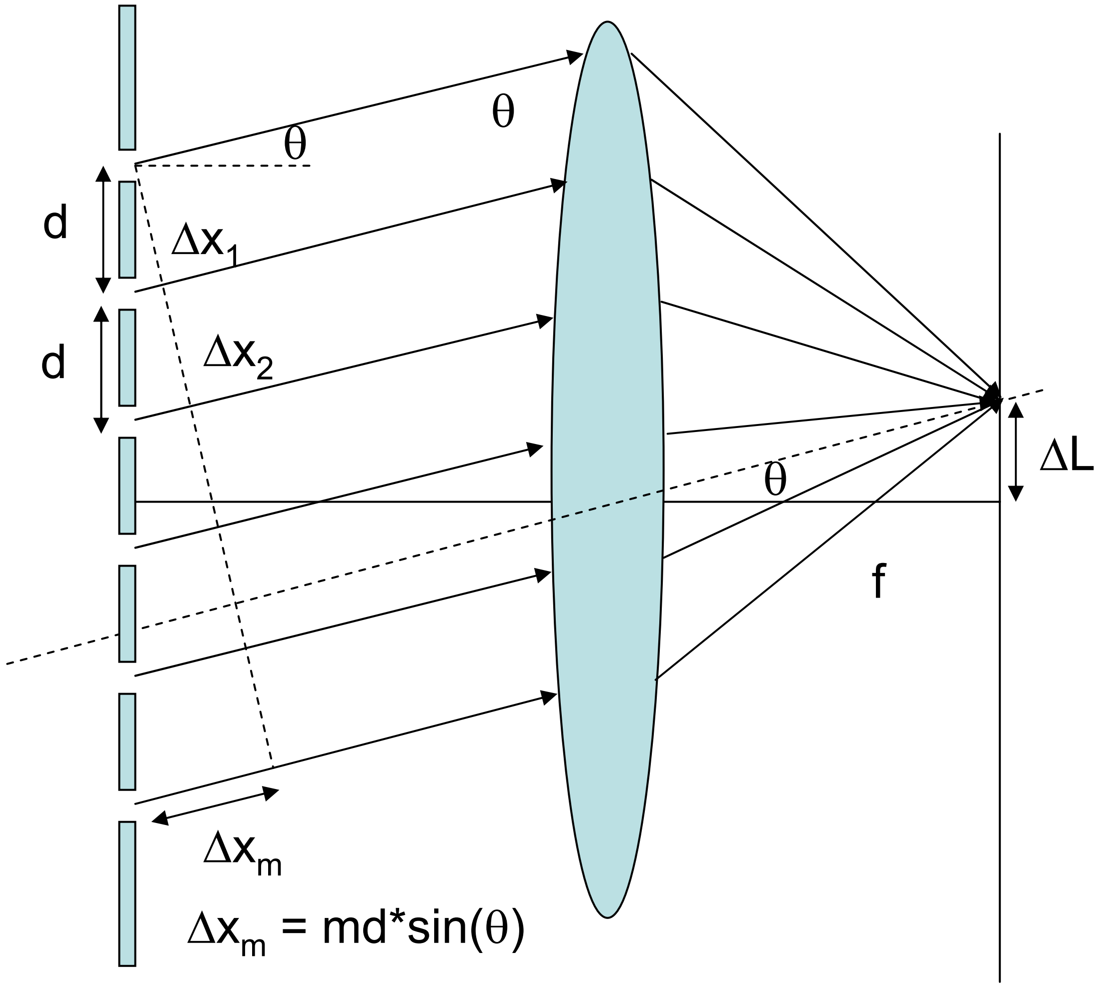
# 1: grating




$$\Delta x_m = md^*\sin(\theta)$$

$$\Delta\phi_m = k^*\Delta x_m = (2\pi/\lambda)\, md^*\sin(\theta)$$

For the grating, d = 1.0μm, f = 20cm. m = 20.

