Review Worksheet of lens ray diagrams…

Is this a converging or diverging lens?

Any lens that is thicker in the middle is a converging or convex lens
Any lens that is thinner in the middle is a diverging or concave lens

Ray diagrams for multiple lenses
- When there are two lenses, the image from the first lens becomes the object for the second
- Ex 32-10

What if the first image is beyond the second lens?
The object for the second lens will be negative, this is the only time you can have a negative object distance

Your eye is a lens, it focuses the light rays to the retina where the optic nerve sends this information to the brain
Nearsighted

Correct with a diverging lens to add extra divergence needed

Farsighted

Correct with a converging lens to add extra convergence needed

**Telescope types**

- **Refractor** (like binoculars, US Naval Observatory in DC, Greenwich 1894, Royal observatory and Galileo’s original telescope), problem: different wavelengths refract differently, weight at top
- **Newtonian Reflector** (not popular for large telescopes because observer in awkward place, you can buy one of these), problem: support for top mirror gives classic cross pattern on stars
- **Compound (Cassegrain Reflector)** - Hubble, Keck Observatory in Hi, Rattlesnake mountain Obs in Tricities

**Phase difference**

- Two waves can combine, the result is predictable
  - If the waves are in phase (no phase difference), they combine to form maximum intensity
  - If the waves are out of phase (phase difference is 180 degrees), they combine to form minimum intensity, “they cancel each other out”
  - Otherwise, the combination is somewhere in between…
- Define path length difference
- Define phase difference

**Example 33-1**

a) What is the minimum path length difference that will produce a phase difference of 180 degrees for light of 800nm (red light)?

b) What phase difference will that path length produce in light of wavelength 700nm (orange-red light)?
Interference in thin films

- Interference - reason for colored bands in soap or oil film
- Light reflected from top and bottom of film surface
- Color depends on thickness of film
- Reflected and refracted, reflected ray combine
- Sun light contains all colors (wavelengths)
- Different thicknesses cause interference for different wavelengths at different points

At which reflections or refractions has a phase change occurred?

How about now?
If the light ray enters perpendicularly (not shown here), what is the difference in path length?

The top part of this soap film appears black. Why?

- The reflected light from the front surface is phase changed by half a wavelength.
- At the top, this film thickness is so small the thickness is negligible.
- So the reflected-then-refracted and just-reflected wave cancel each other out and you see black (no light).