Diffraction grating

$$\boxed{I = I_0 \frac{\sin^2\beta}{\beta^2} \frac{\sin^2 N\gamma}{\sin^2\gamma}}$$

Dispersion

Angular dispersion $= \dfrac{\Delta\theta}{\Delta\lambda}$.

$$d\sin\theta = m\lambda$$

$$\frac{\Delta\theta}{\Delta\lambda} = \frac{m}{d\cos\theta}$$

Overlapping of orders

Suppose at a given angle θ

third order

$d\sin\theta = 3 \times 7000$ → red light

green light of 4^{th} order

equal.

$d\sin\theta = 4 \times 5250$.

4250×5 → 5^{th} order violet.

for visible light $\lambda_1 = 7200 \mathring{A} \leftrightarrow \lambda_2 = 4000$

first and second order no overlap.

Width of principal maximum

m^{th} order principal max forming at θ.

Net path diff $= Nm\lambda$

$Nm\lambda + \lambda \rightarrow$ zero intensity

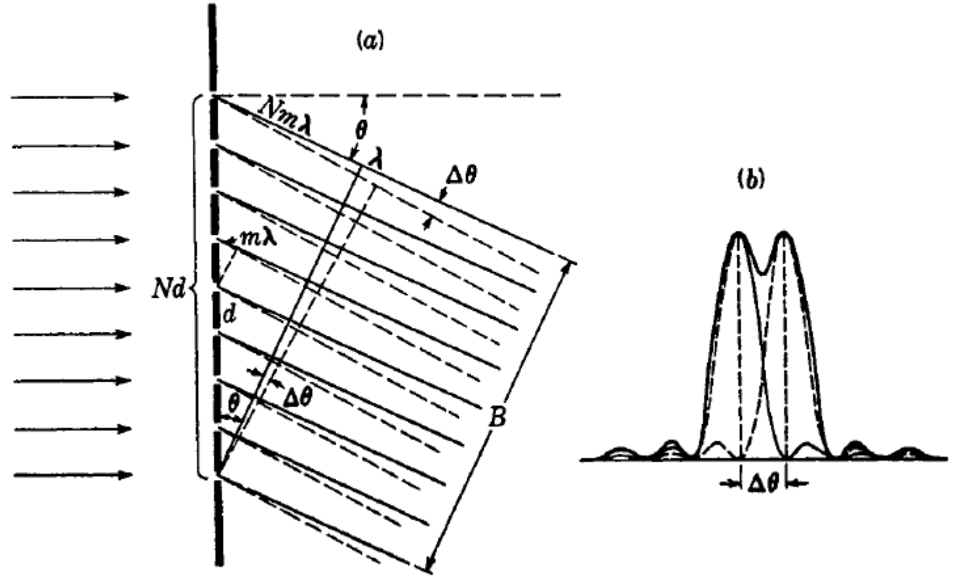


FIGURE 17G
Angular separation of two spectrum lines which are just resolved by a diffraction grating.

$\gamma = m\pi$ principal max

phase diff $\delta = 2\gamma$ from adjacent slits

$= 2\pi m$

$\rightarrow$ in phase.

first minimum on either side of any principal max will occur

$$N\gamma = mN\pi \pm \pi$$

$$\underbrace{\gamma = m\pi \pm \frac{\pi}{N}}$$

change angle by $\Delta\theta$ so that you a minimum

$$\boxed{\Delta\theta = \frac{\lambda}{B}}$$

$$\boxed{\Delta\theta = \frac{\lambda}{Nd\cos\theta}}$$

Angular half width of maxima.

Resolving power

$\frac{\lambda}{\Delta\lambda} \longrightarrow$ chromatic resolving power

light of wavelength $\lambda + \Delta\lambda$ must form principal maximum at the same angle as the 1st minimum of λ.