(1) What's the first maximum angle and $\Delta L$ for the wavelength $\lambda$=0.5μm (green)?

$$d^*\sin(\theta_m) = m\,\lambda$$

$$\theta_1 \sim \sin(\theta_1) = \lambda/d$$

$$\theta_1 \sim 0.5\text{rad}$$

$$\Delta L = f\,\theta_1 = 10\text{cm}$$

(2) What's the first maximum angle and $\Delta L$ for the wavelength $\lambda$=0.6μm (red)?

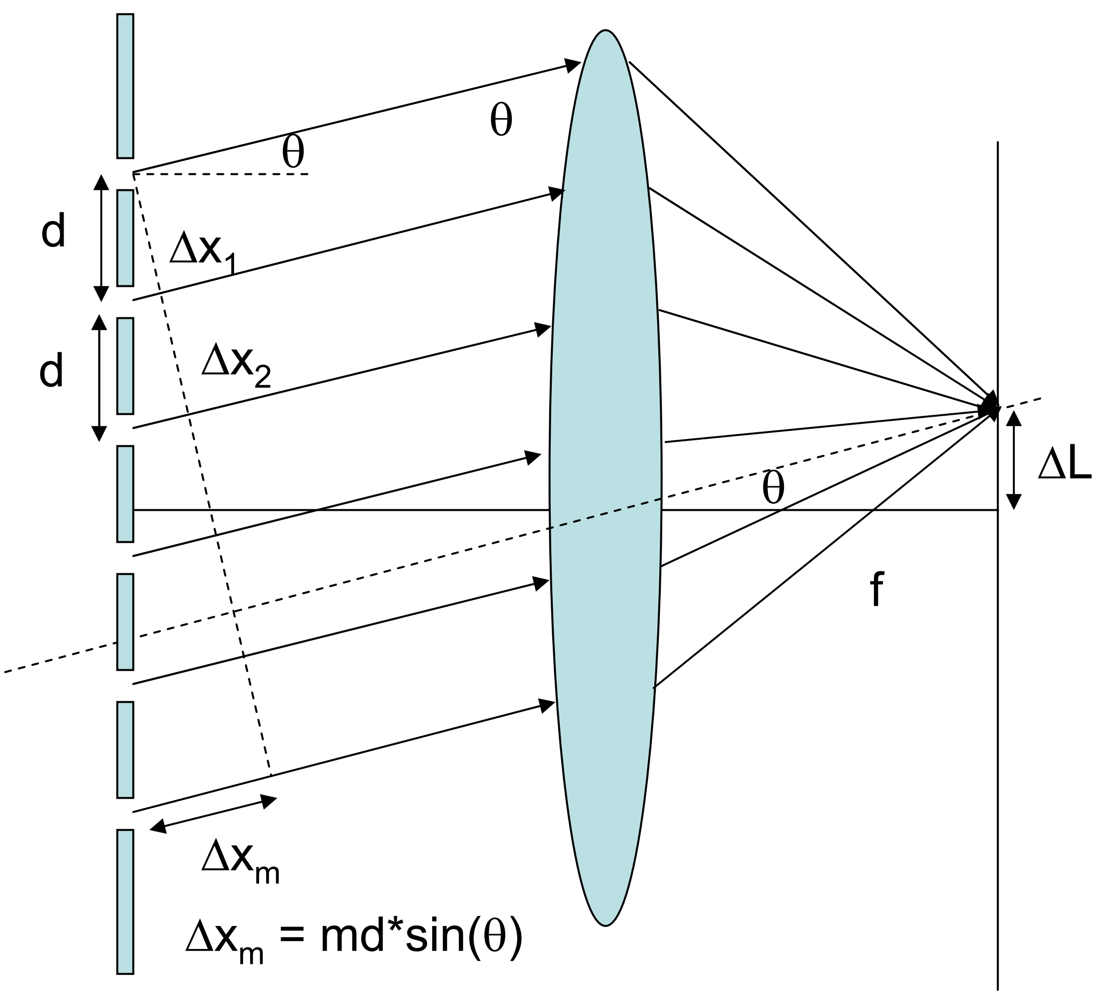
$$d^*\sin(\theta_m) = m\,\lambda$$

$$\theta_1 \sim \sin(\theta_1) = \lambda/d$$

$$\theta_1 \sim 0.6\text{rad}$$

$$\Delta L = f\,\theta_1 = 12\text{cm}$$

# 1: grating




$$\Delta x_m = md^*\sin(\theta)$$

$$\Delta\phi_m = k^*\Delta x_m = (2\pi/\lambda)\ md^*\sin(\theta)$$

For the grating, d = 1.0µm, f = 20cm. m = 20.

