Optics

Reflection: $\theta_1 = \theta_2$; Snell's law for refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

Images form by refraction: $\frac{n_o}{o} + \frac{n}{i} = \frac{n - n_o}{R}$; n_o is the index of refraction where object is, and n is the index of refraction of the other medium. Note that the interface is a spherical surface.

Equation for spherical mirrors and thin lenses: $\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$
Mirrors: $f = R/2$; thin lenses: $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$, where R_1 is radius of first surface the light from the object meets. Focal length is the same for either side of the lens.

Rules for signs:

1. The object distance o is positive if it is in the same side as the incoming light
2. The image distance i is positive if it is in the same side as the outgoing light
3. The radius is positive if the center C is in the side of the outgoing light

Note: for mirrors, the opposite of incoming light or outgoing light side is the dark side

Magnification: lateral $m = \frac{h'}{h} = -\frac{i}{o}$. Angular magnification $M_\theta = \left|\frac{\theta_i}{\theta_o}\right|$.

The strength of the eyeglass lens and magnifying lens is given by $d = \frac{1\text{ m}}{f}$ in units of diopters.
Near sighted: Signs far away are blurry; solution: take an object at infinity and move its image to far point
Far sighted: cannot read the paper at Near point; solution: put object at Near point and take it image to closest point

Magnifying Lens: $M_\theta = \frac{0.25\text{ m}}{f}$
Compound microscope: $M = -\frac{(25\,cm)}{f_2}\frac{1}{\frac{o_1}{f_1}-1}$.
Diffracting telescope: $M = \left|\frac{f_1}{f_2}\right|$.

Wave optics:
Two slits ($N = 2$) bright fringes happens when $d\sin\theta_m = \pm m\lambda$ for $m = 1,2,3,\ldots$, while dark fringes when $d\sin\theta_n = \pm(n - 1/2)\lambda$ for $n = 1,2,3,\ldots$; n, m are called the order.
($N > 2$) minima are found at $d\sin\theta_k = \pm\frac{k}{N}\lambda$, where $\frac{k}{N} \neq m$, (not a integer multiple).

Bragg diffraction: $2d\sin\alpha = m\lambda$ where α is the angle between the incoming x-ray and the crystal structure plane

Single opening (one slit) produces a central peak with first minima at $\sin\theta = \pm\frac{\lambda}{a}$

Circular openings has the first dark circle at $\sin\theta = 1.22\frac{\lambda}{d}$.
Parallel light through a lens is not focus at a point but rather within an Airy disk or radius $r = 1.22\frac{\lambda f}{d}$; since the best ratio $\frac{f}{d} \approx 1$ then the smallest diameter of a dot is about 2.5λ

Energy momentum relation for matter and radiation: $E^2 = p^2c^2 + m^2c^4$.
An amazing result found in nature: $E = hf$ and $p = h/\lambda$
for light relation between them is simple: $f = c/\lambda$
for matter is: $f^2 = c^2/\lambda^2 + m^2c^4/h^2$