$\Downarrow$

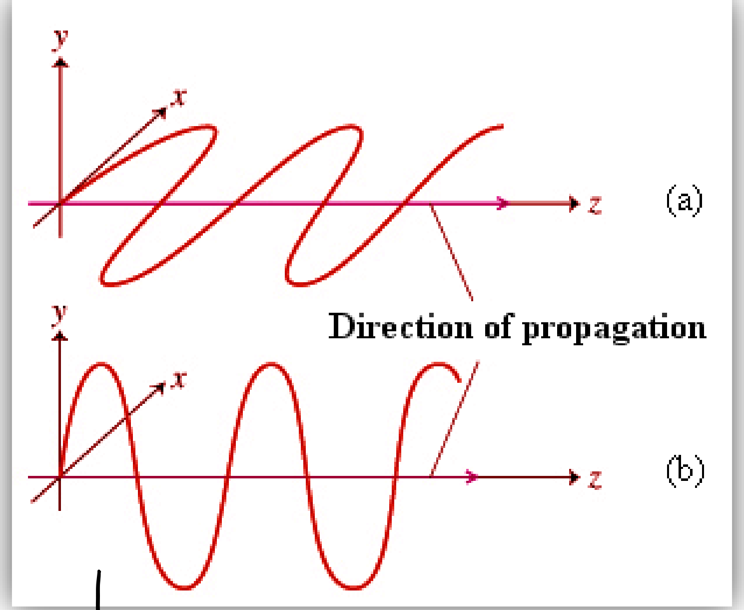
Hence

$$mN\lambda + \lambda = mN(\lambda + \Delta\lambda).$$

$$\boxed{\frac{\lambda}{\Delta\lambda} = mN}$$

Polarization

So far we have not needed the transverse nature of light.



Transverse vibration of a string.