(3) What's you conclusion from the two lights? That's why CDs show beautiful colors.

The maximum of different wavelengths appear at different locations. Gratings are dispersive optical elements.

(4) for the wavelength $\lambda$=0.5µm, m = 10, what's the first dark angle and $\Delta L$ ?

Dark positions: $kmd^*\sin(\theta_m) = 2n\pi+\pi$

$2md^*\sin(\theta_1) = \lambda$

$\theta_1 \sim \sin(\theta_1) = \lambda/(md)$

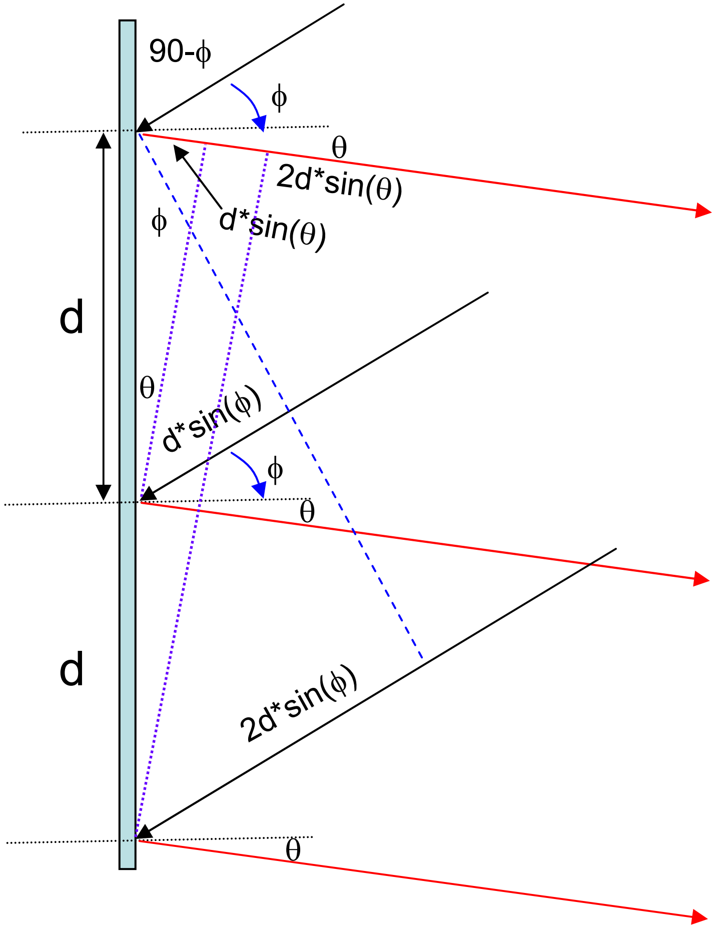
For m = 10, $\theta_1 \sim 0.05$rad

$\Delta L = f\ \theta_1 = 1$cm

For m = 100, $\theta_1 \sim 0.005$rad

$\Delta L = f\ \theta_1 = 0.1$cm

## 2: reflective grating




For the grating, d = 1.0μm, incident angle is 10º.

