Lecture # 35

Diffraction

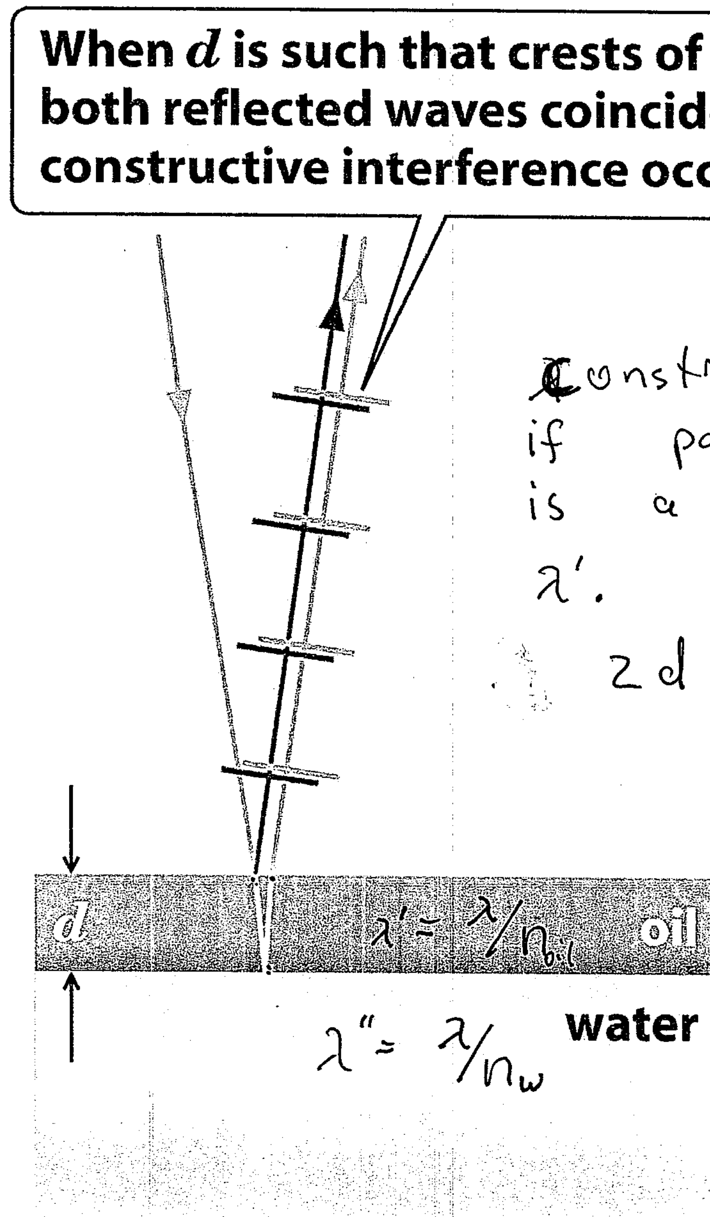

Figure 35-4 Physics for Engineers and Scientists 3/e

$n_{oil} = 1.25$

$n_{water} = 1.33$

Constructive interference if path length difference is a multiple of a wavelength λ'.

$$2d = m\lambda' = \frac{\lambda m}{n_{oil}}$$

$$d = \frac{\lambda m}{2 n_{oil}}$$

destructive interference if

$$2d = (m + 1/2)\lambda' = \frac{(m + 1/2)\lambda}{n_{oil}}$$

However important modification occurs depending on film and backing material.

