THE PHYSICS OF LIGHT AND OPTICS

Girls in STEM Conference workshop

May 6th 2017

University of Toronto

Physics
UNIVERSITY OF TORONTO

WHY IS LIGHT IMPORTANT?

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- What is optics?

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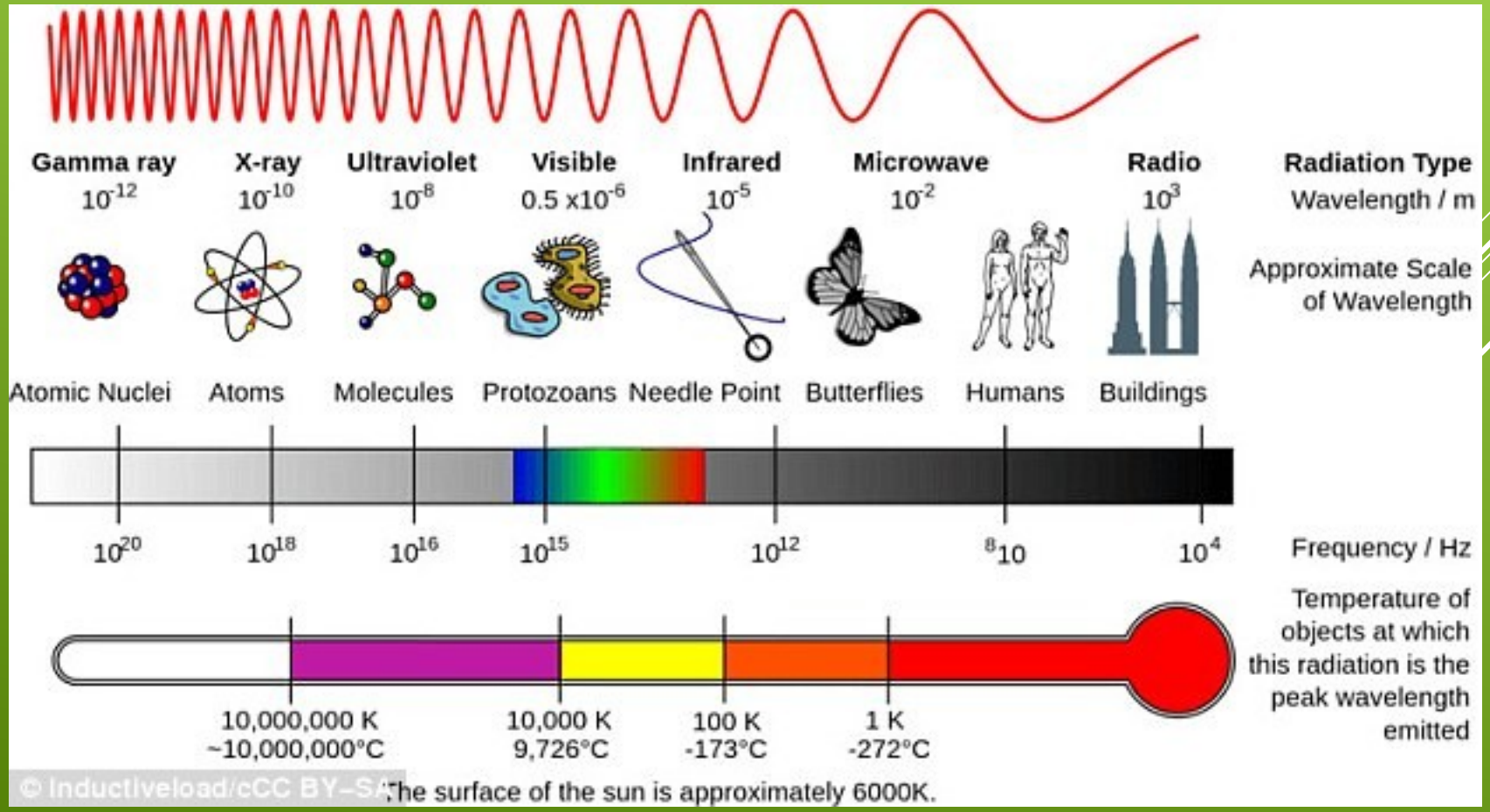

HOW DOES LIGHT BEHAVE?

