Moves to the right.
(3) Stays at the same location.

RO.2.L2-7:

Description: Definition question about focal point. (4 minutes)

Learning Objectives: [?]

Problem Statement: What is the focal point?

(1) The place where the rays converge.
(2) The place the rays appear to converge.
(3) The location where a screen could be placed to show a focused image.
(4) None of the above.

RO.2.L2-8:

Description: Sketch thin lens ray diagram for single converging lens. Identify if image is real or virtual for single lens. Identify real or inverted image for single lens. Estimate magnification for single lens. (4 minutes + 1 minute + 1 minute + 2 minutes)

Learning Objectives: [?]

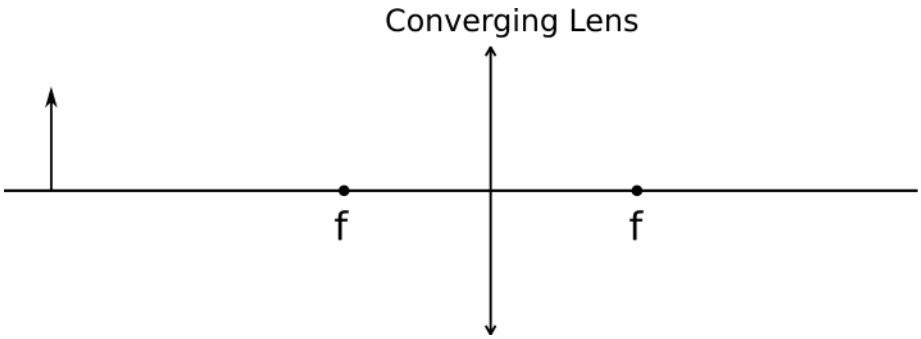
Problem Statement: Below is the start of a physical representation that will be useful when trying to determine how a lens bends light from a source.

(a) Use the ray tracing rules for thin lenses to sketch the location, orientation, and type of image creased using the given lens.

(i) Ray from object, parallel to optical axis, refracts through far focal point.

(ii) Ray from object, through near focal point, refracts parallel to optical axis.

(iii) Ray from object, through center of lens, exits undeflected.



(b) Is the image real or virtual?

(1) Real
(2) Virtual

(c) Is the image inverted or the same orientation as the source?

(1) Inverted
(2) Same orientation as source

(d) Estimate the magnification of the image.

RO.2.L2-9:

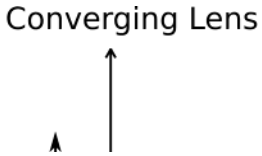
Description: Sketch thin lens ray diagram for single converging lens. Identify if image is real or virtual for single lens. Identify real or inverted image for single lens. Estimate magnification for single lens. (4 minutes + 1 minute + 1 minute + 2 minutes)

Learning Objectives: [?]

Problem Statement: Below is the start of a physical representation that will be useful when trying to determine how a lens bends light from a source.

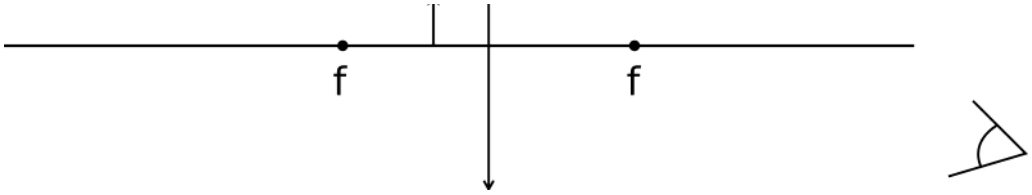
(a) Use the ray tracing rules for thin lenses to sketch the location, orientation, and type of image creased using the given lens.

(i) Ray from object, parallel to optical axis, refracts through far focal point.



(ii) Ray from object, through near focal point, refracts parallel to optical axis.

(iii) Ray from object, through center of lens, exits undeflected.



(b) Is the image real or virtual?

(1) Real
(2) Virtual

(c) Is the image inverted or the same orientation as the source?

(1) Inverted
(2) Same orientation as source

(d) Estimate the magnification of the image.

RO.2.L2-10:

Description: Sketch thin lens ray diagram for single diverging lens. Identify if image is real or virtual for single lens. Identify real or inverted image for single lens. Estimate magnification for single lens. (4 minutes + 1 minute + 1 minute + 2 minutes)

Learning Objectives: [?]

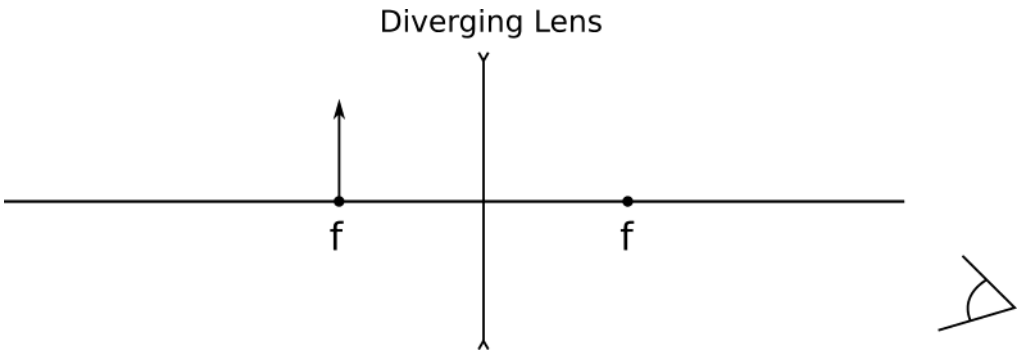
Problem Statement: Below is the start of a physical representation that will be useful when trying to determine how a lens bends light from a source.

