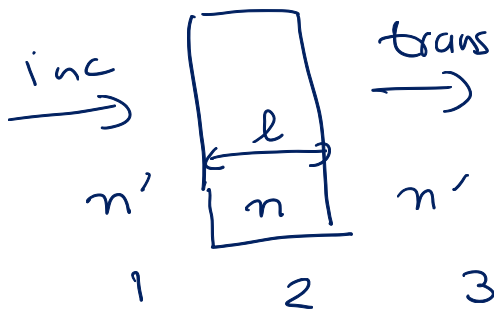
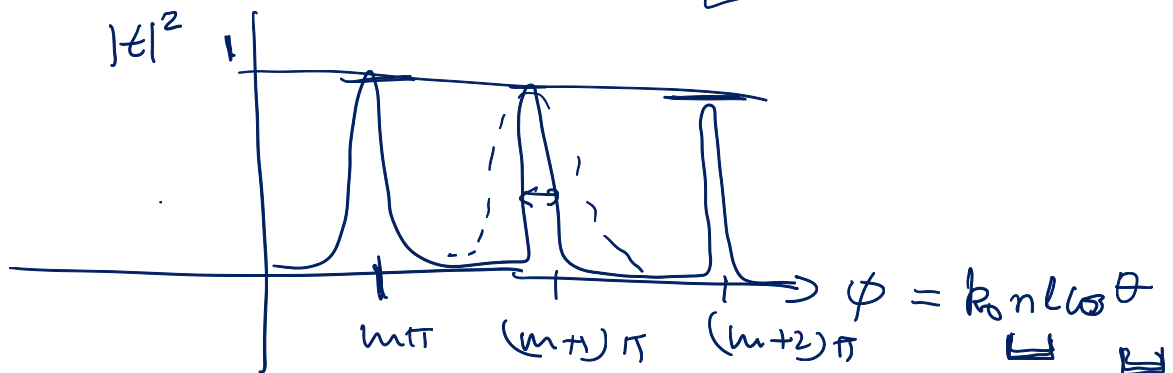


# FPI



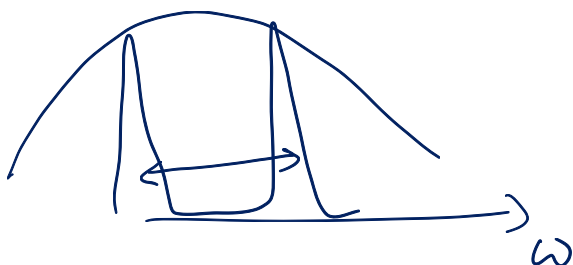
$$|t|^2 = \frac{(1-R)^2}{(1-R)^2 + 4R \sin^2 \phi}$$



$$k_0 = \frac{2\pi}{\lambda_{0m}} = \frac{2\pi}{c} (f_m) \quad \phi = m\pi$$

$$\frac{2\pi f_m}{c} n l \cos \theta = m\pi$$

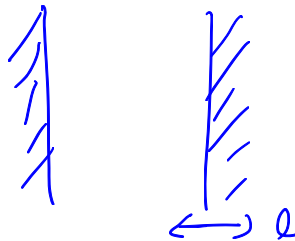
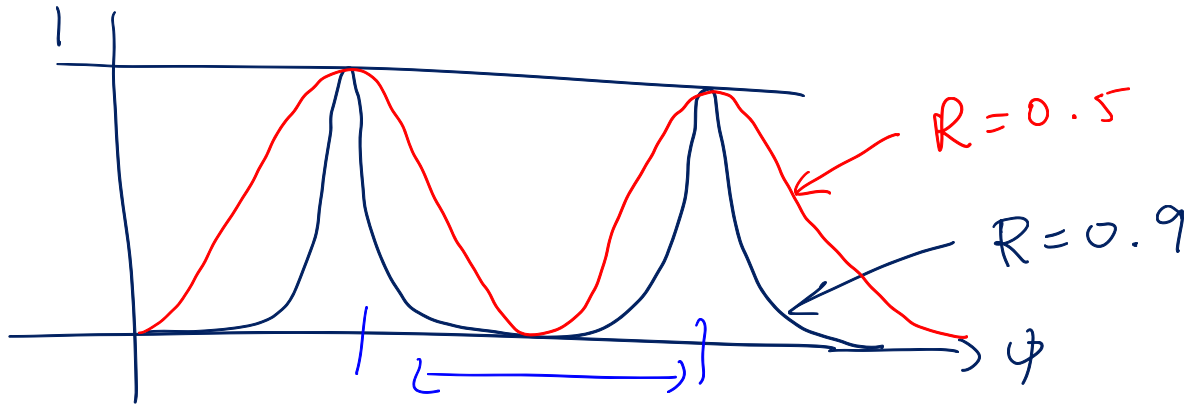
$$f_m = \frac{m c}{2 n l \cos \theta}$$