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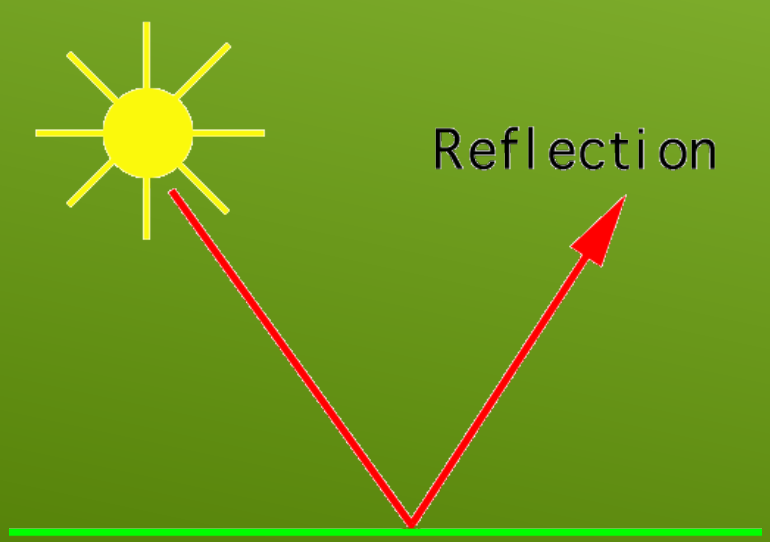
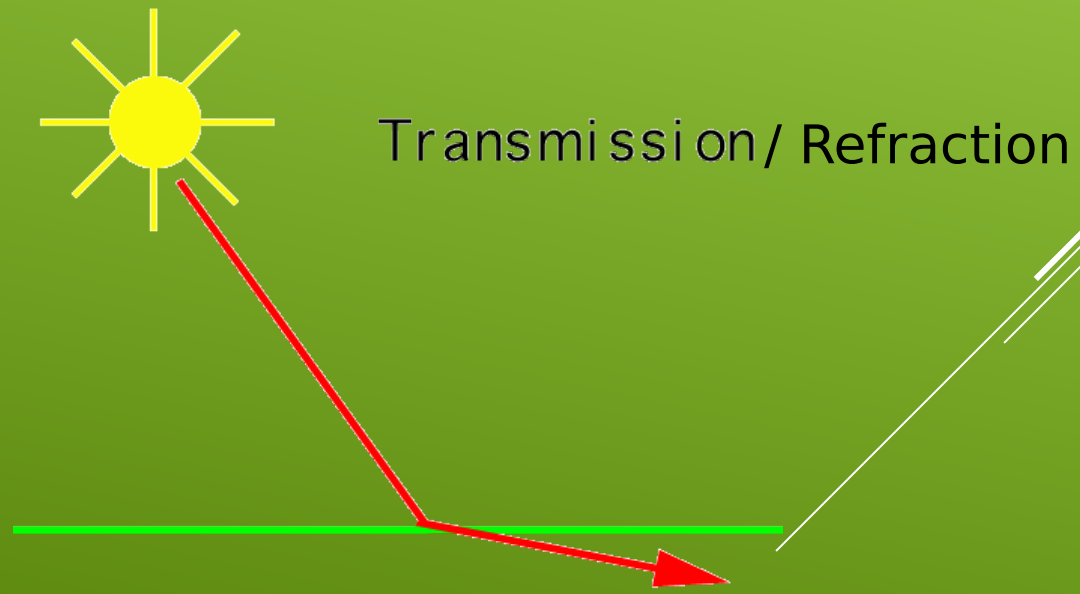
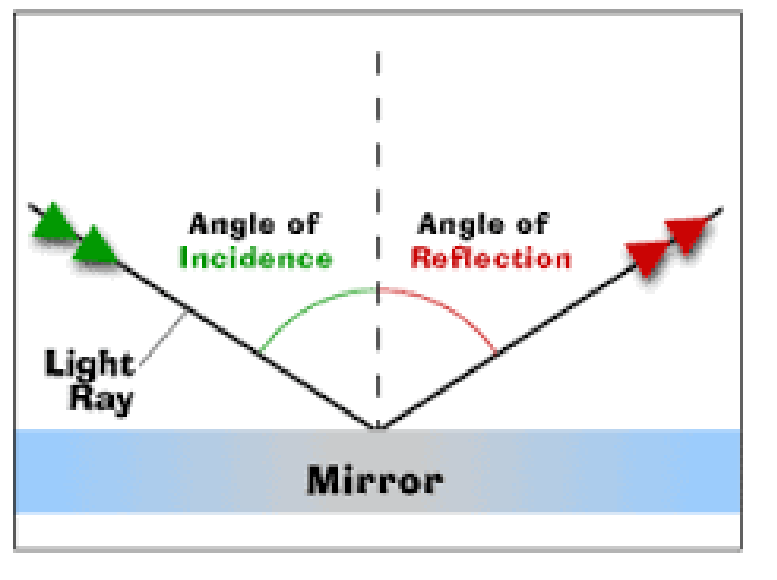