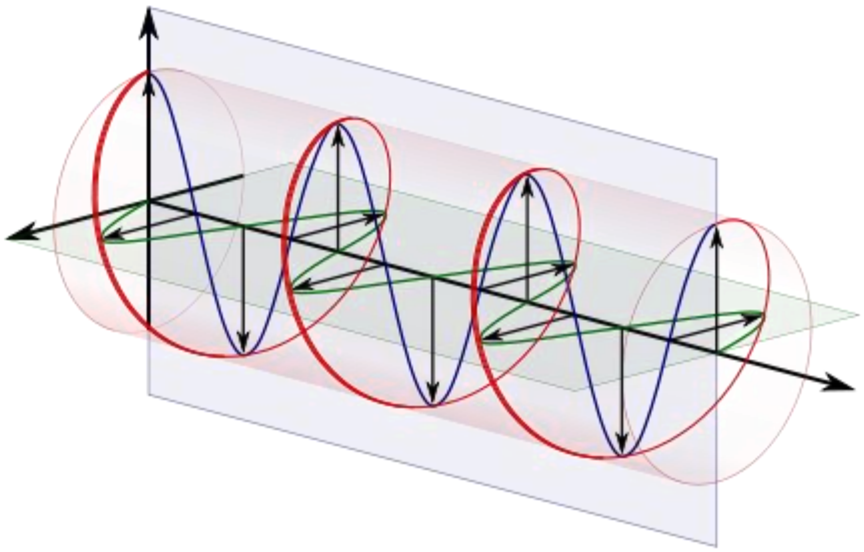
x - polarized → linearly polarized wave

$$x(z,t) = a\cos(kz - \omega t + \phi_1)$$

$$y(z,t) = 0 \ .$$

$$y(z,t) = a\cos(kz - \omega t + \phi_2)$$

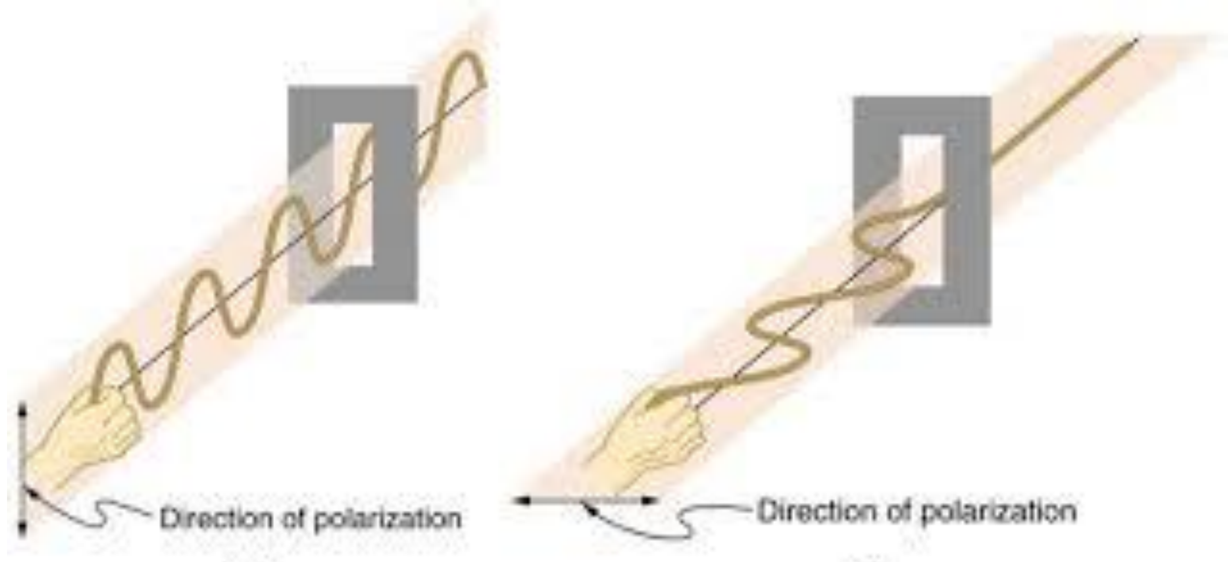
$$x(z,t) = 0$$



circular polarization

$$x(z,t) = a\cos(kz - \omega t + \phi)$$

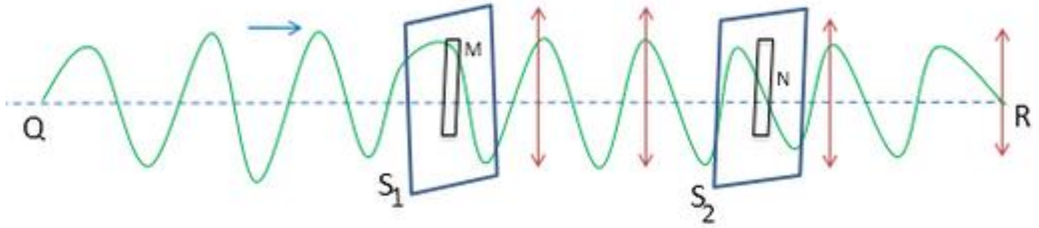
$$y(z,t) = a\sin(kz - \omega t + \phi).$$

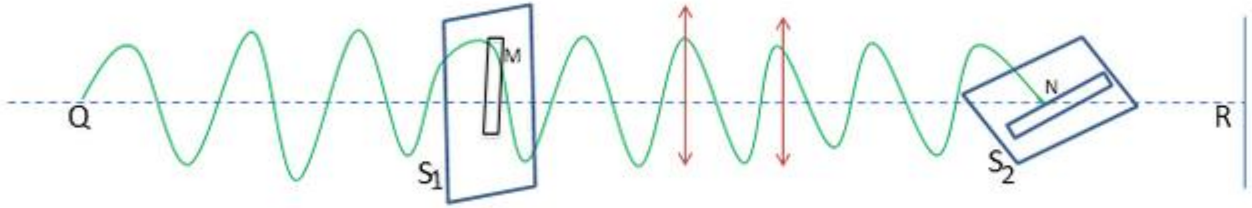


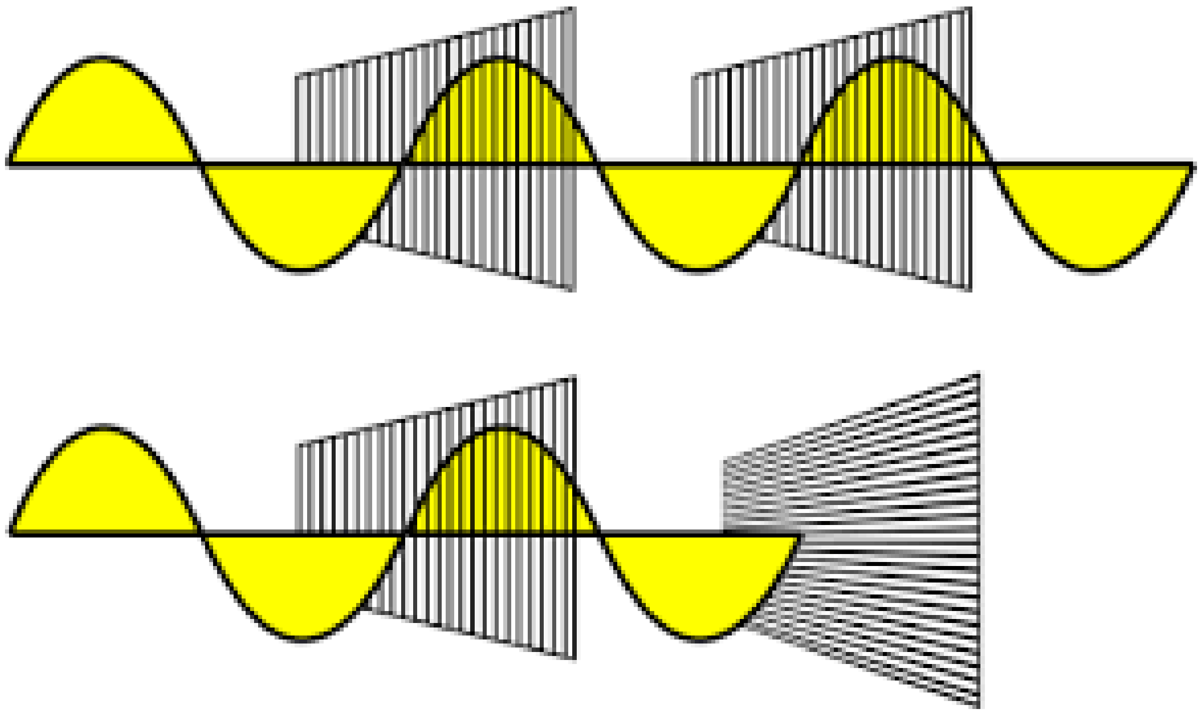
(a) (b)