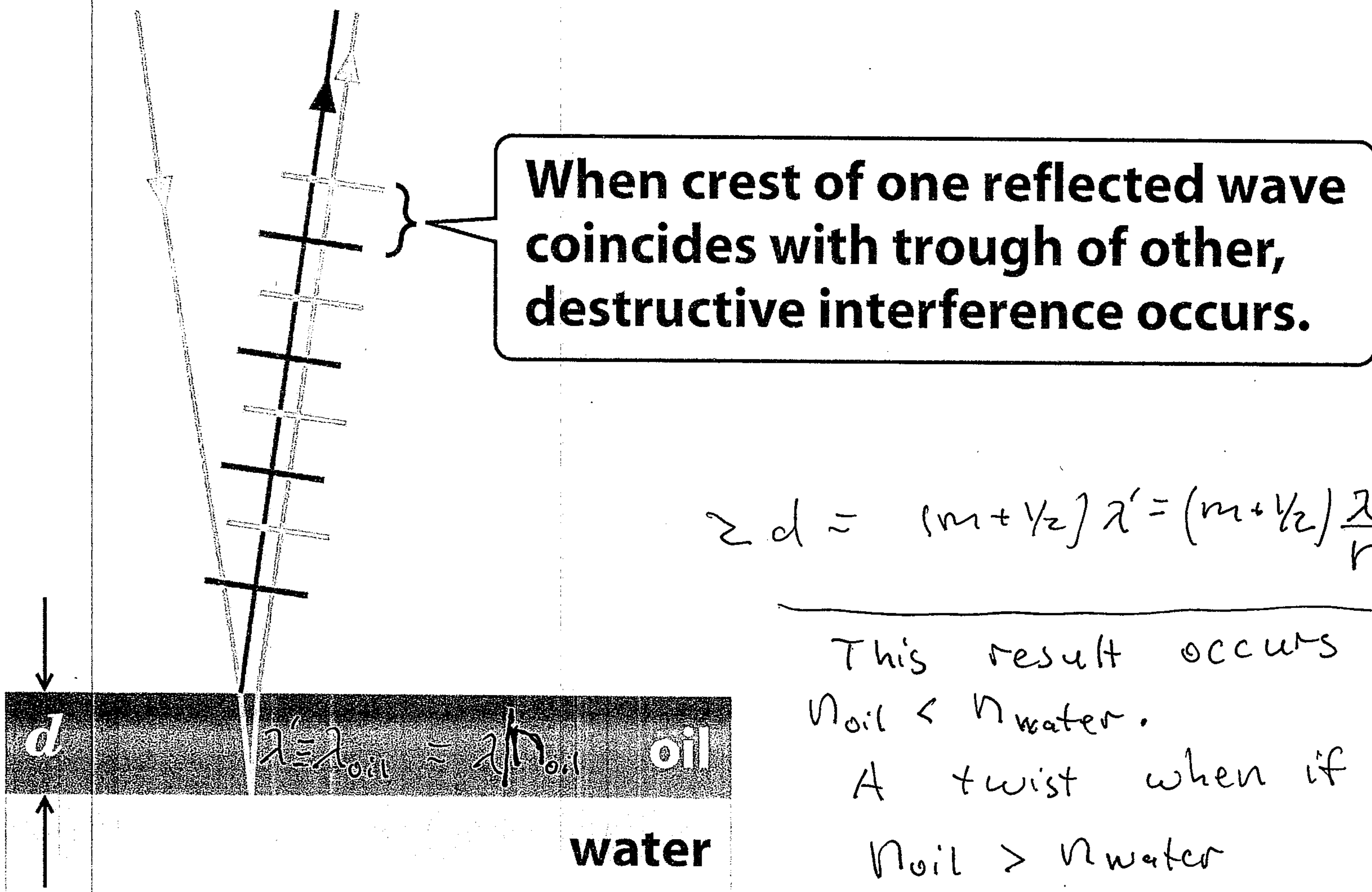

Figure 35-5 Physics for Engineers and Scientists 3/e

$2d = (m + 1/2)\lambda' = (m + 1/2)\frac{\lambda}{n_{oil}}$

This result occurs if $n_{oil} < n_{water}$.

A twist when if $n_{oil} > n_{water}$

E-field changes sign if light reflection from larger index of refraction material. Leads to an interchange of formulas for constructive & destructive interference

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The electric field at a point x of a monchromatic light wave is: $E_0(t)\hat{y}$ If this light wave has a wavelength λ, how far in front of this point of the light wave will the electric field be $-E_0(t)\hat{y}$

(a) $\lambda/4$

(b) $\lambda/2$

(c) λ

$$\hat{E}_0 \cos\left(\frac{(ct-x)}{\lambda}2\pi\right)$$

at ~~x→x+d~~ $x \to x+d$

$$+E_0 \cos\left(\frac{ct-x+d}{\lambda}2\pi\right)$$

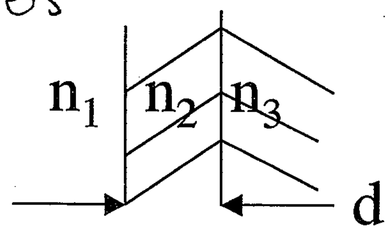
$d = \frac{\lambda}{2}$

$$= -E_0 \cos\left(\frac{ct-x}{\lambda}2\pi\right)$$

$$= E_0 \cos\left(\frac{(ct-x)}{\lambda}2\pi - \frac{\lambda}{2\lambda}2\pi\right)$$

