Compendium Lenses

**Single Lens systems**
The gaussian form of the thin lens formula is

\[ \frac{1}{p} + \frac{1}{i} = \frac{1}{f} = (n - 1) \left( \frac{1}{r_1} + \frac{1}{r_2} \right), \tag{1} \]

- \( n \) is the index of refraction of the lens material
- \( p \) is the distance between the object and the lens
- \( i \) is the distance between the image and the lens
- \( f \) is the focal length of the lens.
- \( r_1, r_2 \) are the radii of curvature of the two sides of the lens

For a single lens:

1. A convex (concave) lens has a focal length which is positive (negative).
2. The radii \( r_1 \) are taken as positive (negative) if the corresponding lens surface is convex (concave).
3. A real image corresponds to a positive image distance \( i \), and the image lies on the opposite side of the lens from the object. ...
4. A virtual image corresponds to a negative image distance \( i \), and the image lies on the same side of the lens from the object. ...
5. Linear magnification
6. Angular magnification

**Systems of lenses**
Optical instruments like lenses and telescopes have more than one lens or mirror. For a two lens system constructed from lenses of focal lengths \( f_1 \) and \( f_2 \), a distance \( d \) apart, the location of the final image produced by the two-lens system is constructed by the following prescription.

1. Determine the location of the image formed by the first lens \( i_1 \), using the thin-lens equation:
   \[ \frac{1}{i_1} = \frac{1}{f_1} - \frac{1}{p_1} \tag{2} \]
   Consider the original object as lying to the left of the first lens. If \( i_1 \) is positive, the image formed is real and is located to the right of the first lens. If \( i_1 \) is negative the image formed is virtual and to the left of the first lens.

2. The image of lens 1 is now the object for lens 2. This object distance is:
   \[ p_2 = d - i_1, \tag{3} \]
   where \( d \) is the separation between the two lenses. If \( i_1 > d \) the image of the first lens lies to the right of the second lens and \( p_2 < 0 \).
2. Use the thin-lens equation to calculate the final object distance \( i_2 \)

\[
\frac{1}{i_2} = \frac{1}{f_2} - \frac{1}{p_2}
\]  

(4)