Interference / Diffraction

Superposition

$$\sum \vec{F} = \vec{F}_1 + \vec{F}_2 = m\vec{a}_{TOT}$$

$$\vec{E}_{TOT} = \vec{E}_1 + \vec{E}_2 + \cdots$$

$$\vec{B}_{TOT} = \vec{B}_1 + \vec{B}_2 + \cdots$$

$$I_{TOT} = I_1 + I_2$$ Intensity

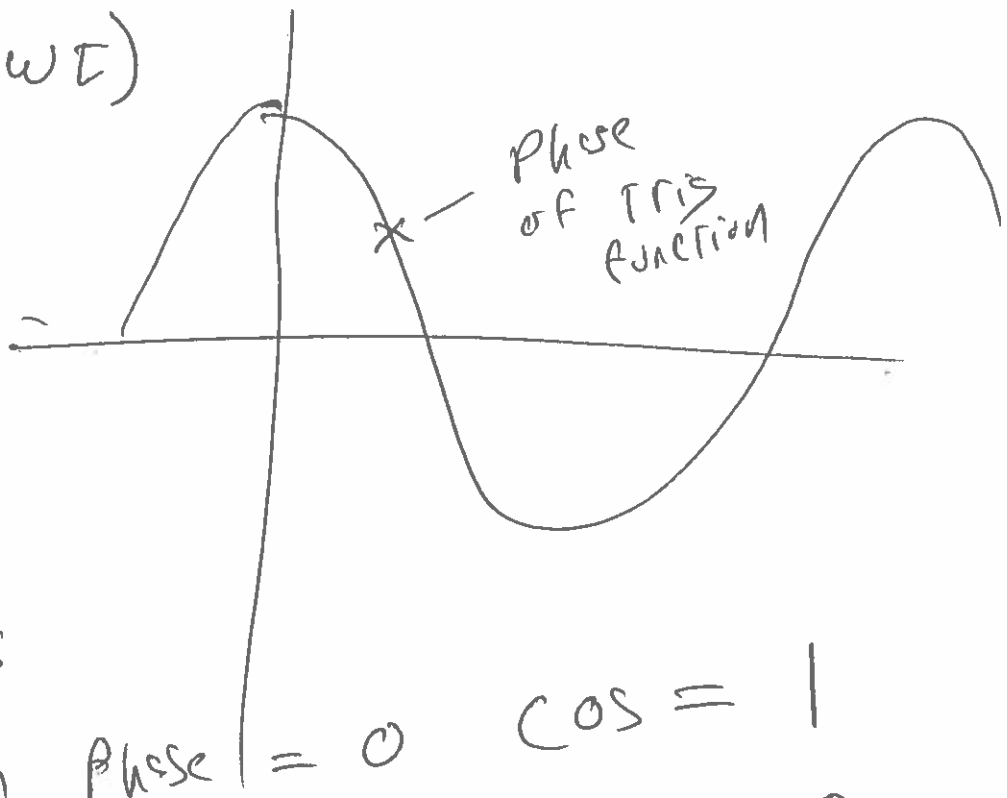
$$I \propto |E|^2$$

$$I_1 + I_2 \overset{?}{=} |E_1|^2 + |E_2|^2$$

$$\overset{?}{=} |E_1 + E_2|^2$$ Phase

$$|E_1 + E_2|^2 = |E_1|^2 + |E_2|^2 + \underbrace{2|E_1||E_2|}_{\text{Interference}}$$

cos (ωt)



