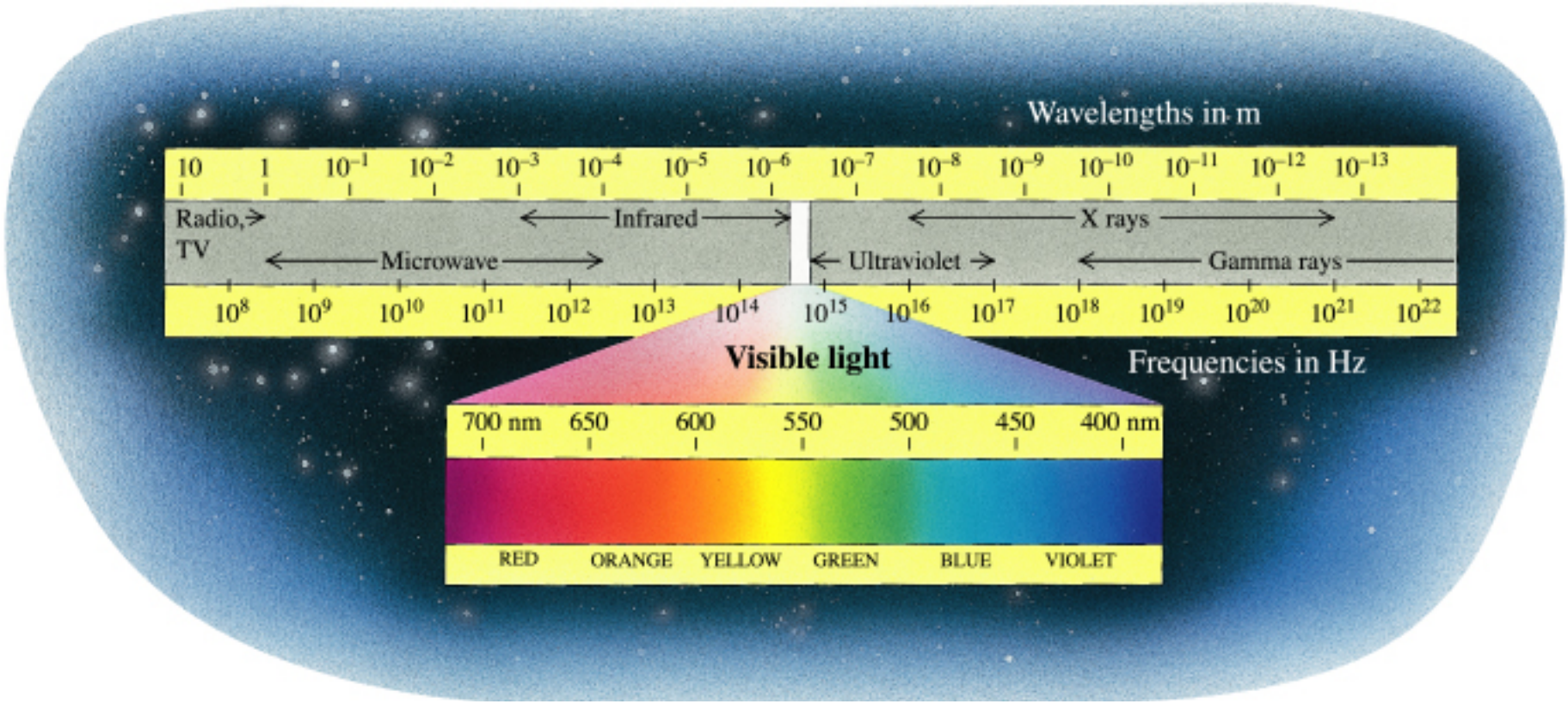
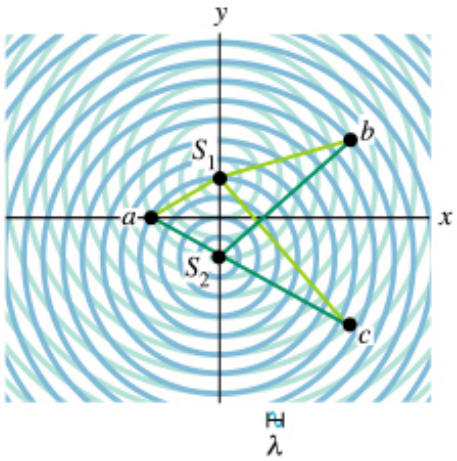
Ch 35. Interference