(a) Use the ray tracing rules for thin lenses to sketch the location, orientation, and type of image creased using the given lens.

(i) Ray from object, parallel to optical axis, refracts as if it came from near focal point.

(ii) Ray from object, towards far focal point, refracts parallel to optical axis.

(iii) Ray from object, through center of lens, exits undeflected.



(b) Is the image real or virtual?

(1) Real
(2) Virtual

(c) Is the image inverted or the same orientation as the source?

(1) Inverted
(2) Same orientation as source

(d) Estimate the magnification of the image.

RO.2.L2-11:

Description: Sketch a to-scale thin lens ray diagram for single converging lens. Identify if image is real or virtual for single lens. Identify real or inverted image for single lens. Estimate height of image for single lens. Estimate the image distance for single lens. Estimate magnification for single lens. (4 minutes + 1 minute + 1 minute + 1 minute + 2 minutes)

Learning Objectives: [?]

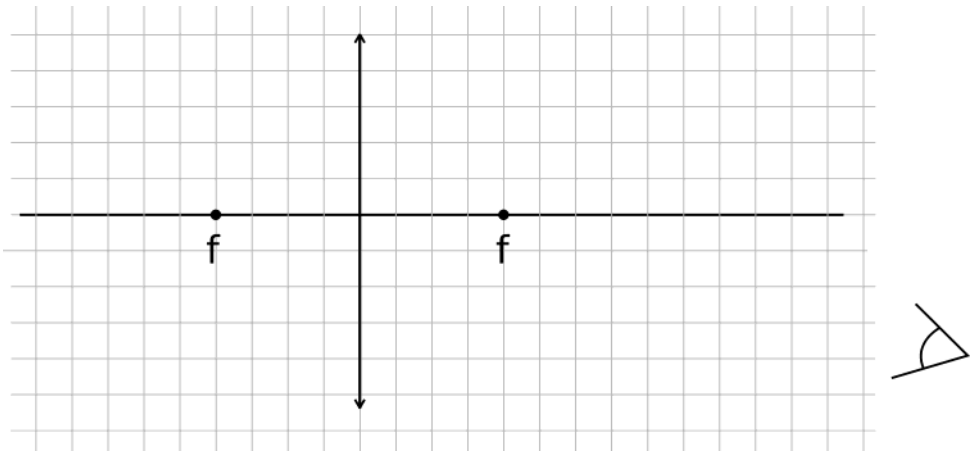
Problem Statement: Below is the start of a physical representation that will be useful when trying to determine how a lens bends light from a source. Ray optics is often referred to as geometric optics, because you can use geometry to determine the relevant thin lens information if the physical representation is drawn *carefully* and to scale.

(a) A 4 cm tall source is located 12 cm from a converging lens of focal length 8 cm. Use the ray tracing rules for thin lenses to *carefully* sketch the location, orientation, and type of image creased using the given lens.

(i) Ray from object, parallel to optical axis, refracts through far focal point.

(ii) Ray from object, through near focal point, refracts parallel to optical axis.

(iii) Ray from object, through center of lens, exits undeflected.



(b) Is the image real or virtual? **(c)** Is the image inverted or the same orientation as the source? **(d)** Estimate the height of the image.

(1) Real
(2) Virtual

(1) Inverted
(2) Same orientation as source

(e) Estimate the image distance. **(f)** Estimate the magnification of the image.

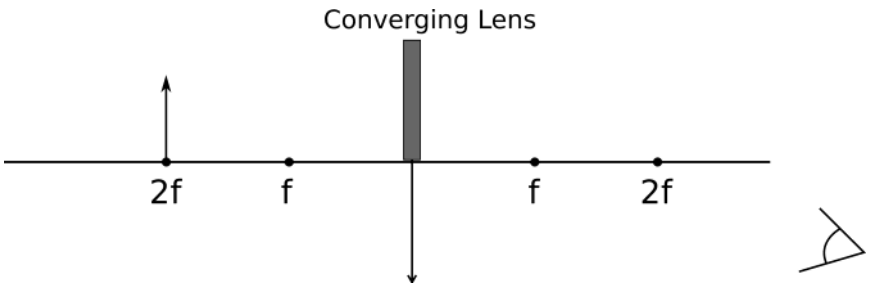
RO.2.L2-12:

Description: Conceptual question about covering portion of thin lens. (4 minutes)

Learning Objectives: [?]

Problem Statement: A lens is used to image an object onto a screen. If the top half of the lens is covered,

(1) the bottom half of the image disappears.
(2) the top half of the image disappears.
(3) the entire image disappears.
(4) the image becomes blurred.
(5) the image becomes fainter.



Conceptual questions for discussion

1. Focal length dependence on n question

Hints

RO.2.L2-1: No hints.

RO.2.L2-2: No hints.

RO.2.L2-3: No hints.

RO.2.L2-4: No hints.

RO.2.L2-5: No hints.

RO.2.L2-6: No hints.

RO.2.L2-7: No hints.

RO.2.L2-8: No hints.

RO.2.L2-9: No hints.

RO.2.L2-10: No hints.

RO.2.L2-11: No hints.

RO.2.L2-12: No hints.

RO.2.L2-13: No hints.

RO.2.L2-14: No hints.

RO.2.L2-15: No hints.

RO.2.L2-16: No hints.

RO.2.L2-17: No hints.

RO.2.L2-18: No hints.

RO.2.L2-19: No hints.

RO.2.L2-20: No hints.