for cos

When Phase = 0 cos = 1

When Phase = 90° cos = 0

When Phase = 180° cos = -1

When Phase = 270° cos = 0

When Phase = 360° cos = 1

Phase can also referred by fractions of Wavelength

$0\lambda \Rightarrow \cos = 1$

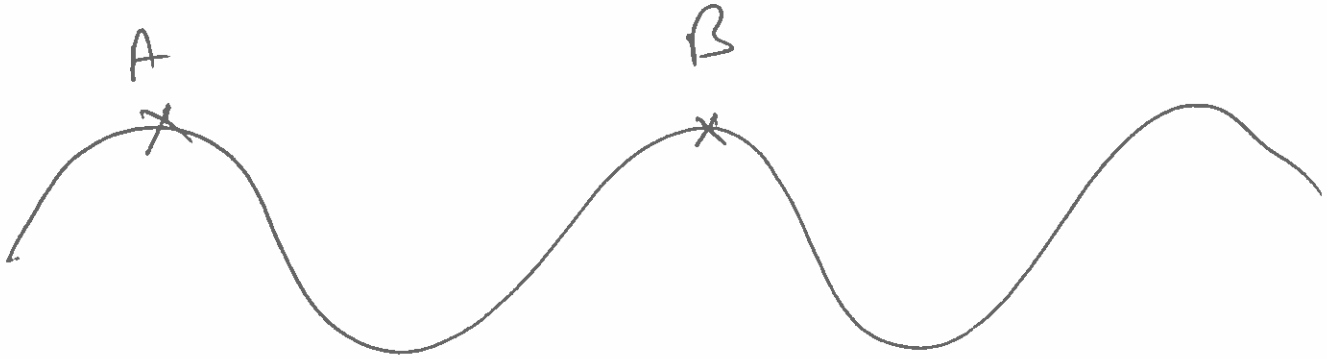
$\frac{1}{4}\lambda \Rightarrow \cos = 0$

