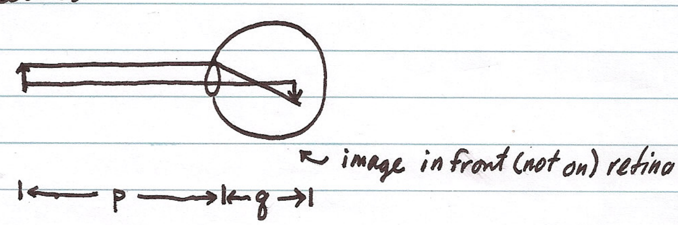
Using the Thin Lens Equation

(1) Why does bringing an object closer to a myopic eye cause it to come into focus?

> Myopic eye focusses distant objects <u>in front</u> of retina



> So image distance q is too small

> Reducing object distance p <u>increases</u> image distance q (according to the Thin Lens Equation)

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

- $\frac{1}{f}$: Constant for eye trying to focus on object
- $\frac{1}{p}$: decreasing p increases this term
- $\frac{1}{q}$: Therefore this term must decrease, i.e. q must <u>increase</u>

How correcting lenses* work: They create an image at a distance at which the uncorrected eye can focus

*eye glasses

② Correcting for Farsightedness

> Hyperopic (farsighted) eye does not refract (bend) light strongly enough

> Need a <u>converging</u> lens for extra refraction

> Nearest distance at which eye can focus is called the "near point" (increases with age)

> Use thin lens equation to find focal length of converging lens that reduces near point to desired value

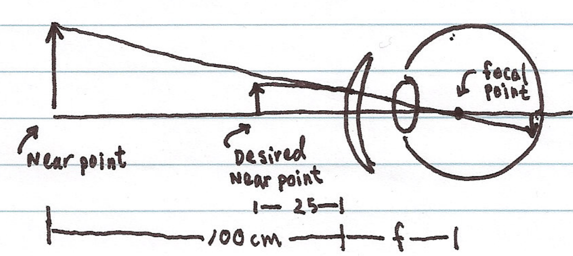
Example

Near point = 100 cm

Desired near point = 25 cm

What is f ?

Want an object at the desired near point to create an image at the actual near point (where the ~~iss~~ eye can focus)



Object distance $p = 25\text{ cm}$ (location of object we want to focus on)

image distance $q = -100\text{ cm}$ (location of the image that we want lens to produce. <0 because q is defined to be negative on front side of lens)

$$f^{-1} = p^{-1} + q^{-1}$$

$$\frac{1}{f} = \frac{1}{25\text{ cm}} + \frac{1}{-100\text{ cm}} = .04 - .01 = .03\text{ cm}^{-1}$$

$$f = \frac{1}{.03\text{ cm}^{-1}} = 33\text{ cm} \longleftarrow$$

$$\text{diopter} = \frac{1}{f} = \frac{1}{.33\text{ m}} = +3$$

(f in meters)

higher diopter $\Rightarrow$ stronger lens

③ Correcting for Nearsightedness

> Myopic eye refracts light too strongly

> Need <u>diverging</u> lens to reduce refraction

> Farthest distance at which eye can focus is called the "far point"

> Use thin lens equation to find focal length of diverging lens that increases far point to desired value

Example

Far point = 50 cm
Desired far point = ∞ (want to focus on stars)
What is f?

object distance $p = \infty$
image distance $q = -50\,cm$ (<0 because we want image to be in <u>front</u> of lens)

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{\infty} + \frac{1}{-50} = \frac{1}{-50}$$

$f = -50$ cm ($<0 \Rightarrow$ diverging (concave) lens)

$$\text{diopter} = \frac{1}{f} = \frac{1}{-0.5\,m} = -2.0$$

Summary

Condition to correct	Description	Type of lens to correct	sign of focal length & diopter
Myopia	Cannot focus farther than far point	diverging	−
Hyperopia	Cannot focus nearer than near point	converging	+