THIN-FILM INTERFERENCE
of Reflected Waves

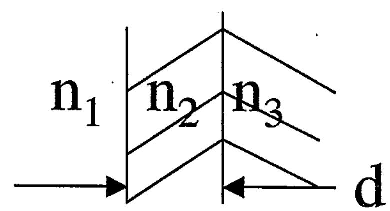
When $1=n_1 < n_2 < n_3$



Maxima: $2d = \lambda_1/n_2,\ 2\lambda_1/n_2,\ 3\lambda_1/n_2 \ldots$

Minima: $2d = \lambda_1/2n_2,\ 3\lambda_1/2n_2,\ 5\lambda_1/2n_2 \ldots$

When $1=n_1 < n_2 > n_3$



Maxima: $2d = \lambda_1/2n_2,\ 3\lambda_1/2n_2,\ 5\lambda_1/2n_2 \ldots$

Minima: $2d = \lambda_1/n_2,\ 2\lambda_1/n_2,\ 3\lambda_1/n_2 \ldots$

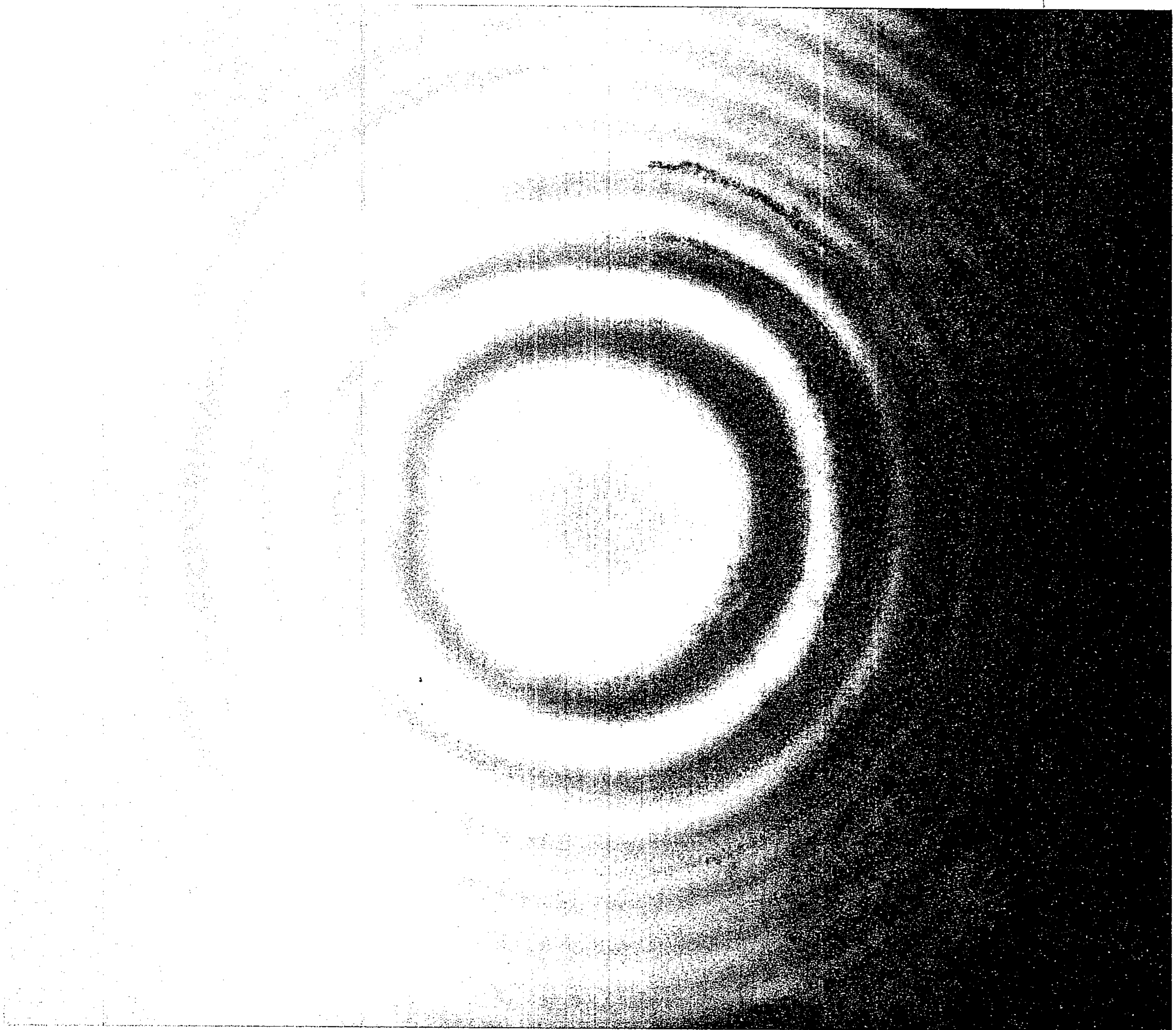
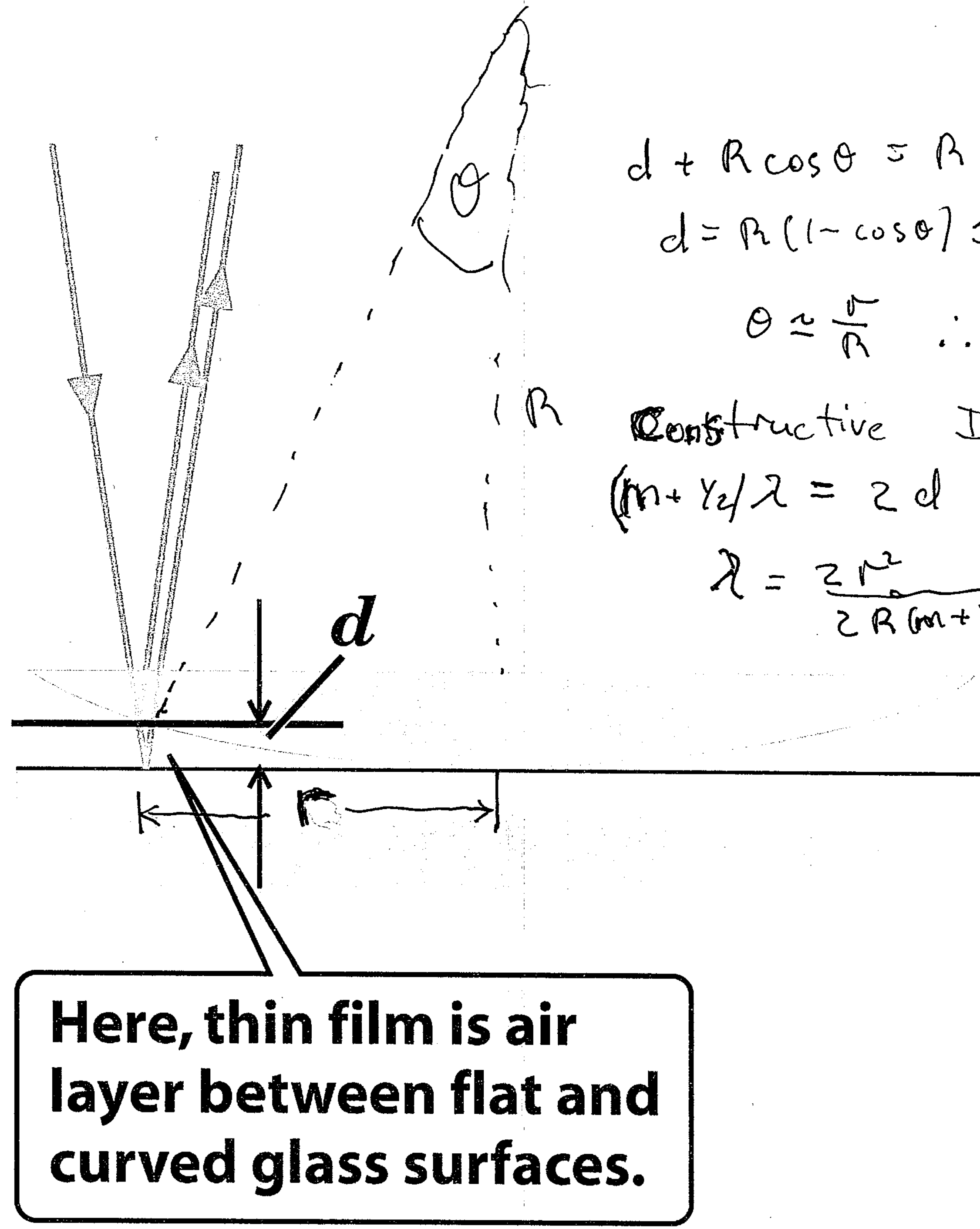