LAWS OF REFLECTION AND REFRACTION

Reflection

- The angle of the incident angle is the same as the angle of the reflected ray
  - Ie. The original ray and the reflected ray are symmetric



Refraction

- The incident and refracted angle are related through Snell's Law:

$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$$

- Ie. The refracted ray will be bent compared to the original ray – they won't line up!

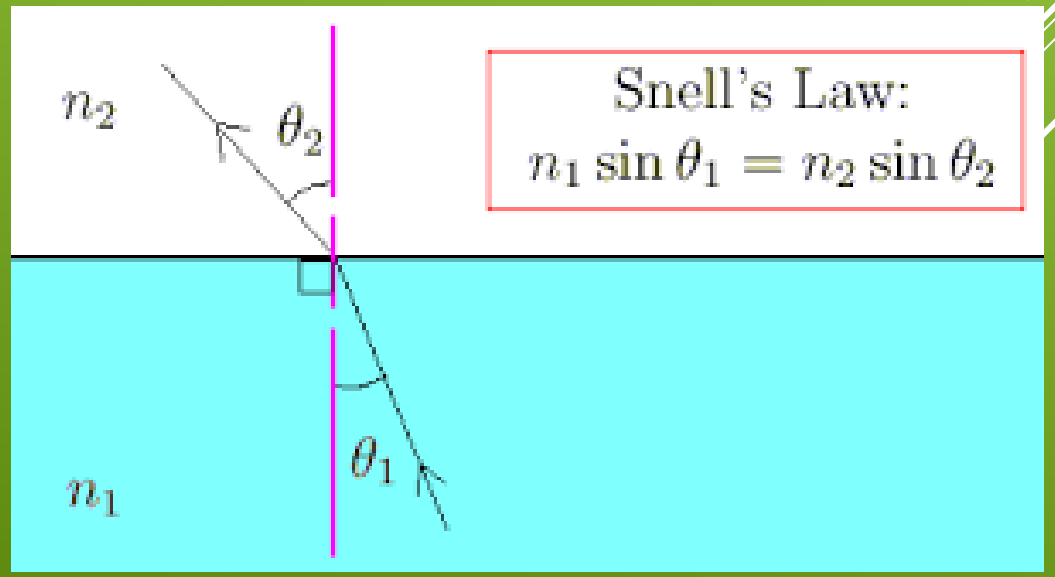


Image credit: UBC math dept

INVESTIGATING REFRACTIVE INDEX: ACTIVITY 1: WATER, OIL, & GLASS

- Each group has 2 beakers and 4 test tubes.
- Put a test tube of water in each beaker, and a test tube of oil in each beaker.
- Examine both test tubes in each beaker very carefully and record your observations + hypothesis!

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- The refractive index of water: $n_{water} = 1.33$
- For oil: $n_{oil} = 1.467$
- For glass: $n_{glass} = 1.517$

TAKE A STEP BACK: THE SCIENTIFIC METHOD

- You may not realize it, but you all have just used the scientific method in Activity 1!
- Can anyone define the scientific method?

