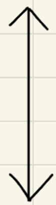
thin lenses



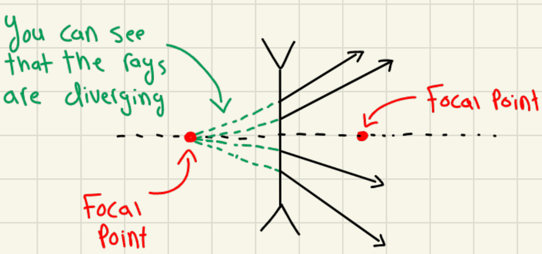
- this is a Converging lens

- this is a diverging lens

- Focal Point

- a Focal Point in thin lenses is a Specific Point Where light rays either Converge (come togther) or diverge (spread out From)

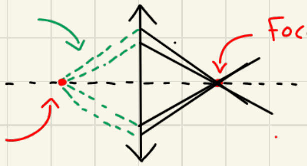
- diverging



- the dashed horizontal line is Called optical axis

- Converging

You can see that at the focal point they began to converge



Focal Point

Focal Point

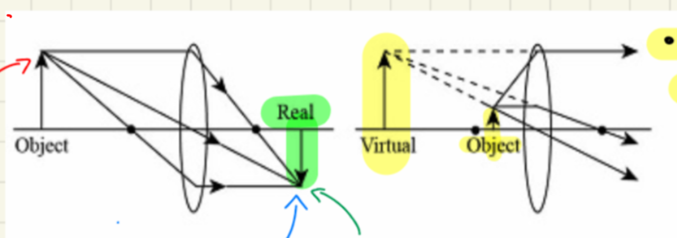
- Virtual image

- a virtual image is a image that cannot be projected on the screen because light rays don't actually meet

- Converging

- when you have a converging lens a virtual image forms on the same side as the object if its a real image it will form on the other side of the object

this here is the object



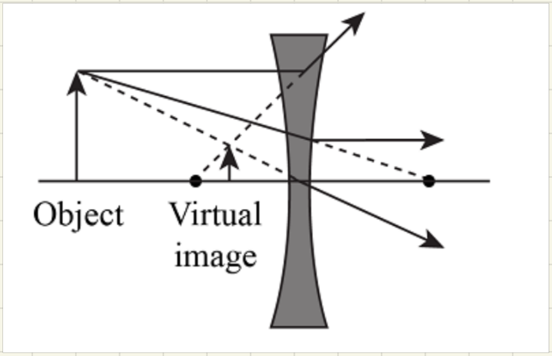
- the object and the image are on the same side

this is a real image

this is where you would see the image

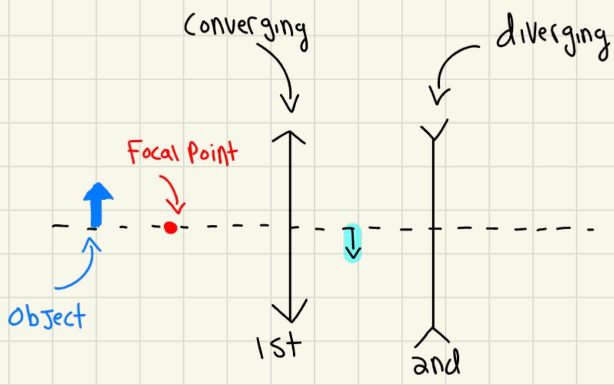
- a real image can be represented with a down arrow (↓)
- a virtual image can be represented with a upward arrow (↑)

- Diverging
  - unlike converging lenses a diverging lens Never Forms a real image
  - the "image" is always on the same side as the object
  - real image Forms when actual light rays converge at a Point but diverging lenses Spread the rays apart so the rays Never actually Meet on the oppisite side
  - however if you trace the diverging ray backward they appear to come From a Point on the same side as the object that is a virtual image



- For converging if you Place the object on the image you will Not get a image
- For diverging you always get a virtual image No matter where the object is Placed

- two lenses



- the First "o" (object distance) cannot be negitive in other words the object distance For converging cannot be negitive

- the First lens is converging and Forms a image that image will be here but For the second lens that image will act as the object but its behind the second lens so it will act as a virtual image and give you a negitive "o"

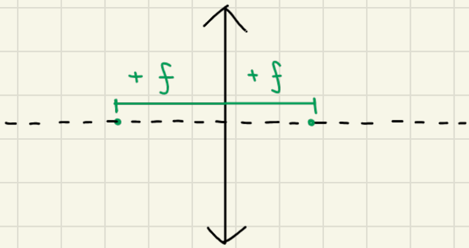
☆ a negitive "o" means the lens sees a virtual object not a real one

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$

- this equation works For converging and diverging lenses

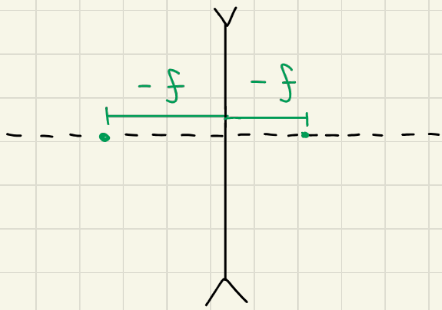
Converging

• "f": is the Focal length it goes From the lens to the Focal Point



if it is a converging lens "f" is Positive No Matter Where you approach From the left or the right Still going to be Positive

diverging

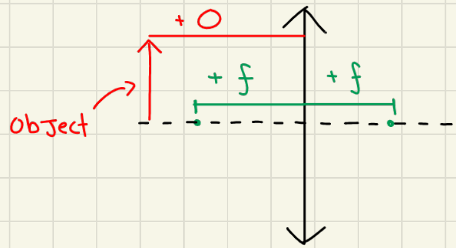


if you have diverging lens then the "f" is Negitive No matter on What Side you approach it From the "f" will be negitive