$\frac{1}{2}\lambda \Rightarrow \cos = -1$

$\frac{3}{4}\lambda \Rightarrow \cos = 0$

$\lambda \Rightarrow \cos = 1$

Wavelength $\Rightarrow$ Spatial Phase



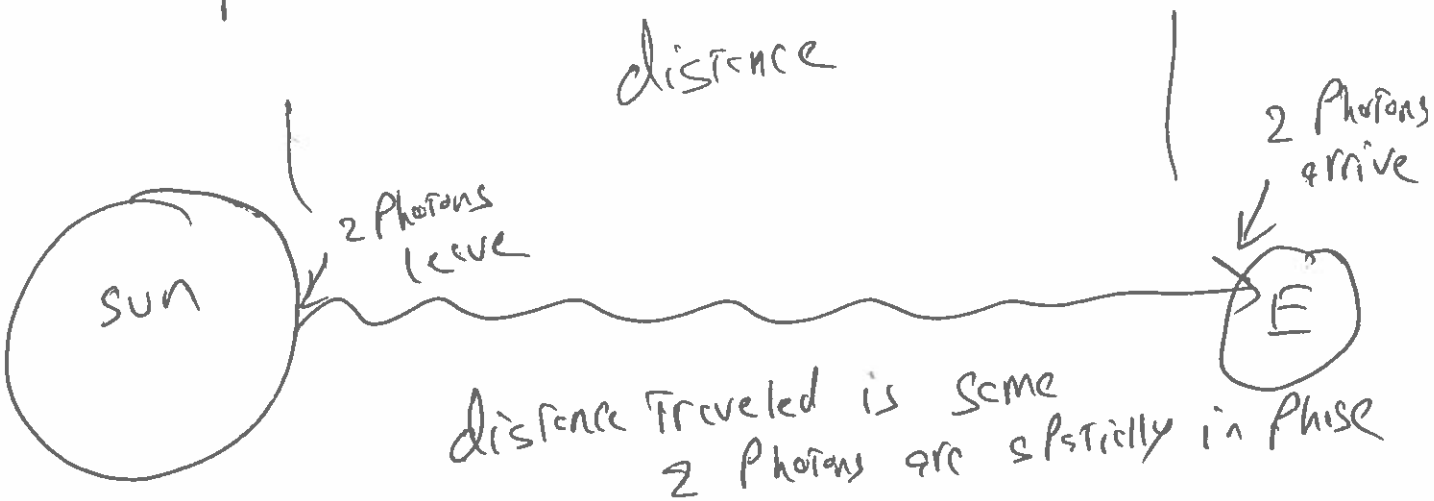
$N = \lambda f$

B is 1 λ from A

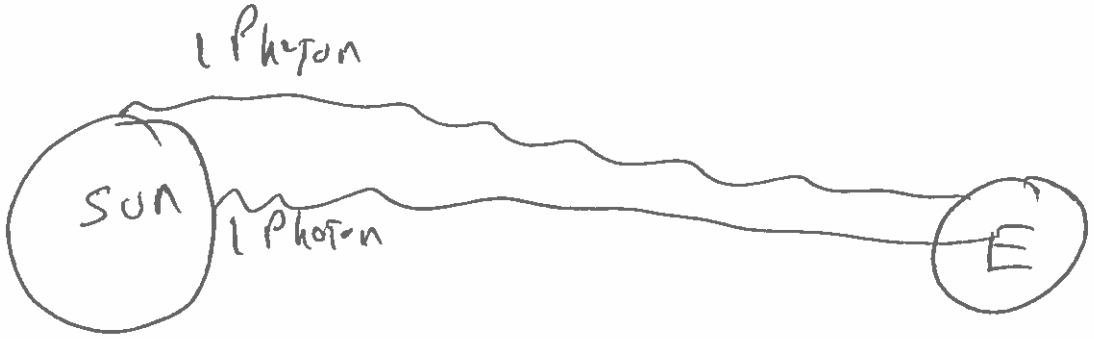
B is 1 cycle or frequency ahead of A

Temporal Phase

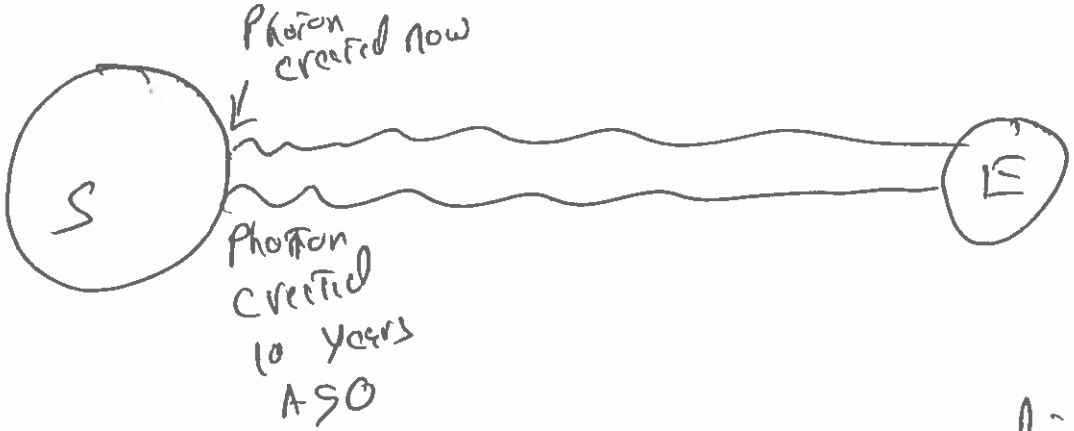
Coherency refers to being in synch with phase BOTH spatially and temporally.



distance Traveled is same
2 Photons are spatially in Phase



These 2 Photons are not in Phase as 1 Photon Traveled αR_{sun} more Than The other.