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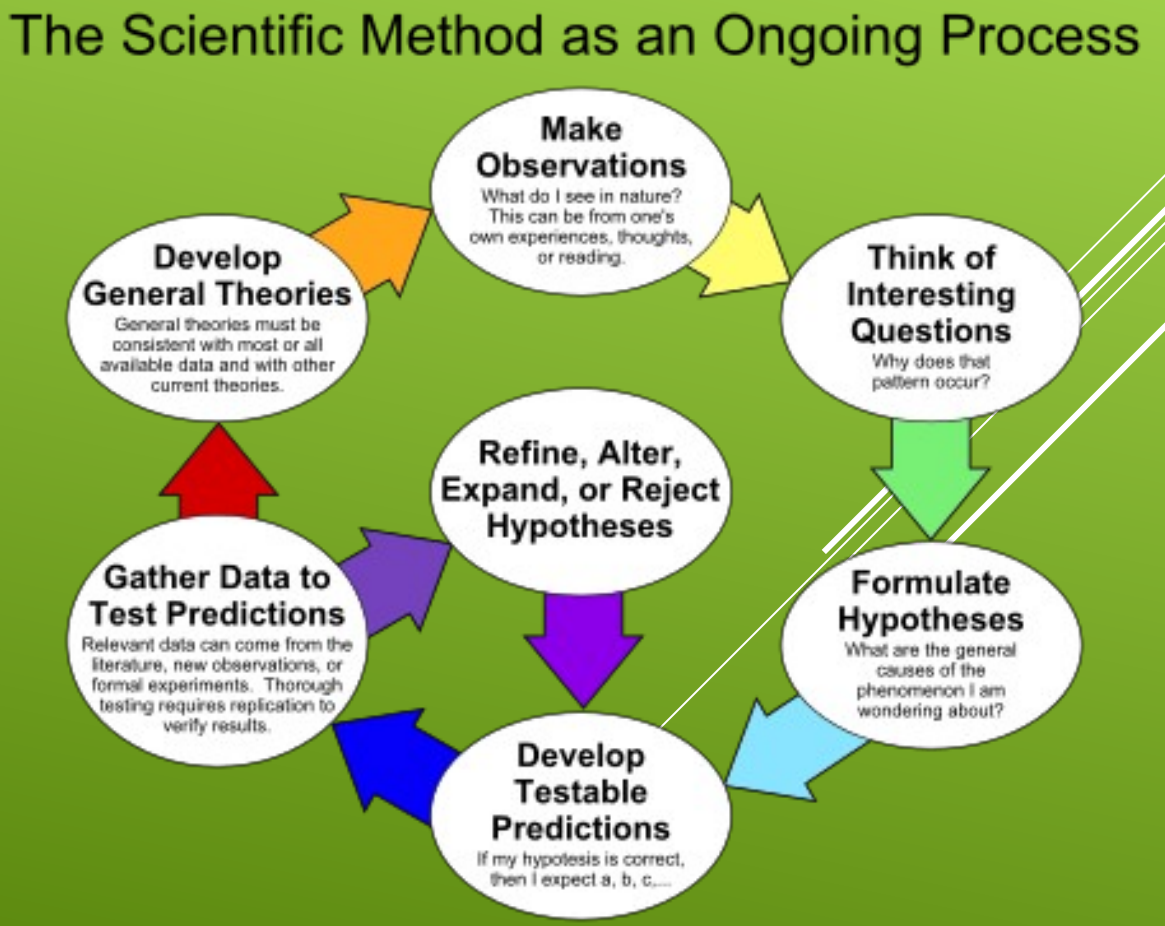
- We'll be using this method throughout the workshop, and it's used throughout the world!
- Now let's get back to light ^^