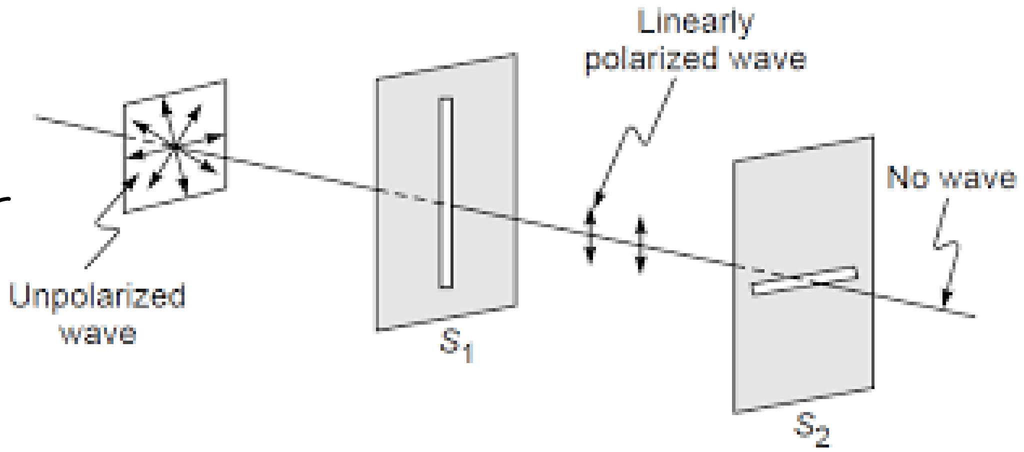
slit in direction
of vibration
entire amplitude
gets transmitted

⊥ to direction of polarization
nothing gets transmitted.

