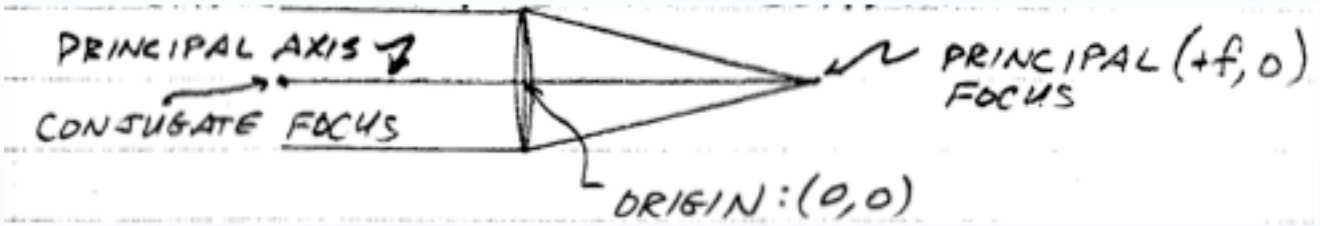
Optics: Lenses

Thin Lenses

- Thin Lenses: Any device which concentrates or disperses light.
- Types of Lenses:

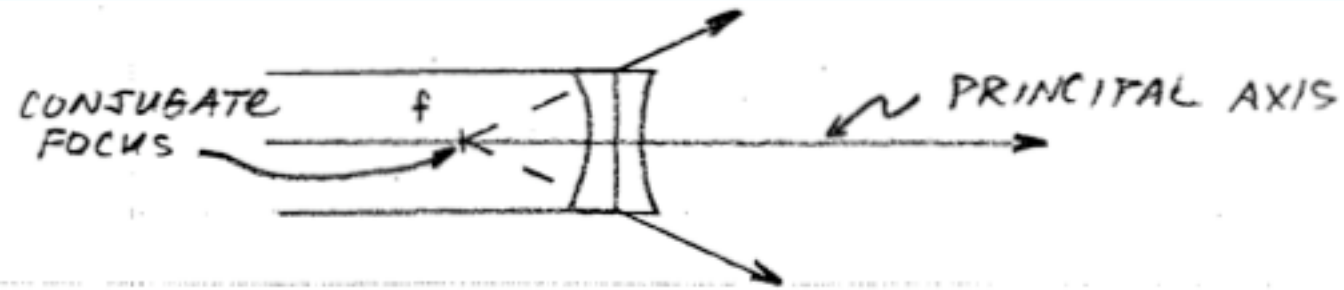
A. **Converging Lens**: Parallel rays of light are concentrated at a point called the principal focus. Shape: convex



All distances measured from the origin. The light bends because of refraction.

The focal length is the distance at which sunlight is concentrated at the burning point.

B. **Diverging Lens**: Parallel light is dispersed as if it had come from the focus. Shape: concave



- Solid lines are actual light paths.
- Dashed lines are where we thing the light travels because our brain things that light travels in straight lines.

Converging Lenses

A. f (+) = Focal Distance

p (+) = object location

q = image location

- q (+) = real, inverted image. The light rays actually intersect. We can view these images on a screen, record them on film or detect them on our retina.
- q (-) = virtual, upright image. The light rays do not actually intersect. We cannot view them on a screen. They exist only in our mind.

B. Formulas:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$Magnification, M = \left|\frac{q}{p}\right|$$

$$Height: H_{image} = M * H_{object}$$

Ex: A candle, 12 cm tall, stands 60 cm from a converging lens, whose focal length is 20 cm.

Find the location and nature of the image.

Find the magnification and the size of the image.

Cartoon: Center ray straight. Horizontal ray bends through f.

Ex: A candle, 72 cm tall, stands 45 cm from a converging lens whose focal length is 180 cm.

Find the location and nature of the image.

Find the magnification and the size of the image.

Ex: Given: p = 80 f = 80 Find q.

Diverging Lenses

- Parallel light is dispersed as if it had come from the focus.

A. f (-) = Focal Distance

p (+) = object location

q (-) = image location

Note: For all diverging lenses, regardless of the object location, the image location, q, will always be (-). Therefore, the image will always be virtual and upright. We cannot view these images on a screen. They only exist in our mind, since the light rays do not actually intersect.

B. Formulas:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$Magnification, M = \left|\frac{q}{p}\right|$$

$$Height: H_{image} = M * H_{object}$$

Ex: A candle, 12 cm tall, stands 60 cm from a diverging lens, whose focal length is -30 cm.

Find the location and nature of the image.

Find the size of the image.