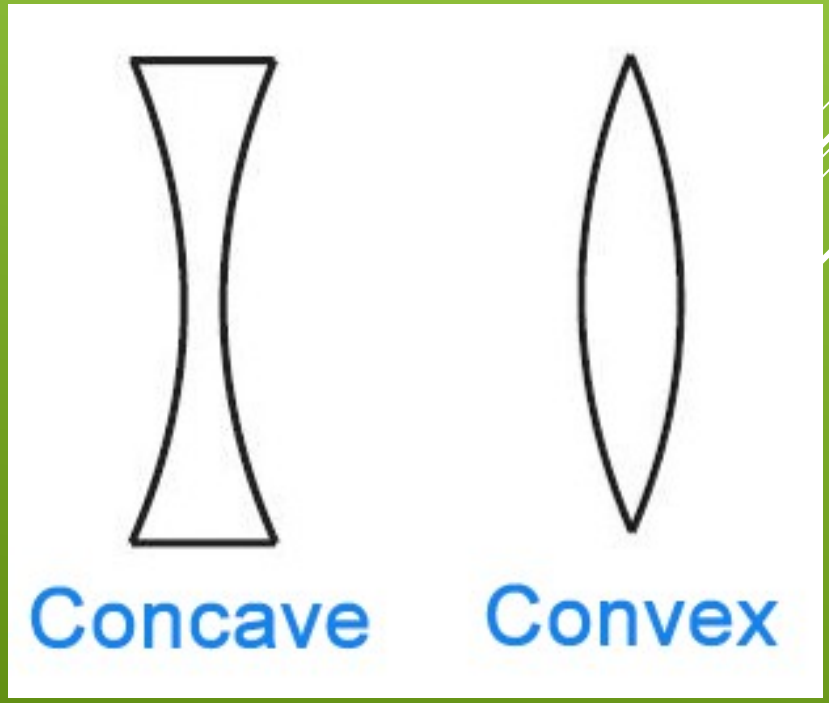


LIGHT AND PRISMS: ACTIVITY 2: REFLECTION AND REFRACTION

- Let’s combine our knowledge! Reflection and refraction at the same time.
- Each group has a light box and a box of prisms. You’ll need to use the ray side of the light source: the part that has a knob.
- Using the 1-ray option, what happens when you put the trapezoidal prism in the light path? Does this change when you use different sides?

DIFFERENT KINDS OF PRISMS
ACTIVITY 3: CONCAVE AND CONVEX PRISMS

- You may have noticed that you have 2 additional prisms besides the trapezoidal prism.
- Concave: sides bending in
- Convex: sides bending out
- What happens when you use the 3-ray light setting on these prisms? How are they different?



COMBINING YOUR KNOWLEDGE: ACTIVITY 4: MAKING WHITE LIGHT

- You’re now familiar with your 3 prism types and how they bend light.
- Using the coloured ray, can you use your prisms to make white light? What does this tell you about the composition of white light?
- **Remember that everything from points to full rays of white count as making white light**

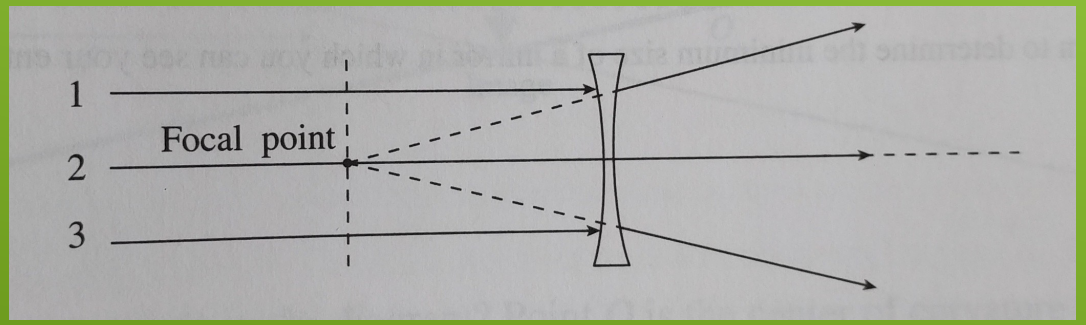
ANALYZING YOUR OBSERVATIONS: ACTIVITY 5: FOCAL POINTS (A)

- You’ve explored using the 3 different prisms. Let’s focus on the concave and convex prisms and their interaction with light.
- Concave and Convex prisms (or lenses) have an additional quality when they interact with light: a focal point. This is where the rays converge.
- Where is the focal point for convex and concave prisms?

INVESTIGATING FURTHER: ACTIVITY 5: FOCAL POINTS (B)

Concave

Convex



- Can you measure where the focal point is for the convex prism? What about for the concave prism?
- How did you take these measurements? Where did you choose your origin to be?

Image credit: Etkina, Gentile, & Van Heuvelen, College Physics Guide

FOCAL POINTS AND FOCAL LENGTH

- The measurements you took for the convex and concave prisms is called a focal length – where the focal point is from the centre of the prism. These can be larger or smaller for different prisms.
- Now we have 3 ways of qualitatively defining a prism or lens:
    1. **Concave or Convex** (bending inwards or outwards)
    2. **Refractive index** (how much light bends at the surface)
    3. **Focal length** (where the focal point is)

APPLYING YOUR KNOWLEDGE: ACTIVITY 6: MAGNIFYING GLASS

- A magnifying glass is a convex lens. Can you describe and draw a ray diagram to show how it works?
- Feel free to use the convex lens you have to help you think!

