1) A plane wave is incident on an opaque object that has two narrow slits a distance $d$ apart. Before one of the slits, there is a small piece of glass, index of refraction $n$, thickness $t$. Find the expression that relates the angle of light to interference maxima at a screen far away.
1. Find an expression for interference maxima as a function of $\theta$. Physics ideas: double slit interference, relative phase change due to differences in index of refraction.

\[
\phi = \frac{2\pi}{\lambda} (r_2 - r_1)
\]

\[
d\sin \theta = m\lambda \quad \text{when sources in phase}
\]

2. Find phase difference from traveling through glass, compared to air.

\[
\phi_{\text{glass}} = \frac{2\pi}{\lambda} t
\]

\[
\phi_{\text{air}} = \frac{2\pi}{\lambda} t
\]

Path length related phase difference:

\[
\phi = \frac{2\pi}{\lambda} d\sin \theta
\]

Constructive interference when

\[
\phi_{\text{air}} + \phi_{\text{path}} = \phi_{\text{glass}} + m2\pi
\]

\[
\frac{2\pi}{\lambda} d\sin \theta = \frac{2\pi}{\lambda} t + m2\pi
\]

\[
d\sin \theta = (n-1)t + m\lambda
\]

3. When $t \to 0$ we get back double slit expression, so looks O.K.
2) A magnifier makes the image on your retina of 1 cm worm the same length as a 100m long train located 1 km away. What is the focal length of magnifier?
1. Find the focal length of the magnifier.
   Physics ideas: Magnifier makes virtual image at infinity, rays with some angles get focused to some point.

2. Writing worm and train vertically for easier diagrams

3. Use fact that eye is focused to infinity in both cases and that rays with some angles converge to some point at the plane that is one focal length from lens

4. \( \theta_{\text{train}} = \theta_{\text{worm}} \) so \( \theta_{\text{train}} = \theta_{\text{worm}} \)

   \[ \tan \theta = \frac{100\, \text{m}}{1000\, \text{m}} = \frac{1\, \text{cm}}{s_{\text{mag}}} \]

   \[ s_{\text{mag}} = 10\, \text{cm} \]

5. Correct units, but \( s_{\text{mag}} \) seems correct for a magnifying glass.