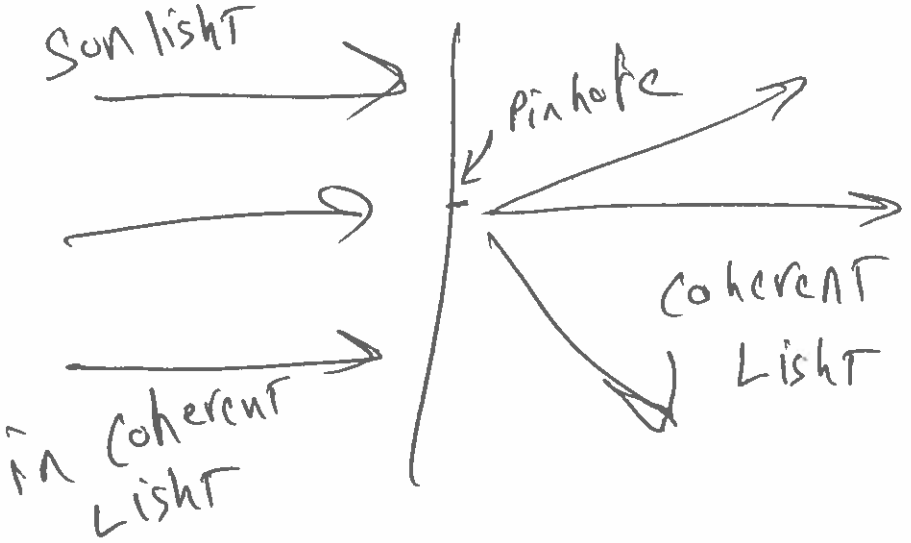


These 2 Photons Travel same distance but Their Phases differ due to Time.

$\Rightarrow$ In General Sunlight is incoherent Light Not in Phase either Spatially or Temporarily!

Generally coherent light is created by a single point source.

Usually use a pinhole.



Modern Device making coherent light is a Laser.