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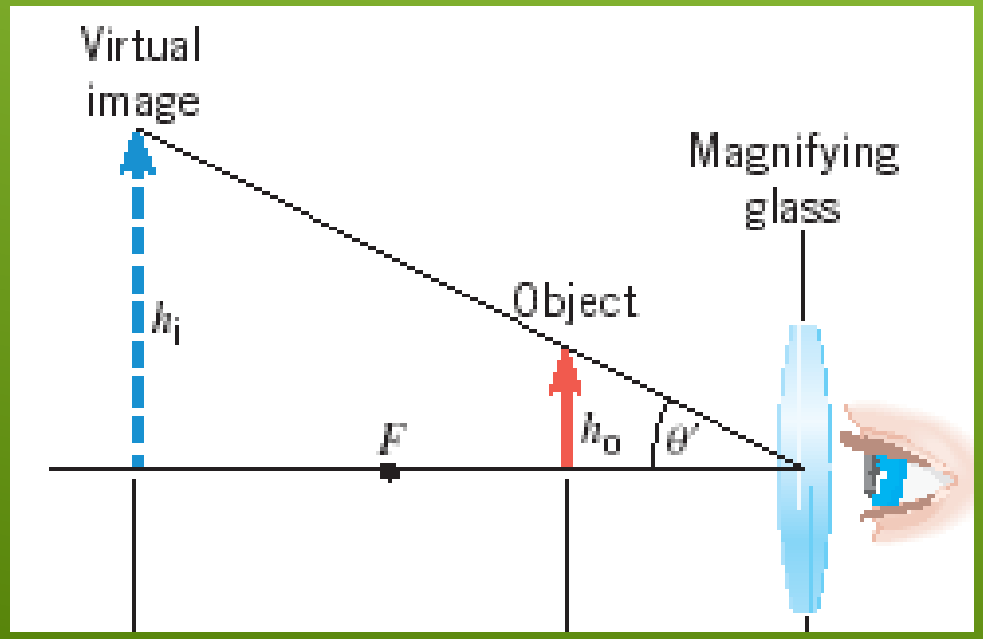
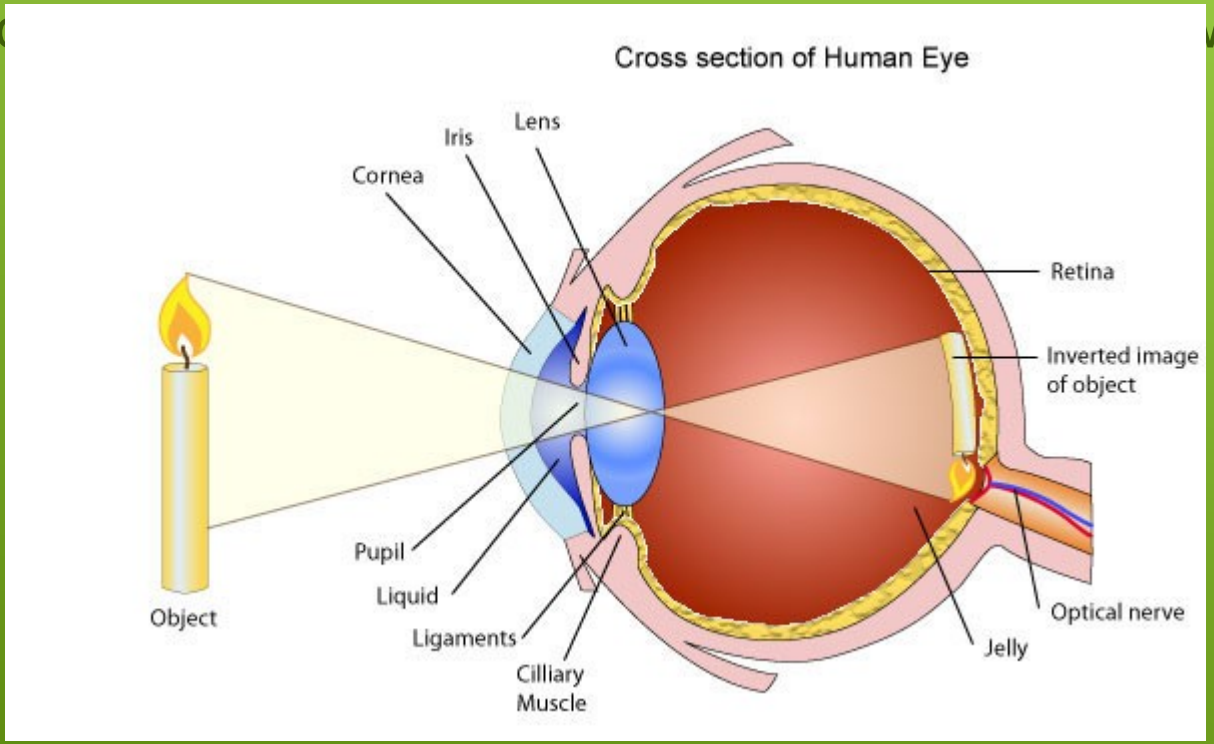
Investigate this on your own! Use a magnifying glass in your home or school and see if you can find its focal length!



