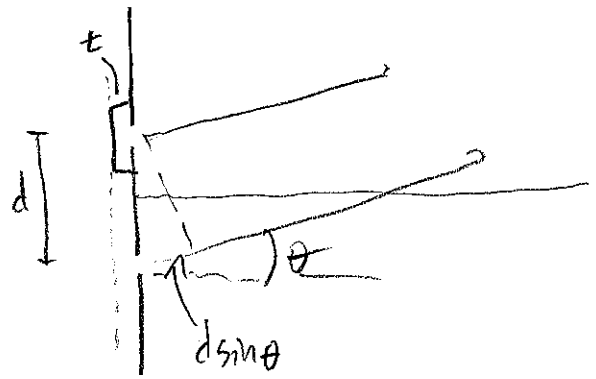
1) A plane wave is incident on an opaque object that has two narrow slits a distance d apart. Before one of the slits, there is a small piece of glass, index of refraction n, thickness t. Find the expression that relates the angle of light to interference maxima at a screen far away.

(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.

(2.)



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

$d\sin\theta = m\lambda$ ← when sources in phase

(3.) find phase difference from traveling through glass, compared to air
find phase difference from path length difference
give expression for total phase difference as multiples of 2π

(4.) glass phase difference: $\phi_{glass} = \frac{2\pi}{\lambda/n}(t)$

air phase difference $\phi_{air} = \frac{2\pi}{\lambda}t$ ← wavelength is smaller in glass

path length related phase difference: $\phi_{path} = \frac{2\pi}{\lambda}d\sin\theta$

constructive interference when (bottom ray) $\phi_{air} + \phi_{path} = \phi_{glass} + m\,2\pi$ (top ray)

$\frac{2\pi t}{\lambda} \quad \frac{2\pi}{\lambda}d\sin\theta = \frac{2\pi nt}{\lambda} + m2\pi$

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

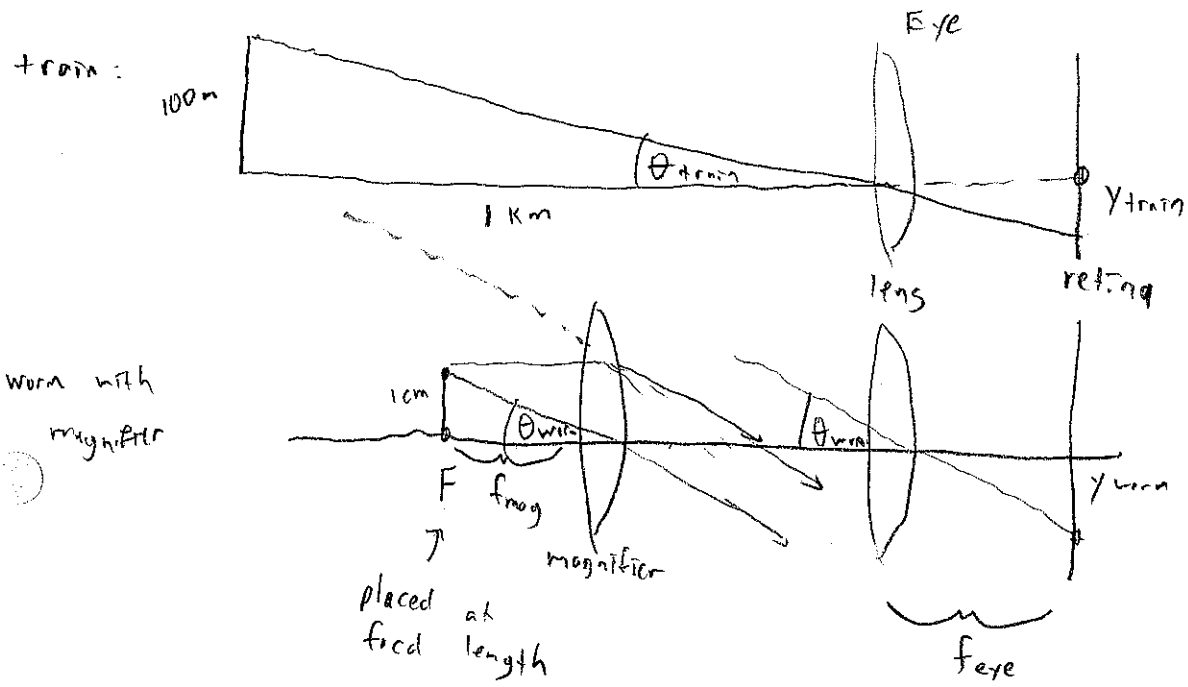
(5.) when $t \to 0$ we get back double slit expression, so looks O.K.

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: Manifier makes virtual image at infinity, rays with some angles get focused to some point.

(2.) writing worm and train vertically for easier diagrams



$M = \frac{\theta'}{\theta}$

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

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

$$\tan\theta = \frac{100\,m}{1000\,m} = \frac{1\,cm}{f_{mag}}$$

$f_{mag} = 10\,cm$

(5.) correct units, but f_{mag} seems correct for a magnifying glass