- the type of lens tells What you Should Plug in a Positive Focal length or a negitive Focal length

$f_d < 0$ and $f_c > 0$

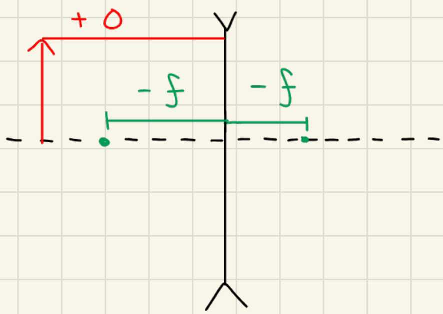
Converging



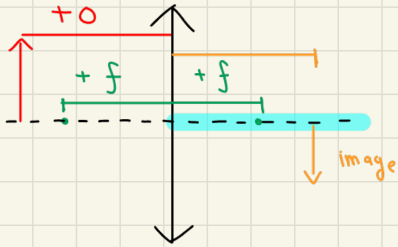
• O : the is the Object distance it is Measured From the lens to Object

the object distance will alway be Positive For Converging it is Possible to get negitive "O" but you would need to be dealing with more then one lens

diverging



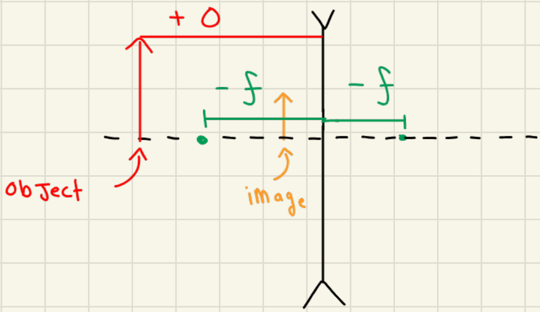
Converging



• i : the image distance this is measured from the lens to the image

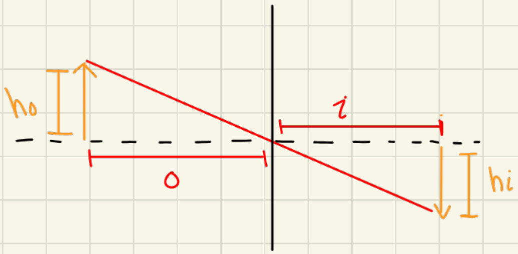
image distance will be positive if the image distance is on this side of the other side of the lens

diverging



if the image is on the same side as the object it is negitive

• Magnification equation



• notice these are similar triangles:

$$\frac{h_o}{o} = \frac{-h_i}{i}$$

the negitive comes from the h_i pointing downward

- a sensible definition of magnification is the ratio of the height of the image to the height of the object

$$M = \frac{h_i}{h_o}$$

height of image

height of object

• hence by rearanging what we had

$$M = \frac{h_i}{h_o} = \frac{-i}{o}$$

Positive Magnification Means image is upright (↑)
Negitive magnification means image is inverse (↓)

- Multiple lenses

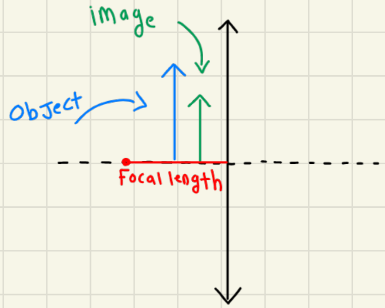
★ this is very important ★

- in a system with multiple lenses the image of the first lens becomes the object for the second lens

$$M = \left(-\frac{i}{o}\right)\left(-\frac{i}{o}\right)\cdots\cdots$$

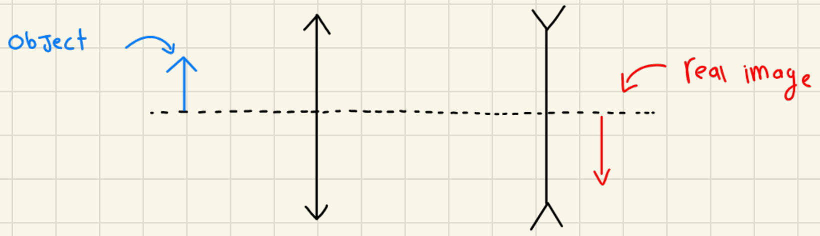
- by default there is a negitive

• You can get a virtual image From a Converging lens this only happens When you Place the object in the Focal length



• For diverging lens it does not Matter where you Place it You will always get a Virtual image

☆ You can get a diverging lens to Produce a real image but You Need a converging and diverging lens



• the converging lens needs to be Placed before the diverging lens

to get a diverging lens Produce a real image you generally need a negitive object distance (virtual object) Meaning rays are already converging before entering diverging lens