Figure 35-7 Physics for Engineers and Scientists 3/e
Sciencephotos/Alamy

Newton's Rings



$d + R\cos\theta = R$

$d = R(1-\cos\theta) \simeq \frac{R\theta^2}{2}$

$\theta \simeq \frac{r}{R} \quad \therefore d \simeq \frac{r^2}{2R}$

Constructive Interference

$(m + 1/2)\lambda = 2d \; ; \; \lambda = 2d/(m+1/2)$

$\lambda = \frac{2r^2}{2R(m+1/2)} = \frac{r^2}{(m+1/2)R}$

Figure 35-8 Physics for Engineers and Scientists 3/e

Diffraction

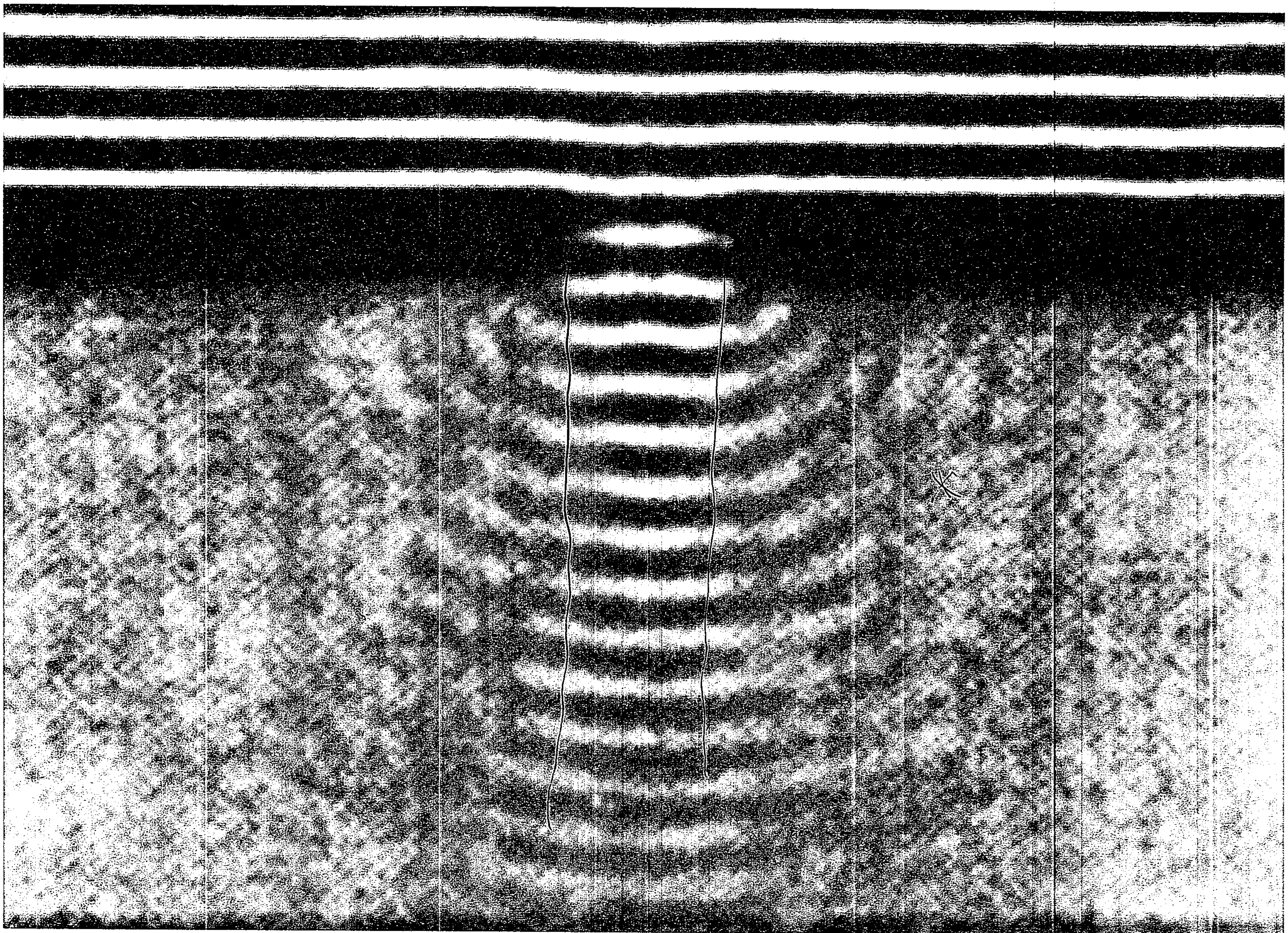


Figure 35-28 Physics for Engineers and Scientists 3/e
***Principals of Physics* by Hans Ohanian**

