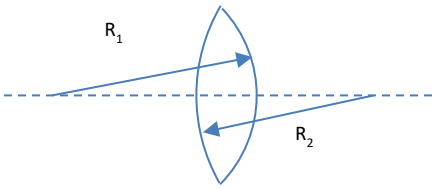
CONCEPT: THIN LENS EQUATION



- For images produced by lenses, we will only consider THIN LENSES
  - Thin lenses are formed by two spherical pieces of glass
  - They can be either converging or diverging lenses

- Thin lenses come in 5 basic types:

  - Lenses that are THICKEST in the middle are [CONVERGING / DIVERGING]
  - Lenses that are THINNEST in the middle are [CONVERGING / DIVERGING]

- For a lens with a focal length f, the image location is given by the THIN LENS EQUATION

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

s_o is the object distance and s_i is the image distance

- There are important sign conventions for the focal length to remember:
  - If the lens is converging → The focal length is [POSITIVE / NEGATIVE]
  - If the lens is diverging → The focal length is [POSITIVE / NEGATIVE]

- There are important interpretations for the image distance:
  - If $s_i > 0$ → The image is [REAL / VIRTUAL] and [UPRIGHT / INVERTED]
  - If $s_i < 0$ → The image is [REAL / VIRTUAL] and [UPRIGHT / INVERTED]

- One can also easily find the magnification of the image formed by the lens: $\boldsymbol{m = -\frac{s_i}{s_o}}$
  - The negative sign is to show whether an image is inverted or not

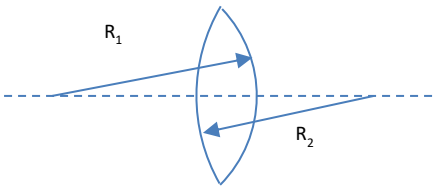
EXAMPLE: A biconcave lens has a focal length of 2 cm. If an object is placed 7 cm in front of it, where is the image located? Is this image real or virtual? Is it upright or inverted?

PRACTICE: IMAGE FORMED BY BICONVEX LENS

A biconvex lens has a focal length of 12 cm. If an object is placed 5 cm from the lens, where is the image formed? Is it real or virtual? Is it upright or inverted? What's the height of the image if the object is 2 cm tall?

CONCEPT: LENS MAKER EQUATION

- The focal length of a thin lens depends on three things:
  - The radius of curvature of the near glass
  - The radius of curvature of the far glass
  - The index of refraction of the glass itself

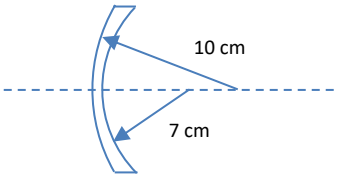


- The LENS MAKER EQUATION gives the focal length for a thin lens

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

- There is a sign convention for the radii of curvature:
  - If the center of curvature is in front of the lens → The radius is [POSITIVE / NEGATIVE]
  - If the center of curvature is behind of the lens → The radius is [POSITIVE / NEGATIVE]

EXAMPLE: The following lens is formed by glass with a refractive index of 1.52. What is the focal length of the following lens when an object is placed in front of the convex side? What about if an object is placed in front of the concave side?



EXAMPLE: WHAT TYPES OF IMAGES CAN BE FORMED BY LENSES?

What types of images can be formed by converging lenses? What about diverging lenses?

EXAMPLE: IMAGE FORMATION BY A BICONCAVE LENS

A biconcave lens has two different radii of curvature. If the radius of curvature of one piece of glass ($n = 1.52$) is 4 cm, and the radius of curvature of the other piece is 7 cm, what is the focal length of the lens? If an object is placed 5 cm from the lens, where will the image be formed? Is this image real or virtual? If the object is 1 cm tall, what's the height of the image?