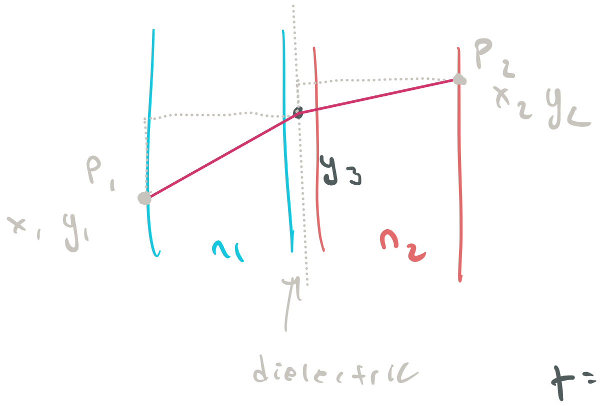
9.1) FERMAT'S PRINCIPLE $\rightarrow$ SNELL'S LAW



time to go from P_1 to P_2

$$t = \frac{n_1}{c}\sqrt{x_1^2 + (y_1 - y_3)^2} + \frac{n_2}{c}\sqrt{x_2^2 + (y_2 - y_3)^2}$$

take derivative $\rightarrow$ + set = 0 to find min

$$0 = \frac{dt}{dy} = \frac{-n_1(y_1 - y_3)}{c\sqrt{x_1^2 + (y_1 - y_3)^2}} + \frac{-n_2(y_2 - y_3)}{c\sqrt{x_2^2 + (y_2 - y)^2}}$$

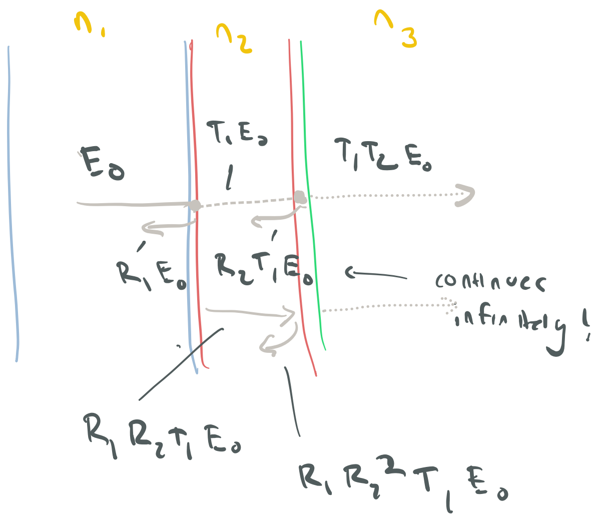
$$0 = -\frac{n_1 \sin\theta_1}{c} + \frac{n_2 \sin\theta_2}{c}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \quad \text{or} \quad \frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1}$$

9, 2)

9.3)

a)



single interface reflectivity

R_1 R_2

Transmissivity

T_1 T_2

can be derived from n_1 & n_2

so we have:

$$R_{total} = E_0 (R_1 + R_2 T_1^2 + R_2^2 T_1^2 R_1 \ldots$$

T_1^2 will remain constant after here

but we keep adding R_1s & R_2s

$$R_{total} = R_1 E_0 + \sum_{n=0}^{\infty} E_0 T_1^2 R_2^{n+1} R_1^n$$

note that we can relate n to T & R by:

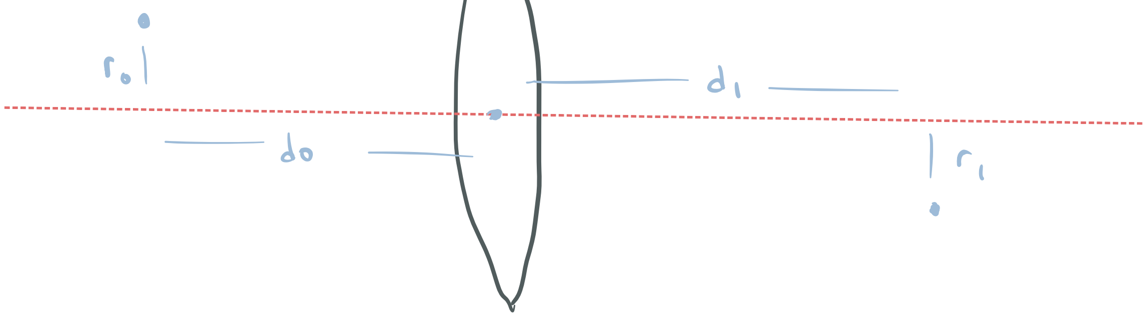
(all θ)

$$R = \frac{n_1 \cancel{\cos\theta} - n_2 \cancel{\cos\theta}}{n_1 \cancel{\cos\theta} + n_2 \cancel{\cos\theta}} = \frac{n_1 - n_2}{n_1 + n_2}$$

$$T = 2n_1 / n_1 + n_2$$

b) to get $R = 0$

9.4)



9.5) for $\lambda = 790$ nm

a) beam divergence angle for dif. grating of 1 μm

since dif. limited:

eq. (9.52) $\theta = \dfrac{\lambda}{\pi n w}$ where n = index of refraction, w = waist radius (min beam diameter)

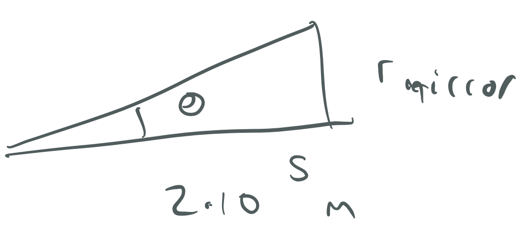
$\theta = \dfrac{790e^{-9}}{\pi(1)(1e^{-6})}$ we know w must be in the order of the grating, so:

< 0.251 rads

b) same but we would need 10x smaller wavelength

c) assuming $w = 1\text{mm} = 1e^{-3}$

$$\theta = \frac{600e^{-9}}{\pi(1)(1e^{-3})} = 190e^{-6}$$



$\tan\theta = \dfrac{r_{mirror}}{2\cdot10^5\text{ m}}$

$= 38$ meters!