35-1. Interference & Coherence Sources

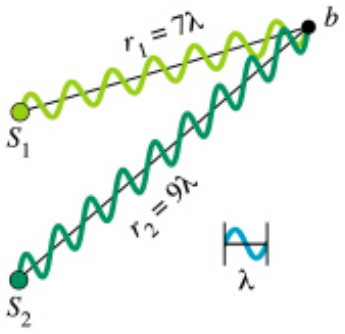


$$c = \lambda f$$

Interference

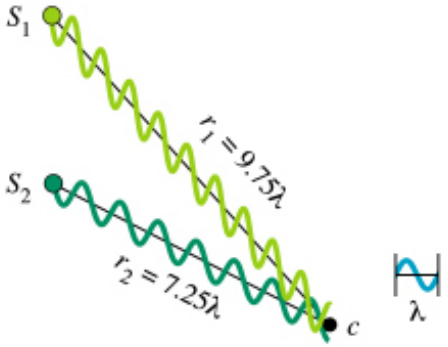


(a)



(b)

Δr=2λ
Constructive



(c)

Δr=2.5λ
Destructive

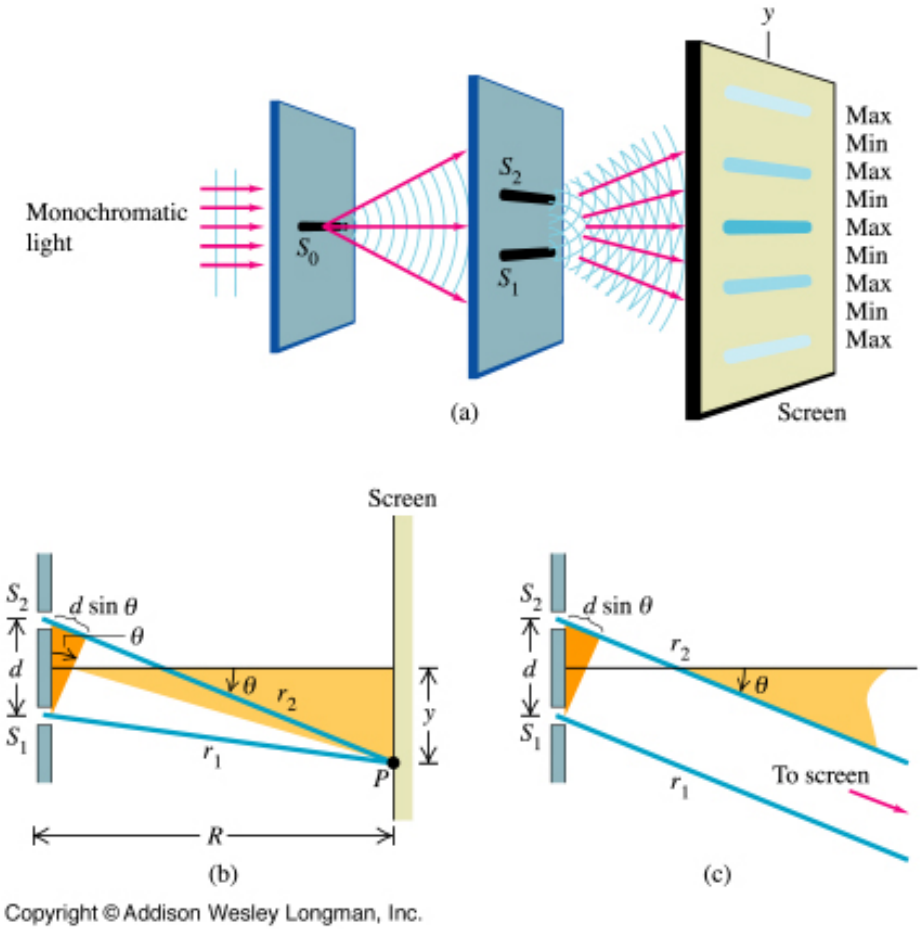
Path difference

λ/2, 3λ/2, 5λ/2…	Destructive interference
0, λ, 2λ, 3λ...	Constructive interference

Coherent Sources: two monochromatic sources of the same frequency & with any definite, constant phase relation (not necessarily in phase).

35-2. Two Source Interference of Light

Thomas Young's experiment (1800)



Assumptions:

Monochromatic

Coherent

Path difference

r_2-r_1=d sinθ

Constructive interference (Bright fringes):

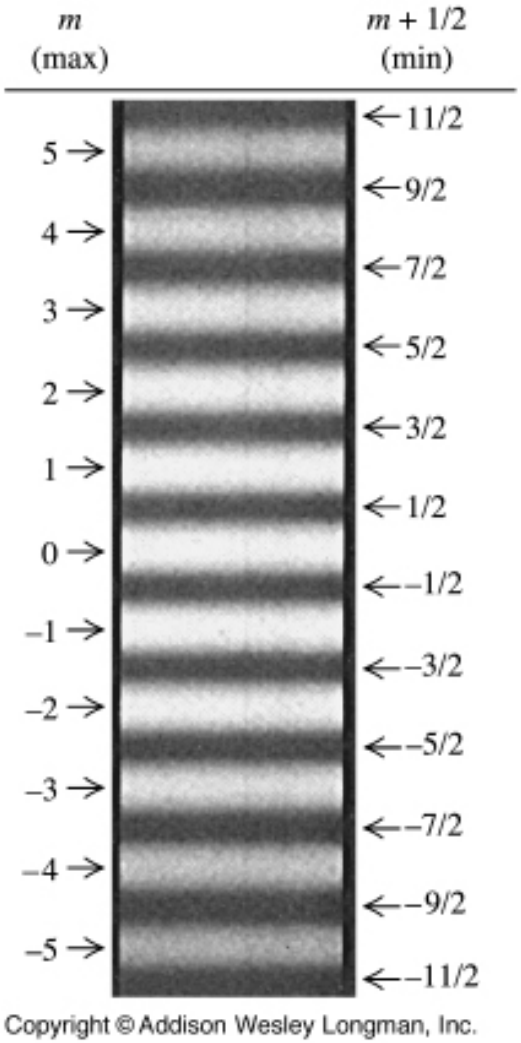
$$d \sin\theta = m\lambda$$

Destructive interference (Dark fringes):

$$d \sin\theta = (m + \frac{1}{2})\lambda$$

$$m = 0, \pm 1, \pm 2, \ldots$$

Interference Fringes



For small angles only

Constructive interference in Young's Exp:

$y_{max} = R \tan\theta_m \cong R \sin\theta_m$

$y_{max} = Rm\lambda/d$ $(R >> d, R >> y_m)$

$= 0, \pm R\lambda/d, \pm 2R\lambda/d, \pm 3R\lambda/d \ldots$

Center is a maximum

$y_{min} = R(m + 1/2)\lambda/d$

$= \pm R\lambda/2d, \pm 3R\lambda/2d, \pm 5R\lambda/2d \ldots$

Spacing between adjacent maxima /minima: $R\lambda/d$

35-3. Intensity in Interference Patterns: Mathematical Method

Electric fields at point P:

$$E_1 = E \cos(\omega t + \phi)$$
$$E_2 = E \cos \omega t$$

Superposition:

$$E_1 + E_2 = E \cos(\omega t + \phi) + E \cos \omega t$$
$$= 2E \cos(\phi/2) \cos(\omega t + \phi/2)$$
$$= E_P \cos(\omega t + \phi/2)$$