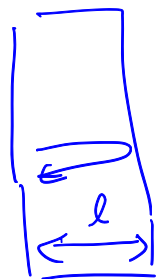
Free spectral range (FSR)

$$\text{FSR} = \Delta f = f_{m+1} - f_m$$

$$|t|^2 = \frac{c}{2nL\omega\Phi}$$



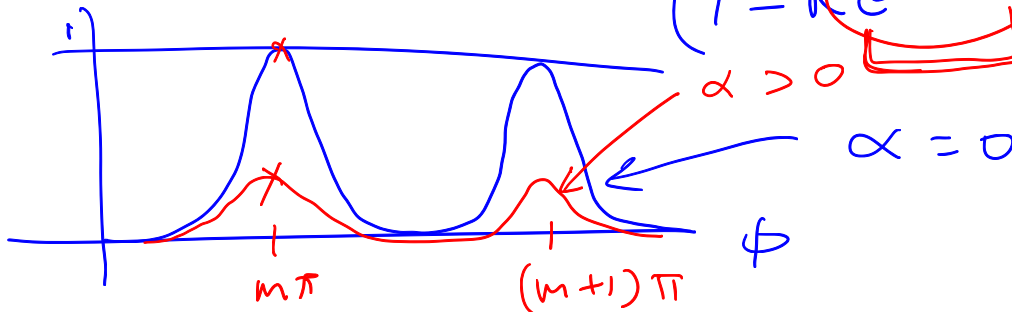
FPI with losses



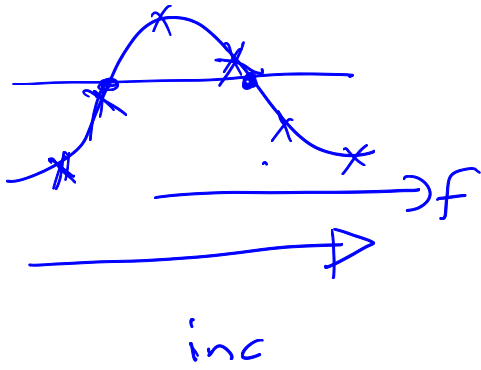
$$t = \frac{T e^{i\Phi} \cdot e^{-\alpha l}}{1 - R e^{2i\Phi} \cdot e^{-2\alpha l}}$$

$$e^{i(n+ik)l k_0} = e^{ink_0 l} e^{-k_0 k l}$$

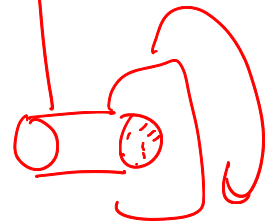
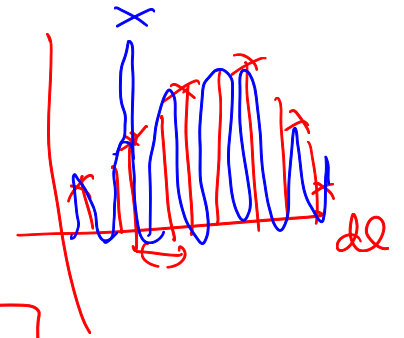
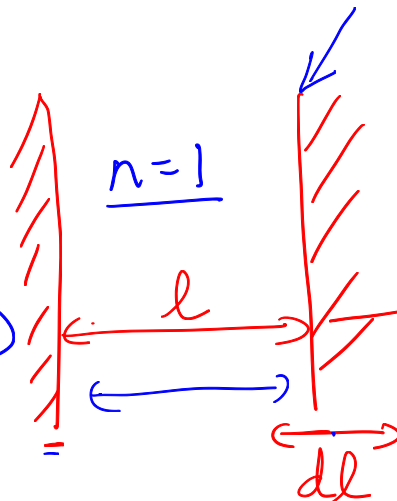
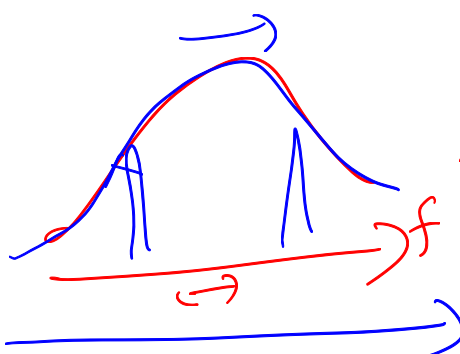
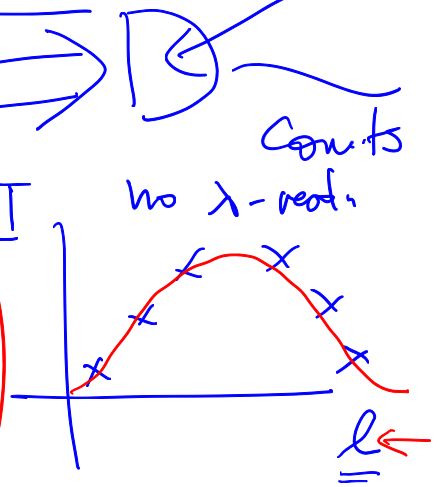
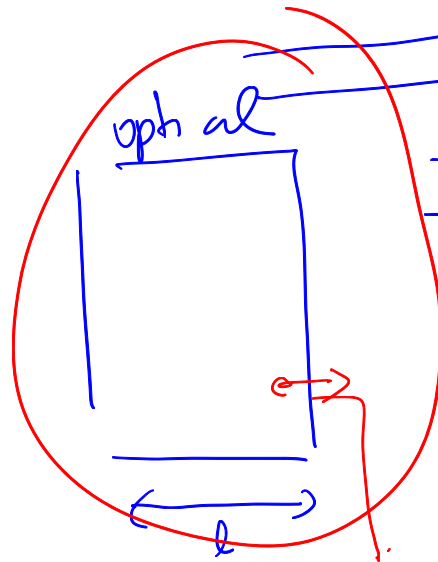
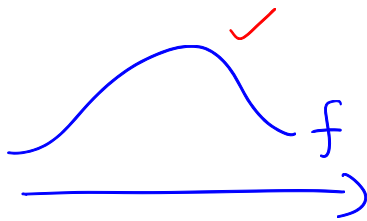
$$\frac{E_x}{|t|^2} \left( |t|^2 \right)_{\max} = \frac{(1-R)^2 e^{-2\alpha l}}{(1 - R e^{-2\alpha l})^2}$$