(1) What's the first maximum angle $\lambda$=0.5μm (green)?

$$d^*\sin(\theta_m) - d\sin(\phi) = m\,\lambda$$

$$\theta_1 \sim \sin(\theta_1) = \lambda/d + \sin(\phi)$$

$$\theta_1 \sim 0.5 + 0.17 = 0.67 \text{ rad}$$

$$\Delta L = f\,\theta_1 = 13.4\text{cm}$$

## 3: photon

$h = 6.67 x 10^{-34}$. $c = 3x10^{8}$ ( m/s)

(1) For the light with wavelength $\lambda$=0.6μm (red), what's the energy of a single photon? What's the frequency of the light? What's the momentum of the photon? What's the k vector of the light?

$v = c/\lambda = 5\times10^{14}$ Hz

$E = hv = 6.67\times10^{-34}\times5\times10^{14} = 3.3\times10^{-19} = 2eV$

$k = 2\pi/\lambda = 1.1\times10^{7}\ m^{-1}$

$p = E/c = 1.1\times10^{-27}$ Ns

(2) For the wavelength $\lambda$=0.5μm, what's the energy of a single photon? What's the frequency of the light? What's the momentum of the photon? What's the k vector of the light?

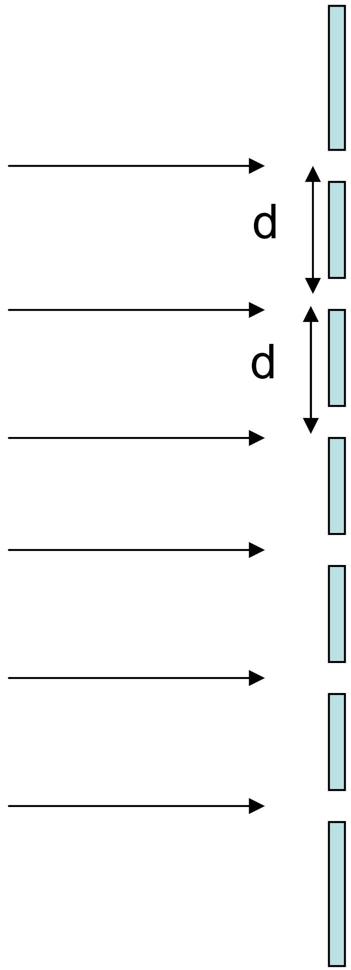
$v = c/\lambda = 6\times10^{14}$ Hz

$E = hv = 6.67\times10^{-34}\times6\times10^{14} = 4.0\times10^{-19} = 2.5$ eV

$k = 2\pi/\lambda = 1.3\times10^{7}\ m^{-1}$

$p = E/c = 1.3\times10^{-27}$ Ns

# $\underline{4}$: phase matching

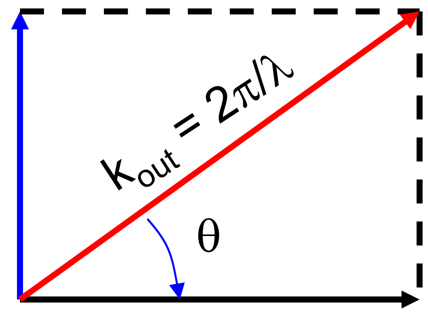



For the left grating:

(1) Draw the phase match diagram of the grating.

