Hecht 4.57:
This is essentially the same phenomenon as total internal reflection, but with the light propagation direction reversed. Rays of light entering the water at (nearly) 90° with respect to the normal are refracted into a transmitted angle equal to the critical angle for the water–air interface. Taking $n_{\text{air}} = 1.00$ and $n_{\text{water}} = 1.33$, we find the cone angle as

$$\theta_c = \sin^{-1}(n_{\text{air}}/n_{\text{water}}) = \sin^{-1}(1.00/1.33) = 48.8^\circ.$$ 

The “darkness” surrounding this cone seen by the fish could be filled with reflections from the sea floor, if it is shallow enough to be illuminated by transmitted sunlight.

Hecht 5.28:
(Solution in back of text.)

Hecht 5.32:
The two locations of the lens correspond to the interchange of object distance $s_o$ and image distance $s_i$. (This can be seen by noting that the Gaussian lens formula is unchanged under the interchange of $s_o$ and $s_i$.) For the $s_o$ and $s_i$ defined by one of the two lens positions, this fact implies

$$s_o - s_i = d.$$ 

(Here, we have taken $s_o > s_i$ for definiteness. We could also have taken $s_i > s_o$, giving $s_i - s_o = d$. The result would be unchanged.)

We also have

$$s_o + s_i = L.$$ 

Combining these two relations, we get

$$s_o = (L + d)/2 \quad \text{and} \quad s_i = (L - d)/2.$$ 

Plugging into the Gaussian lens formula, we get

$$\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i} = \frac{2}{L + d} + \frac{2}{L - d} = \frac{2(L - d) + 2(L + d)}{(L + d)(L - d)} = \frac{4L}{L^2 - d^2},$$

which when inverted gives

$$f = \frac{L^2 - d^2}{4L}.$$
Hecht 5.34:
Consider the doublet to be oriented as follows:

Denote the magnitude of the radius of curvature of both surfaces of the biconvex lens as \( R_A \). The first surface of the negative lens must have a concave surface with a radius of curvature (by convention negative as drawn) whose magnitude is also \( R_A \), if the two lenses are to be in intimate contact.

The focal length of the biconvex lens is related to \( R_A \) by
\[
\frac{1}{f_1} = (n_1 - 1) \left( \frac{2}{R_A} \right).
\]
This focal length is not given, but it can be related to the given focal lengths of the negative lens and the combined lens:
\[
\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \Rightarrow \frac{1}{f_1} = \frac{1}{f} - \frac{1}{f_2}.
\]
Substituting for \( 1/f_1 \) in the first relation and solving gives
\[
R_A = \left[ \frac{1}{2(n_1 - 1)} \left( \frac{1}{f} - \frac{1}{f_2} \right) \right]^{-1} = \left[ \frac{1}{2(1.50 - 1)} \left( \frac{1}{50} - \frac{1}{(-50)} \right) \right]^{-1} \text{cm} = 25 \text{ cm}.
\]
The focal length of the negative lens component is given by
\[
\frac{1}{f_2} = (n_2 - 1) \left( \frac{1}{(-R_A)} - \frac{1}{R_B} \right),
\]
where we have denoted the unknown radius of curvature of its second surface by \( R_B \). Solving this for \( R_B \) gives
\[
R_B = \left[ \frac{-1}{(n_2 - 1)f_2} - \frac{1}{R_A} \right]^{-1} = \left[ \frac{-1}{(1.55 - 1)(-50)} - \frac{1}{25} \right]^{-1} \text{cm} = -275 \text{ cm}.
\]
Thus the negative component of the lens is nearly plano-concave, but the nearly planar side is slightly convex (the interpretation of a negative radius of curvature of its second surface).
Hecht 5.38:  
The positive lens forms a real inverted image of the print at a distance 37.5 cm behind itself, given its focal length of +15.0 cm and the object (i.e., print) position of 25.0 cm in front of it. This intermediate image is magnified by a factor of $-1.50$. It is located at a distance of $60.0 - 37.5 = 22.5$ cm in front of the negative lens.

The negative lens then forms a virtual image of this intermediate image at a position of 9.0 cm in front of itself. This is an erect virtual image of the intermediate image, but an inverted virtual image of the original print. The negative lens demagnifies the intermediate image by a factor of $9.0/22.5 = 0.40$; the two-lens system demagnifies the original print by a factor of $-1.50 \times 0.40 = -0.60$.

Hecht 5.71:  
(Solution in back of text.)

Hecht 5.79:  
By blocking all rays from the object except those that make a very small angle with the optical axis, the pinhole allows the eye to view very nearby objects in focus. Without the pinhole, objects closer than the visual near point would send strongly diverging rays into the eye causing defocus of the retinal image. The drawback of the pinhole is that the amount of light reaching the retina is greatly reduced, so good illumination is required.

Google “pinhole magnifier”!