# APPLICATION: MEASURING OPTICAL SPECTRUM



#photons / (thru)



## Figures of merit

- (1) resolving power
- (2) (useful) spectral range

$$\text{inc: } \theta = 0^\circ ;$$

$$\text{max transmission } \phi = m\pi$$

$$\begin{aligned} k_0 l &= m\pi \\ l &= \frac{m\lambda_0}{2} \quad n=1 \end{aligned}$$

$$\rightarrow f_m = \frac{mc}{2l} \rightarrow \text{FSR} = \frac{c}{2l}$$

$$l = 15 \text{ cm}, \text{ FSR} = 1 \text{ GHz}$$

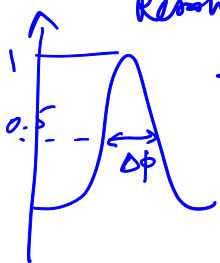
$$df = \frac{mc}{2l^2} dl = \text{FSR} \cdot \frac{m}{l} dl$$

$$\boxed{df = \text{FSR} \cdot \left( \frac{dl}{\lambda_0/2} \right)}$$

$$\boxed{dl < \lambda_0/2} \quad \checkmark$$

Resolution of the spectrum analyzer

— Calculate FWHM



$$|t|^2 = \frac{(1-R)^2}{(1-R)^2 + 4R \sin^2 \phi}$$

$$|t|^2 = 0.5 \Rightarrow \sin^2 \phi = \frac{(1-R)^2}{4R}$$

$$R \approx 1$$

$$\phi = m\pi \pm \frac{1-R}{2\sqrt{R}}$$

$$\Delta f_{1/2} = \frac{1-R}{\sqrt{R}} = \frac{2\pi l}{c} \Delta f_{1/2}$$

$$\Delta f_{1/2} = \frac{c}{2\pi l} \frac{1-R}{\sqrt{R}} = \frac{c}{2l} \left( \frac{1-R}{\pi\sqrt{R}} \right)$$

$1/F$   $\nearrow$  Finesse

## Diffraction

## Huygen - Fresnel principle

$$U(P) = \frac{A e^{i k r_0}}{r_0} \iint_S \frac{e^{i k s}}{s} K(x) dS$$

The diagram illustrates the geometry for the integral equation. It shows a point  $P$  and a point  $P_0$  on a horizontal line. A curved surface  $S$  is shown below the line. A point  $x'$  is marked on the surface  $S$ . A dashed line connects  $P_0$  to  $x'$ , and a solid line connects  $P$  to  $x'$ . The distance from  $P_0$  to  $x'$  is labeled  $r_0$ . The distance from  $P$  to  $x'$  is labeled  $s$ . A small circle around  $x'$  is labeled  $K(x)$ . An arrow points from the text "inclination factor" to the circle  $K(x)$ .