(2) Determine the output angle from the phase matching condition

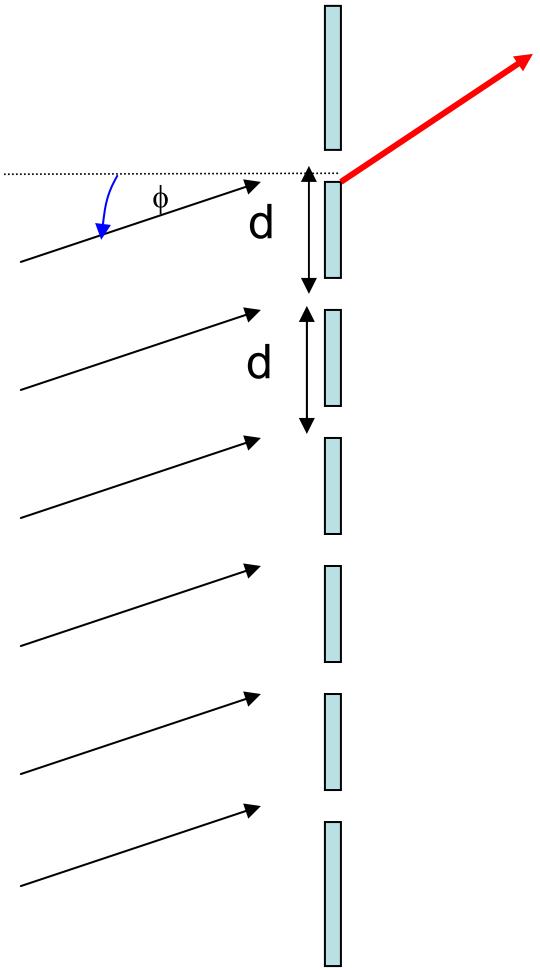
$k_{grating} = 2\pi/d$




$$k_{out} * \sin(\theta) = k_{grating} = 2\pi/d$$

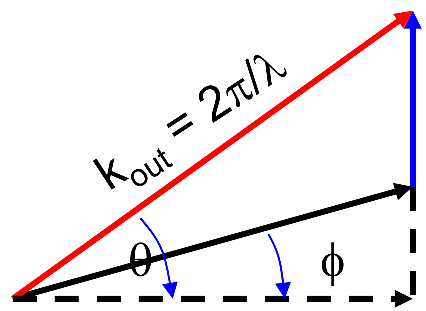
$$d * \sin(\theta) = \lambda$$

# 5: phase matching




For the left grating, if the incident angle is $\phi$ = 10º, d = 1μm,

(1) For $\lambda$ = 1.5 μm, determine the output angle using the phase matching condition.
(2) For $\lambda$ = 0.6 μm, determine the output angle using the phase matching condition.



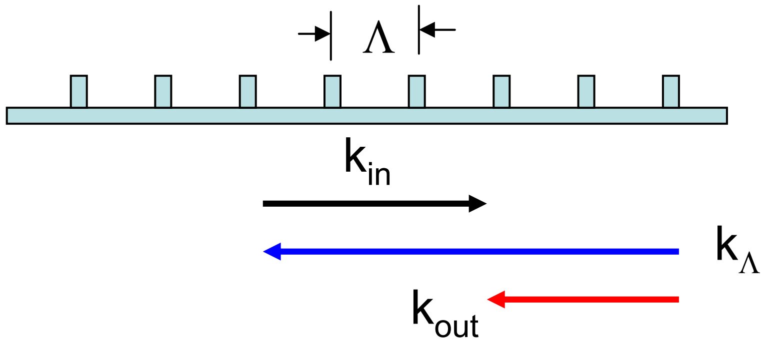

$$k_{out} * \sin(\theta) - k_{in} * \sin(\phi) = k_{grating} = 2\pi/d$$

$$\sin(\theta) = \sin(\phi) + \lambda/d$$

for the wavelength $\lambda$=0.6μm, $\theta$ = 0.87 rad

for the wavelength $\lambda$= 1.5μm, no diffration

# 6: DFB grating




For the DFB grating grating,

(1) For $\lambda$ = 1.5 μm, determine the grating period for effective reflection.

(2) For $\lambda$ = 0.6 μm, determine the grating period for effective reflection.

(1) $k_{\Lambda} = 2k_{in}$ , $\Lambda = \lambda/2 = 0.75\mu m$

(2) $k_{\Lambda} = 2k_{in}$ , $\Lambda = \lambda/2 = 0.3\mu m$