1) Ignoring the small distance between the eyes and the top of the head, the diagram shows that a ray originating from the foot and reflected from the bottom of the mirror will reach the eyes if the mirror is held the height of the person and is mounted with its top at the height of the person.

2) Convex spherical mirror of radius $R \Rightarrow f = R/2$.

Use \( \frac{1}{S_0} + \frac{1}{S_i} = \frac{2}{f} \) and \( M = -\frac{S_i}{S_0} \). My answer: \( R = 14.2 \text{ cm} \)

a) \( S_0 = 40 \text{ cm} \Rightarrow S_i = 12.6 \text{ cm}, M = -0.316 \Rightarrow \) real inverted image

b) \( S_0 = 19.0 \text{ cm} \Rightarrow S_i = 19.4 \text{ cm}, M = -1.02 \Rightarrow \) real inverted image
c) \( S_0 = 9.6 \text{ cm} \Rightarrow S_i = \infty, M = 0 \Rightarrow \) no image

3) Both images are behind the mirror, so that the image distances \( S_i \) and \( S_2 \) are both negative. The closer image must correspond to the convex orientation. Thus,

\[
\begin{align*}
\frac{1}{S_0} + \frac{1}{S_i} &= \frac{2}{R} \\
\frac{1}{S_0} + \frac{1}{S_2} &= -\frac{2}{R}
\end{align*}
\]

My answer: \( S_i = -26 \text{ cm}, S_2 = -10 \text{ cm} \Rightarrow S_0 = 14.9 \text{ cm}, R = 6.5 \text{ cm} \)

4) \( \frac{n_1}{S_0} + \frac{n_2}{S_i} = \frac{n_2 - n_1}{R} \Rightarrow S_i = -\frac{n_2}{n_1} S_0 \)

\( n_1 = 1.33, n_2 = 1 \Rightarrow S_i = -0.752 S_0 \)

The distance from the wall is reduced by the factor \( \frac{1}{n_1} \) as in the apparent speed.
5) Converging lens with \( f = + 19.2 \text{ cm} \). Use \( \frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} \), \( M = - \frac{s_i}{s_o} \).

a) \( s_o = 40.6 \text{ cm} \Rightarrow s_i = 36.4 \text{ cm}, \ M = -0.897 \Rightarrow \text{real, inverted, opposite side}

b) \( s_o = 19.2 \text{ cm} \Rightarrow s_i = \infty, M = \infty \Rightarrow \text{no image}

c) \( s_o = 10.0 \text{ cm} \Rightarrow s_i = -20.9 \text{ cm}, M = 2.04 \Rightarrow \text{upright, virtual, same side}

6) First consider the case of a real image behind a converging lens with focal length \( f \) at a distance \( d = s_o + s_i \) from the object, as sketched.

\[
\begin{align*}
\frac{1}{s_o} + \frac{1}{s_i} &= \frac{1}{f} \\
\frac{1}{s_o} + \frac{1}{s_i} &= \frac{1}{f} \\
\frac{s_o + s_i}{s_o s_i} &= \frac{1}{f} \\
\frac{s_o + s_i}{s_o s_i} &= \frac{1}{f} \\
\frac{s_o + s_i}{s_o s_i} &= \frac{1}{f} \\
\frac{s_o + s_i}{s_o s_i} &= \frac{1}{f} \\
\frac{s_o + s_i}{s_o s_i} &= \frac{1}{f} \\
\end{align*}
\]

Combine eqs. to obtain

\[
s_o^2 - s_o d + fd = 0 \Rightarrow s_o = \frac{d \pm \sqrt{d^2 - 4fd}}{2}
\]

My numbers: \( f = 2.36 \text{ cm}, \ d = 13.2 \text{ cm} \Rightarrow s_o = 3.08 \text{ cm} \) or \( 10.12 \text{ cm} \)

Next consider a virtual image behind the object as sketched. Recognizing that \( s_i < 0, s_o > 0 \) using the sign conventions for lenses, we identify \( d = -(s_o + s_i) \) and obtain

\[
s_o = \frac{\sqrt{d^2 + 4fd} - d}{2}
\]

by changing the sign of \( d \) in the previous solution. We must choose the positive sign for the real case to ensure \( s_o > 0 \). Thus, the nearest lens position is \( s_o = 2.04 \text{ cm} \) and there is no furthest distance.
my numbers: \( s_0 = 15 \text{ cm}, \ f = -34 \text{ cm} \)

\[
\frac{1}{s_0} + \frac{1}{s_i} = \frac{1}{f} \implies s_i = -10.4 \text{ cm}
\]

\[
M = \frac{s_i}{s_0} = 0.694
\]

To correct myopia (nearsightedness), we use a lens with \( f = -s_{fp} \) where \( s_{fp} \) is the distance to the far point, the furthest distance the eye can accommodate. The closest object that can be seen clearly with this prescription is at a distance where the virtual image produced by the lens is located at the near point of the eye, much that \( s_i = -s_{np} \). Then use \( \frac{1}{s_0} + \frac{1}{s_i} = \frac{1}{f} \implies \frac{1}{s_0} = \frac{1}{s_{np}} = \frac{1}{s_{fp}} \).

\[
s_0 = \frac{s_{np} \cdot s_{fp}}{s_{np} - s_{fp}}
\]

my numbers: \( s_{np} = 20 \text{ cm}, \ s_{fp} = 82 \text{ cm} \implies s_0 = 26.5 \text{ cm} \)

The object at distance \( s_0 \) from lens \( f_1 \) produces an image at \( s_{i1} \). The object for lens \( f_2 \) at distance \( d \) to the right of the first lens is the first image and corresponds to an object distance \( s_{02} = d - s_{i1} \). Thus,

\[
\frac{1}{s_0} + \frac{1}{s_{i1}} = \frac{1}{f_1} \quad \frac{1}{d - s_{i1}} + \frac{1}{s_{i1}} = \frac{1}{f_2}
\]

To obtain a final image at \( s_i \), we set \( s_{i1} \to \infty \) and solve for \( d \):

\[
s_{i1} \to \infty \implies d = f_2 + s_{i1} = f_2 + \frac{f_1 \cdot s_0}{s_0 - f_1}
\]

my numbers: \( s_0 = 28 \text{ cm}, \ f_1 = -15 \text{ cm}, \ f_2 = 28 \text{ cm} \implies d = 18.2 \text{ cm} \)
The virtual image produced by the diverging lens is in the focal plane of the converging lens. The final bundle is parallel, at an angle to the optical axis determined using a ray through the center of lens 2.

10a) To obtain good distance vision, the implanted lens must produce an image on the retina for an object at infinity. Hence, the power of the lens in diopters is the inverse of the lens to retina distance in meters. If the distance is 23.9 mm, the power is 41.8 diopters.

b) If the reading distance is 30 cm, reading glasses must have a power of 3.33 diopters to produce a virtual object at ∞, when the implant can focus without accommodation.