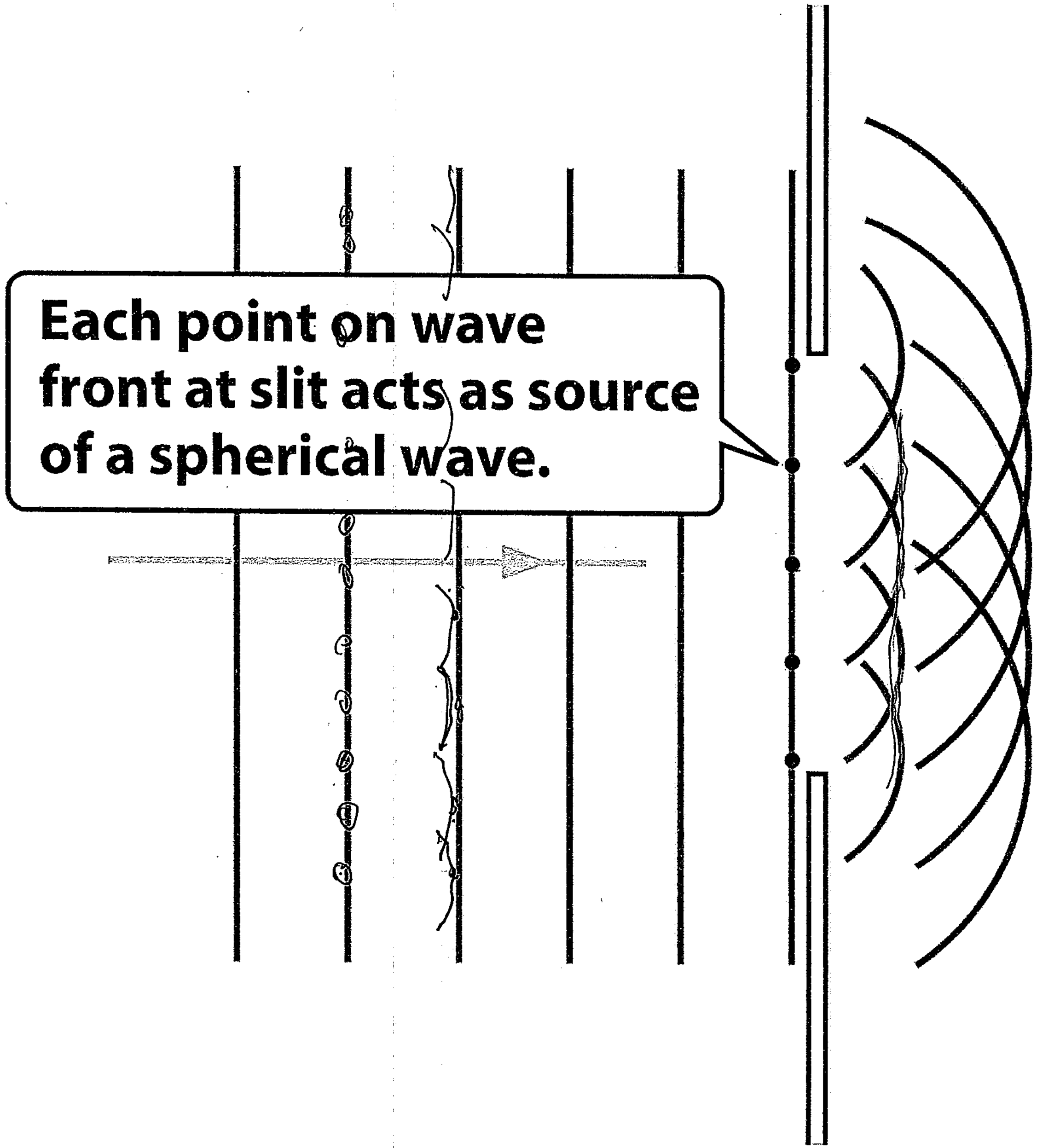