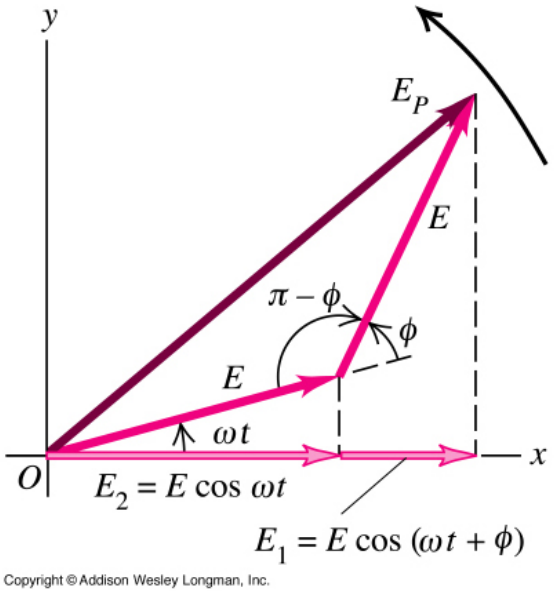
Amplitude: $E_P = 2E \left|\cos(\phi/2)\right|$

Intensity

$$I \propto E_P^2 = 4E^2 \cos^2(\phi/2)$$

Or: $I = I_o \cos^2(\phi/2)$

Intensity in Interference Patterns: Phasor Diagram



Amplitude: $E_P = 2E\,|\cos(\phi/2)|$

Intensity

$$I \propto E_P^2 = 4E^2 \cos^2(\phi/2)$$

Or: $I = I_o \cos^2(\phi/2)$

Intensity at *y*

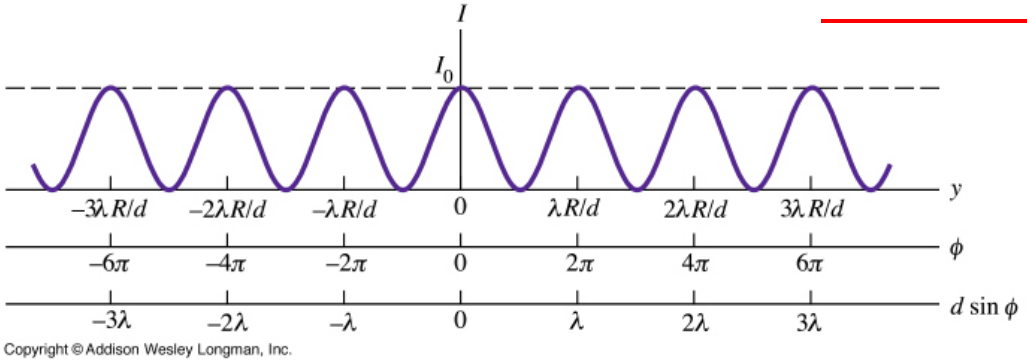
$$\frac{\phi}{2\pi} = \frac{r_2 - r_1}{\lambda}$$

Phase difference: $$\phi = \frac{2\pi}{\lambda}(r_2 - r_1) = k(r_2 - r_1) = kd\sin\theta = \frac{2\pi d}{\lambda}\sin\theta$$

Intensity: $$I = I_o \cos^2\frac{\phi}{2} = I_o \cos^2(\frac{\pi d}{\lambda}\sin\theta)$$

Maximum Intensity: $\frac{\pi d}{\lambda}\sin\theta = m\pi$ or: $d\sin\theta = m\lambda$

Small slits (y<<R, then sinθ = y/R) $$I = I_o \cos^2(\frac{\pi dy}{\lambda R})$$



All peaks have same intensity.