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King Saud University
College of Science
Physics & Astronomy Dept.

Phys 145 (General Physics)

Chapter 7: Mirrors, Lenses and Imaging Systems (part 2)

Week n° 10

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Chapter 7: Mirrors, Lenses and Imaging Systems (Second part)

- **We will learn in this second part of chapter 7:**
- Image Formation
- Power of a Lens; Aberrations

Image Formation: Real Image

Image is made from "real" light rays that converge at a real focal point so the image is REAL.

It can be projected onto a screen because light actually passes through the point where the image appears always inverted.

$$\frac{1}{f}=\frac{1}{S}+\frac{1}{S'}$$

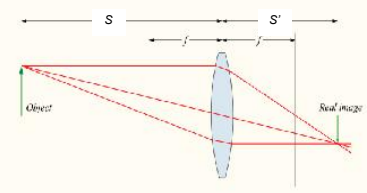
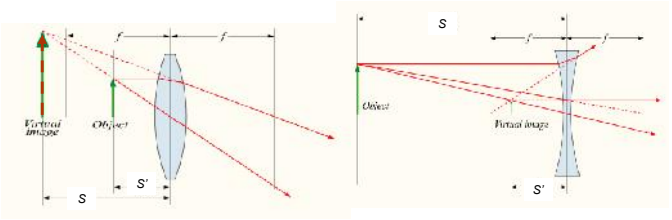


Image Formation: Virtual Image

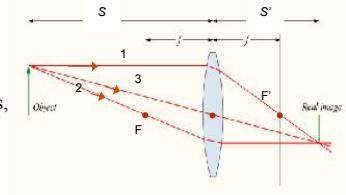
"Not Real" because it cannot be projected.

Image only seems to be there!



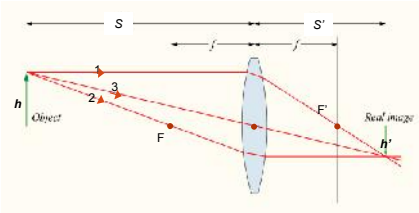
Graphical or ray-tracing

We use the following conventions in the graphical or ray tracing approach to locating the image:
1- Light always goes form left to right.
2- Real objects are to the left of the lens, and real images to the right.
3- Virtual images are to the left of the lens, and virtual objects to the right.



The three numbered rays in the diagram are drawn from the arrowhead as follows:
1- The ray (1) leaving the arrowhead parallel to the axis is deflected by the lens and pass through the focal point **F'**.
2- The ray (2) going through the focal point **F** emerges from the lens parallel to the axis.
3- The ray (3) directed at he center of the lens is undeflected.

Graphical or ray-tracing



S and ***S'*** are the distance of the object and its image from the center of the lens along the axis respectively , while h and h' are the height of the object and its image respectively. And we adopt the following:
1- ***S*** is positive for a real object, negative fro a virtual object.
2- ***S'*** is positive for a real image, negative for a virtual image.
3- The object height ***h*** is positive if it points above the axis and negative if it points below the axis.

Linear Magnification

The linear magnification (***m***) is the ratio of the image and object heights.
The linear magnification is positive when the image is erect and negative when the image is inverted.

$$m = \frac{h'}{h} = -\frac{S' - f}{f} = -\frac{S'}{S}$$

Power of a lens

The power of the lens P is the reciprocal of the focal length.
The unit of the power of a lens is m^{-1} or diopter.

$$P = \frac{1}{f}$$

The power of two lenses placed next to each other are equivalent to a single lens with a foal length f satisfying:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

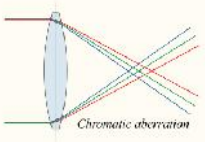
Using the powers of the lens:

$$P = P_1 + P_2$$

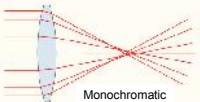
Aberration

Any lens suffers from various kinds of aberration, which limit the sharpness of its image.
Since the refraction index of glass varies with wavelength of the light, the focal length also varies with the wavelength.

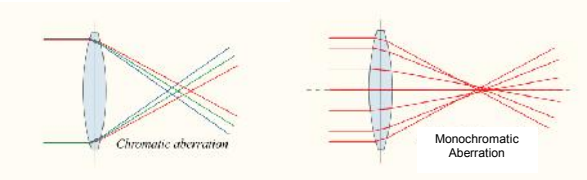
The Chromatic Aberration:
If an object illuminated with white light, if the image on a screen is in focus for one color component, it will be slightly our of focus for the others.



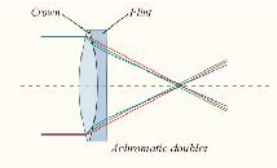
The Monochromatic Aberration:
Aberration occur even fro light of a single wavelength.



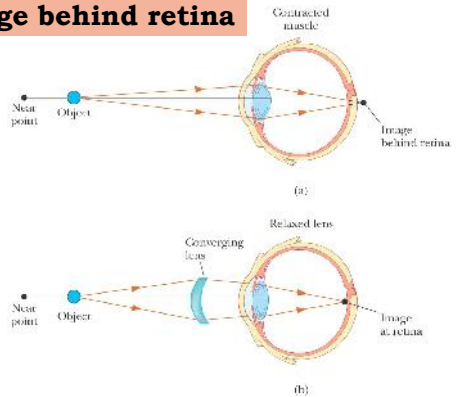
Aberration correction



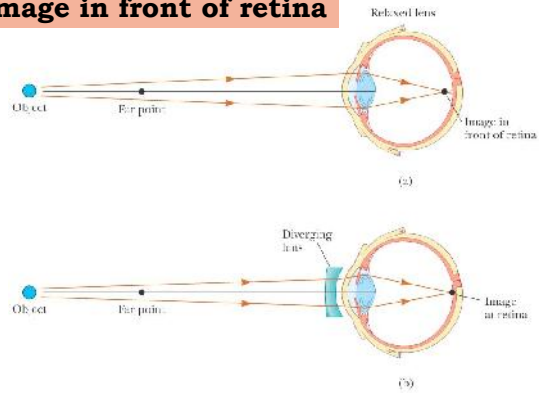
By adding a corrector lens we can reduce or cancel the aberration:



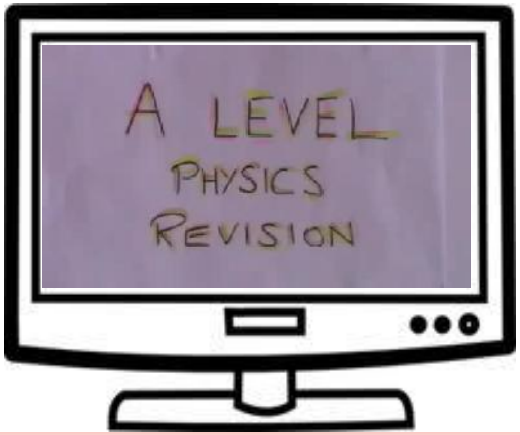
Human imaging system: The Eyes
Image behind retina



Human imaging system: The Eyes
Image in front of retina



Video 01 of week 10: Geometric optics



Summary of week 10

- The distance from a lens to the an object *S* and to an image *S'* are related by:

$$\frac{1}{f}=\frac{1}{S}+\frac{1}{S'}$$

- The power *P* of a lens with a focal distance *f* is: $P=\frac{1}{f}$
- For two accoled lenses, we have:
- or $\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$
- $P=P_1+P_2$

Quiz for week 10