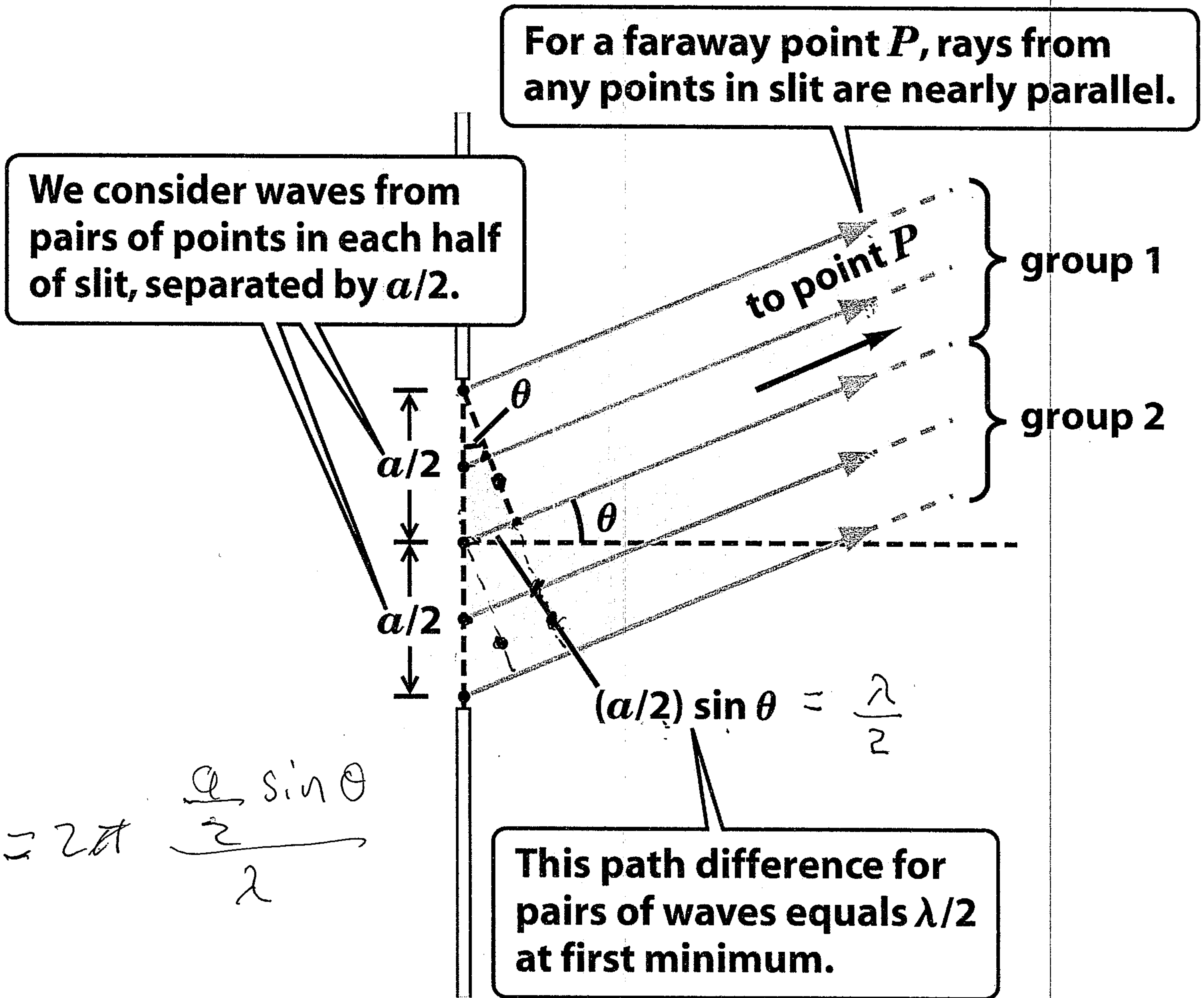