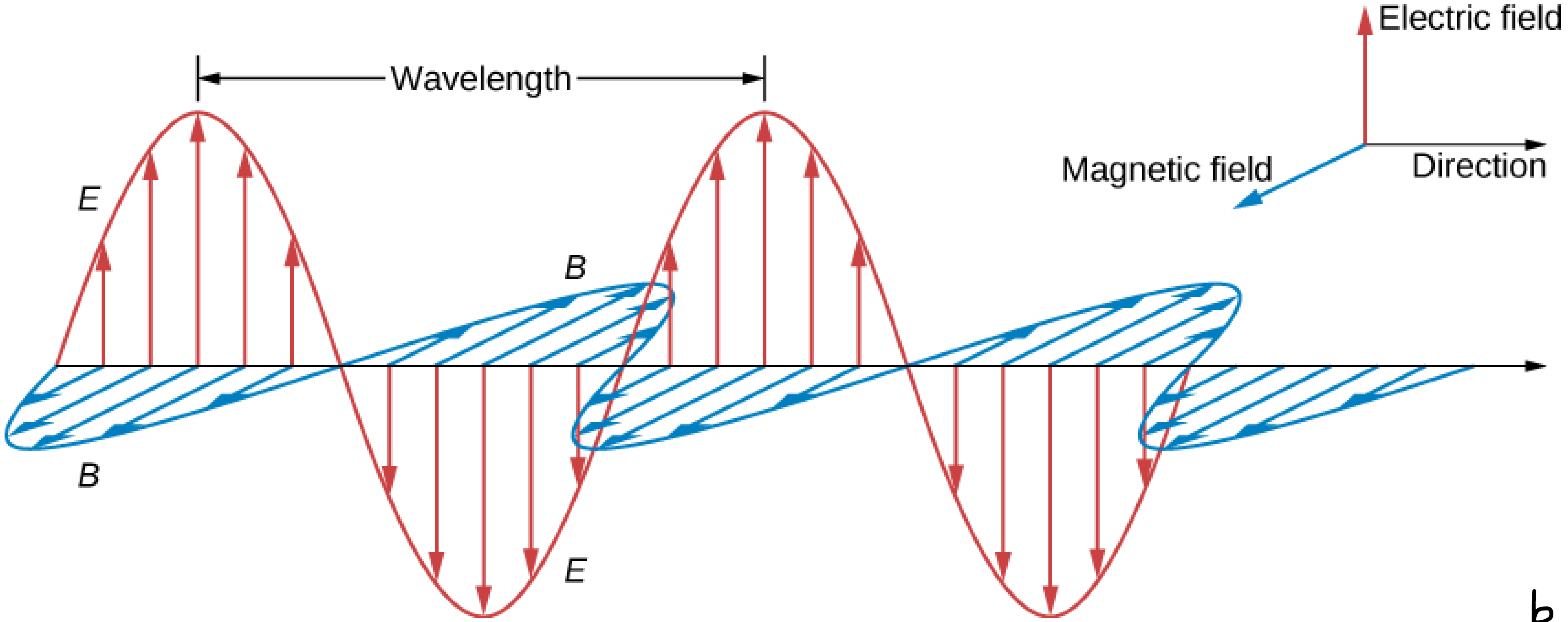

M
N
Q
R
S_1
S_2


M
N
Q
R
S_1
S_2





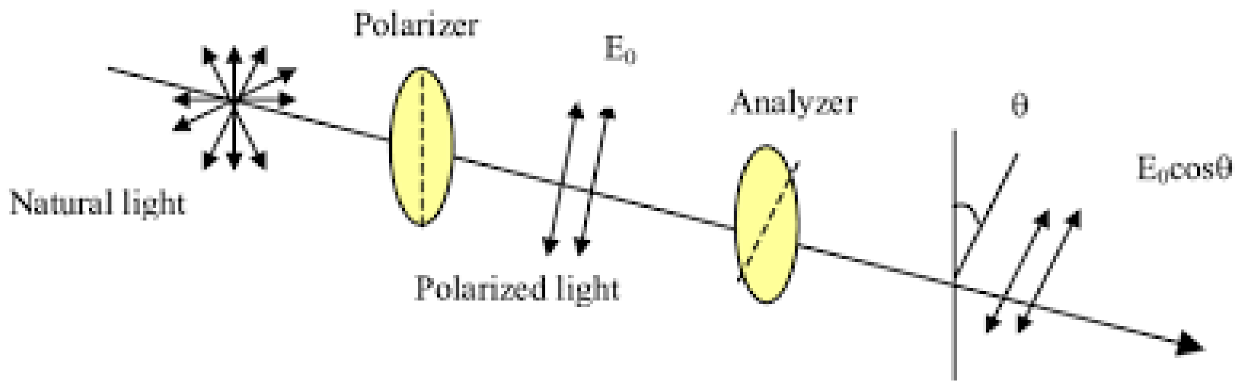
plane of vibration is changed at random at short intervals of time.

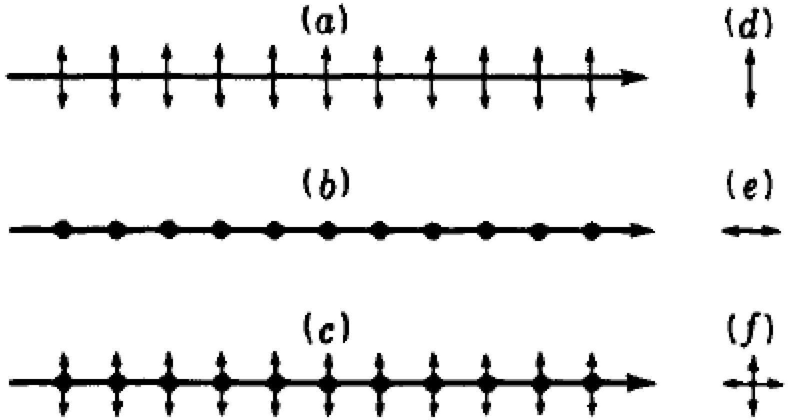


$$\left.\begin{aligned} E_x &= E_0 \cos(kz - \omega t), \quad E_y = 0, \quad E_z = 0 \\ B_x &= 0, \quad B_y = B_0 \cos(kz - \omega t), \quad B_z = 0 \end{aligned}\right\}$$

$$k = \frac{\omega}{c}$$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$


Polarizer
E_0
Analyzer
θ
$E_0\cos\theta$
Natural light
Polarized light


(a)
(b)
(c)
(d)
(e)
(f)