APPLYING YOUR KNOWLEDGE: ACTIVITY 7: EYEBALLS!

- What about other c… w our eyes work!
- Here is an eye:



- Should the lens be concave or convex in this diagram? How do you know?

TAKING IT FURTHER: NEAR AND FAR SIGHTEDNESS

- You’ve learned about lenses and how they relate to our eyes!
- Let’s think about how everyone’s eyes are different. What is near and far sightedness?

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- What could cause these conditions?

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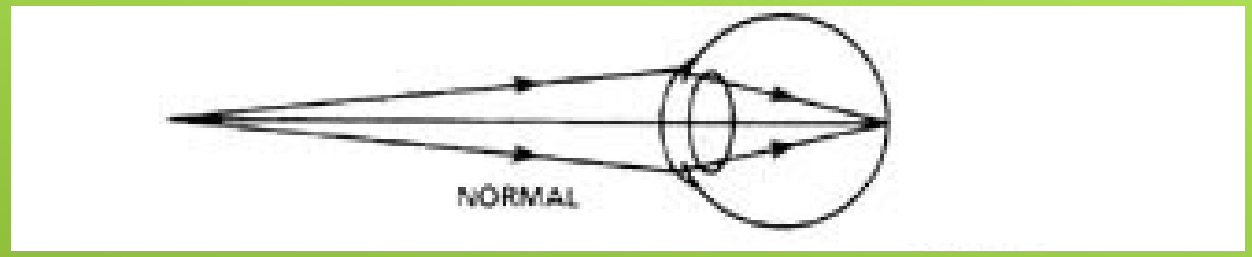
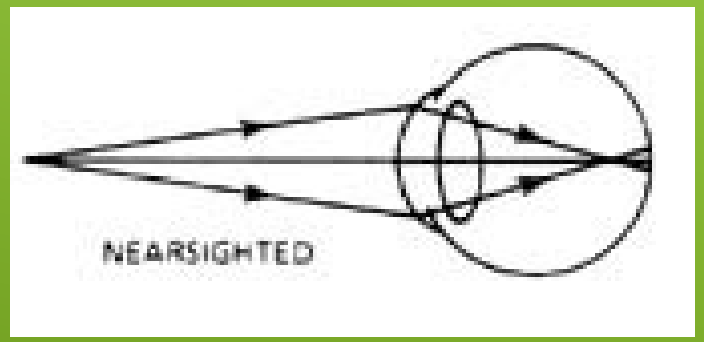
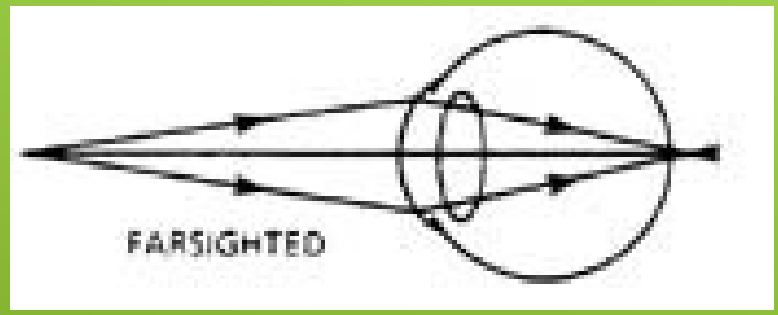
- Let’s put together ray diagrams of the eye in these scenarios!

ACTIVITY 7: NEAR AND FAR SIGHTEDNESS







Near/short sighted:

Light focuses in front of retina

Far sighted:

Light focuses behind retina

See if you can figure out how we correct for these sight conditions! Here’s a hint: usually people get a prescription for glasses. Think about what glasses are made of!

THANK YOU!

- Thank you for participating in the workshop! We in the physics department hope that you enjoyed it and that you learned something!
- Don’t forget to try out your new skills at home – find a magnifying glass and investigate your eye glasses!