Incoherent Light — Intensities Add $\Rightarrow I_{TOT} = |E_1|^2 + |E_2|^2$

Coherent light — Intensities Add $\Rightarrow I_{TOT} = |E_1 + E_2|^2$

$= |E_1|^2 + |E_2|^2 + 2|E_1||E_2|$

$2|E_1||E_2|$ ← Interference

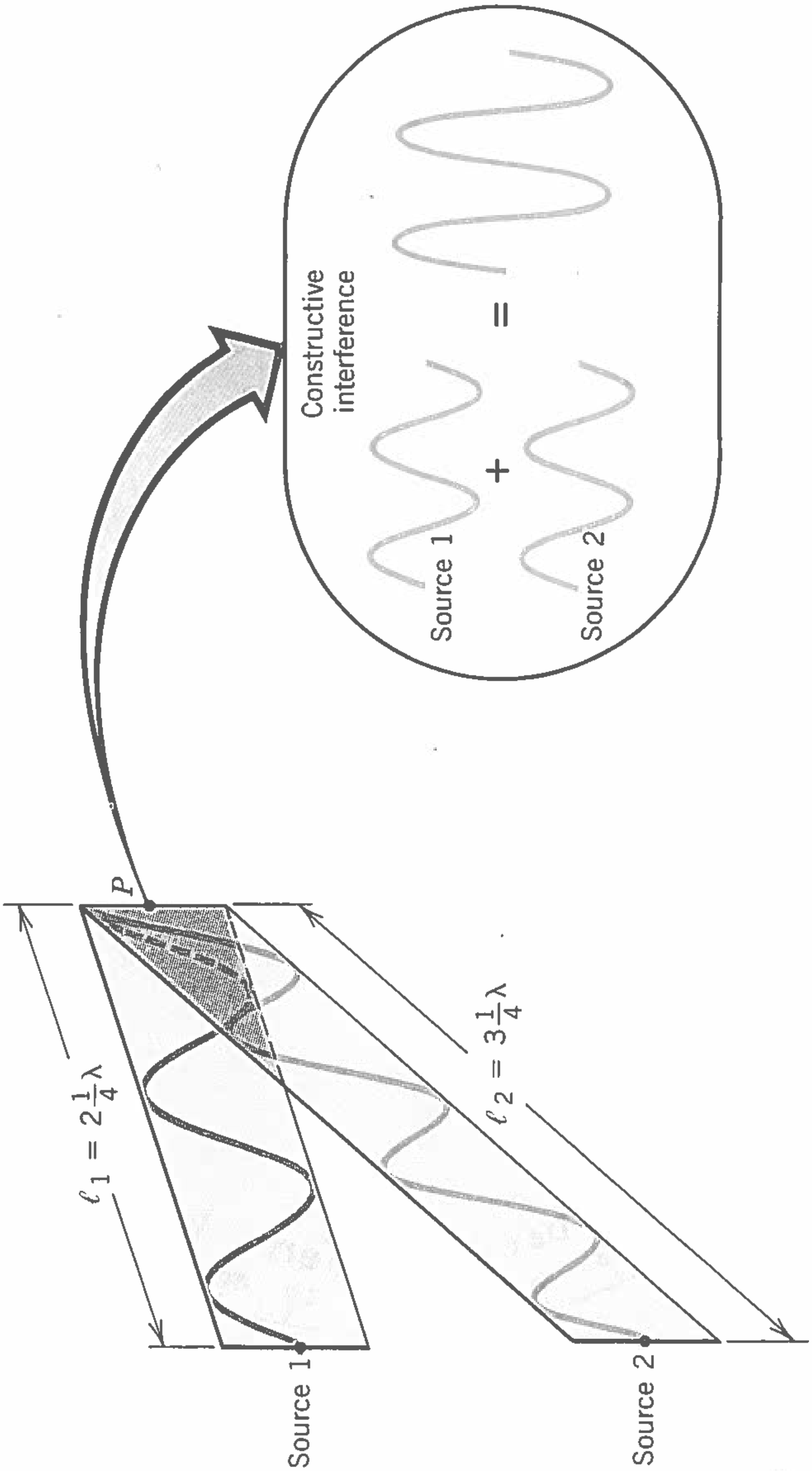


FIGURE 27.1

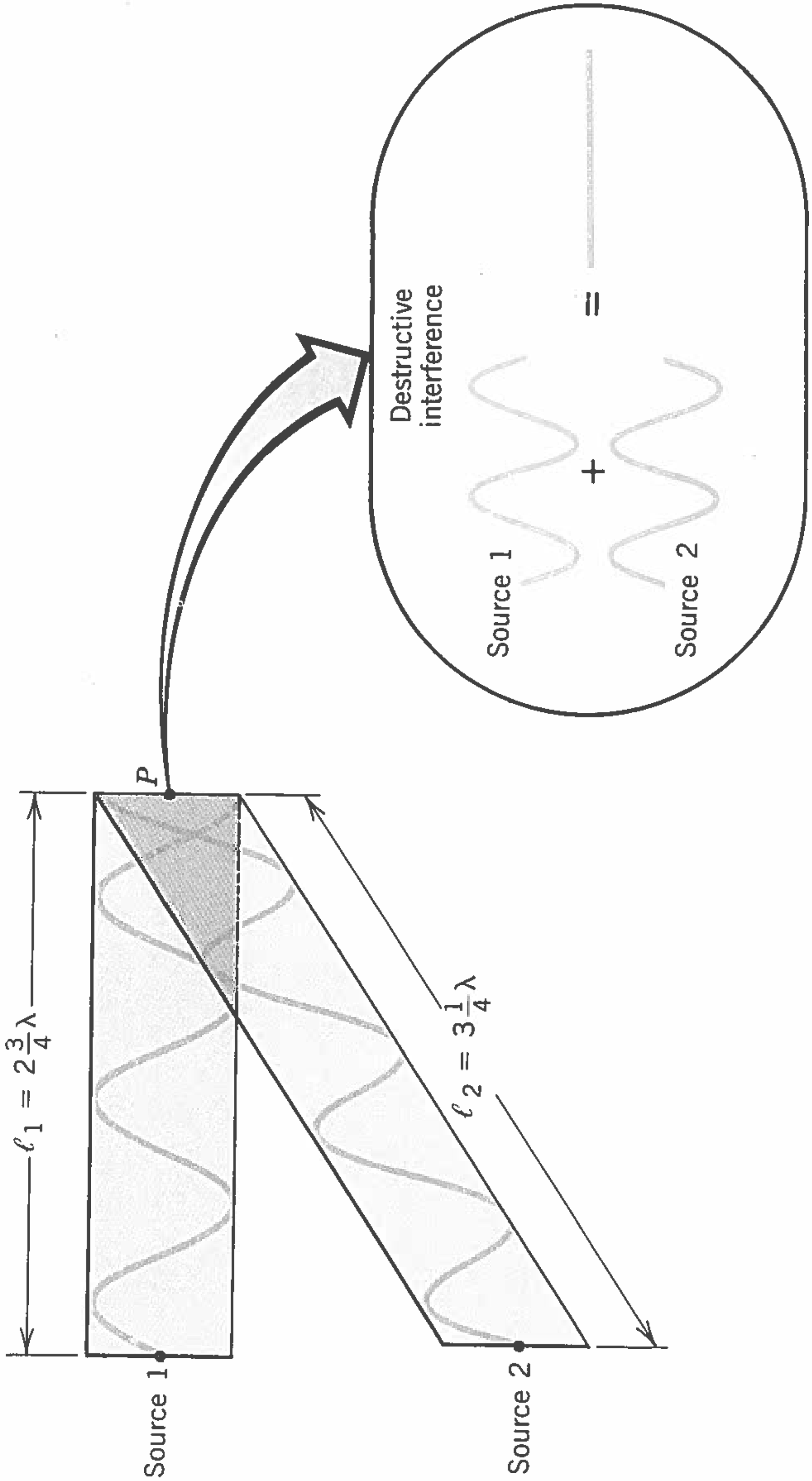
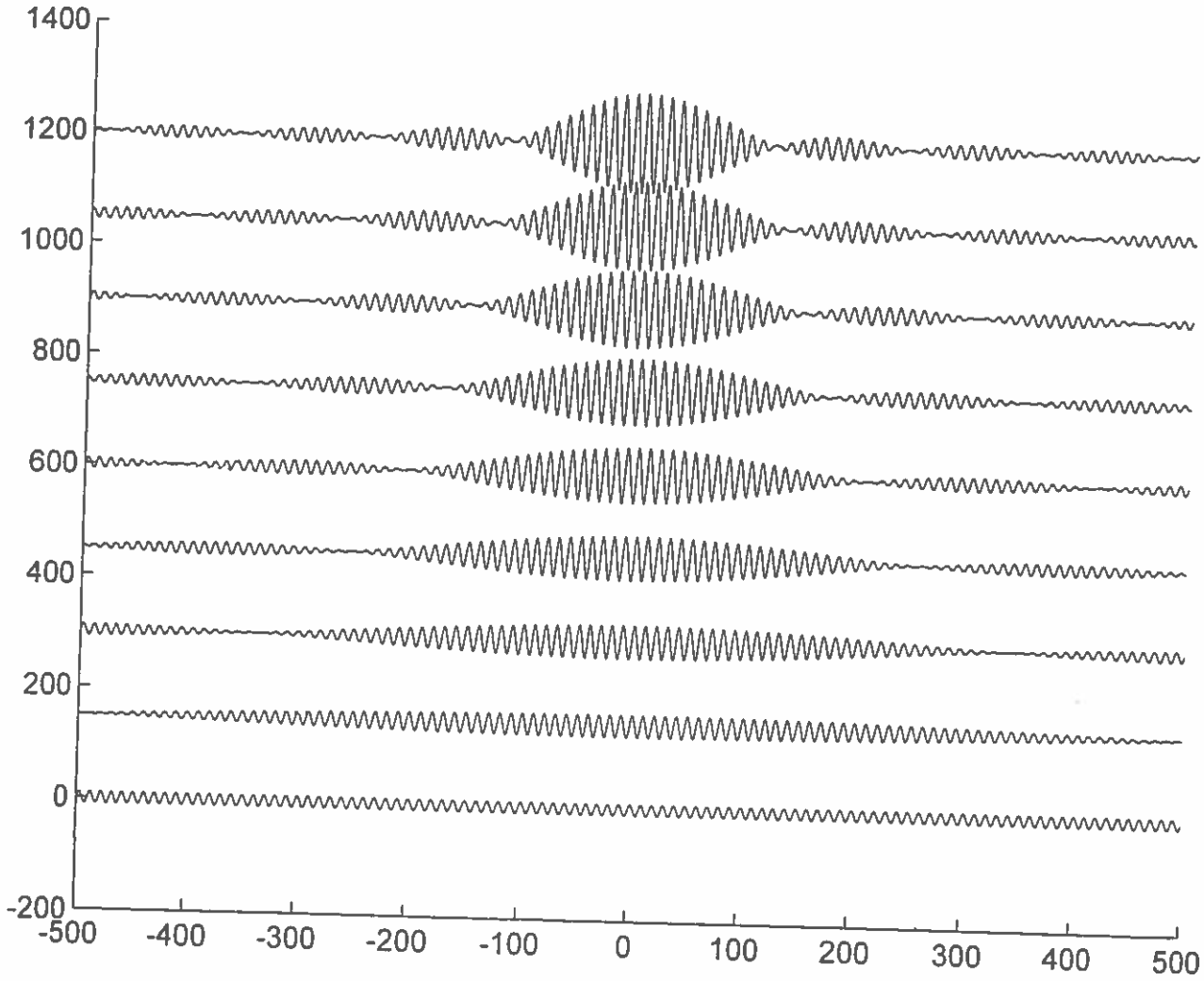


FIGURE 27.2


1400
1200
1000
800
600
400
200
0
-200
-500
-400
-300
-200
-100
0
100
200
300
400
500

Interference

In Phase $\Rightarrow$ Constructive Interference

Completely out of Phase $\Rightarrow$ Destructive Interference

Not exactly in Phase or ~~out~~ completely out of Phase $\Rightarrow$ MATH

$\sin(\text{Phase}_1) + \sin(\text{Phase}_2)$

we need to consider

if Phase $= 0, m\lambda, n2\pi$

all in Phase $\Rightarrow$ constructive Bright or loud

if Phase $= 180, (2m+\frac{1}{2})\lambda, (2m+1)\pi$

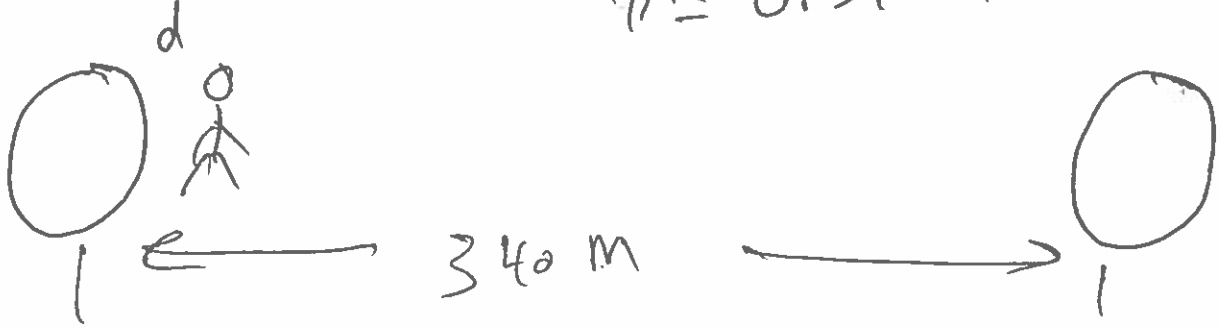
all completely out of Phase $\Rightarrow$ destructive dark or quiet

ex/ $f = 1000\,hz$

$v_s = 340\ m/s$

$\lambda = \frac{v}{f} = \frac{340\ m/s}{1000/s}$

$\lambda = 0.340\ m$



~~$\Delta\lambda = |340m - d| = (m+\frac{1}{2})\lambda$~~

At d from left

1 wave Traveled d

2 wave Traveled 340m-d

Δ Path Traveled $(340m-d)-d$

$$340\,m - 2d = \frac{\lambda}{2}$$

$$680\,m - 4d = \lambda$$

$2000\,\lambda$

$$d = \frac{\lambda}{4} \Rightarrow \text{Phase diff} = \frac{\lambda}{2}$$

$$\lambda = .34\,m$$

$$d = \frac{.34\,m}{4} = .085\,m$$