Figure 35-30 Physics for Engineers and Scientists 3/e

First Minimum Condition



$$\phi = 2\pi \frac{\frac{a}{2}\sin\theta}{\lambda}$$

Figure 35-31 Physics for Engineers and Scientists 3/e

Diffraction Pattern through a slit

Figure 35-33 Physics for Engineers and Scientists 3/e
Courtesy of Chris C. Jones

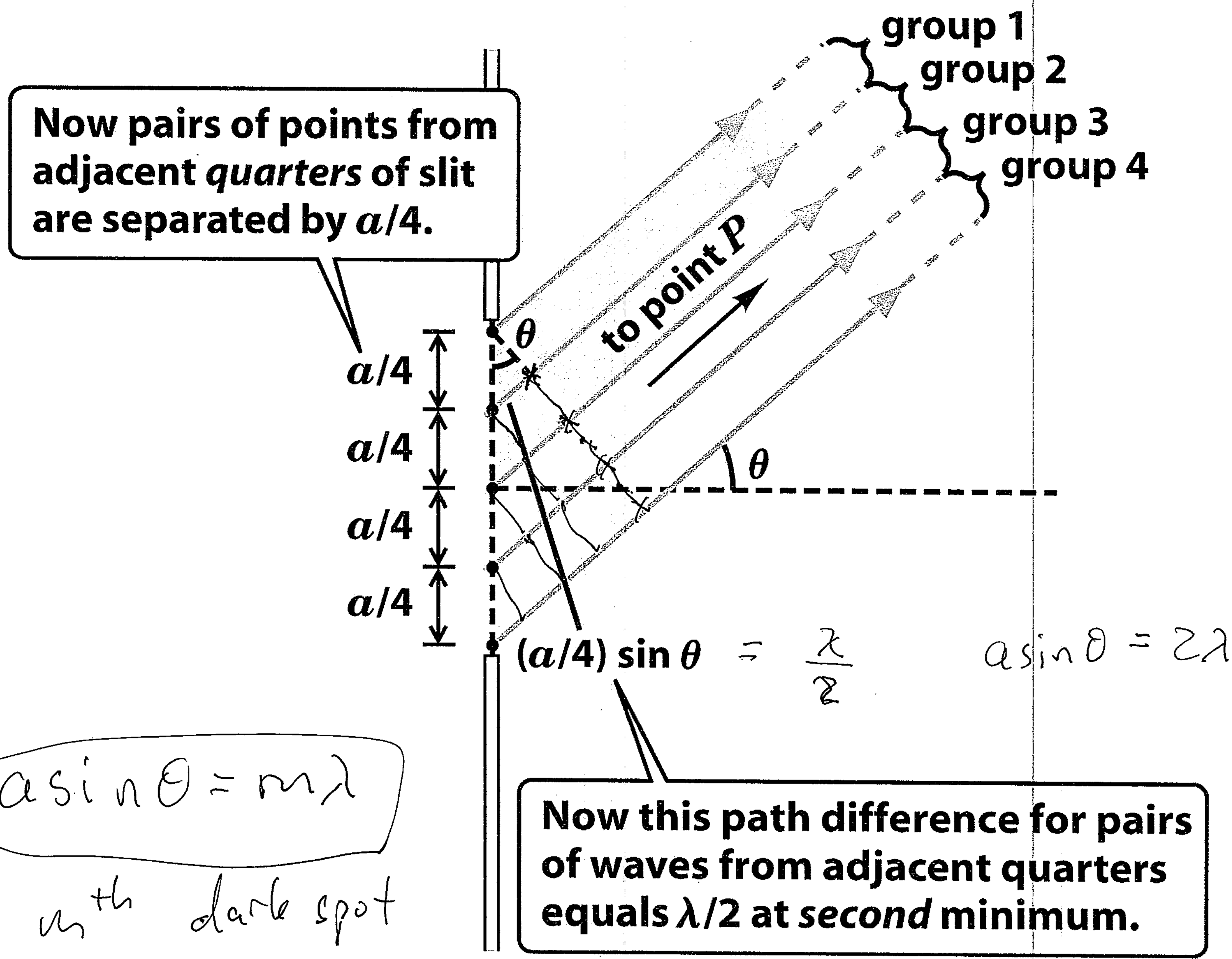
INTENSITY OF SINGLE-SLIT DIFFRACTION ~~APTTERN~~ APERTURE

$$I = I_{max}\left[\frac{\sin(\phi/2)}{\phi/2}\right]^2$$

$$\phi = \frac{2\pi}{\lambda} a \sin\theta$$

Equation 35-25 Physics for Engineers and Scientists 3/e

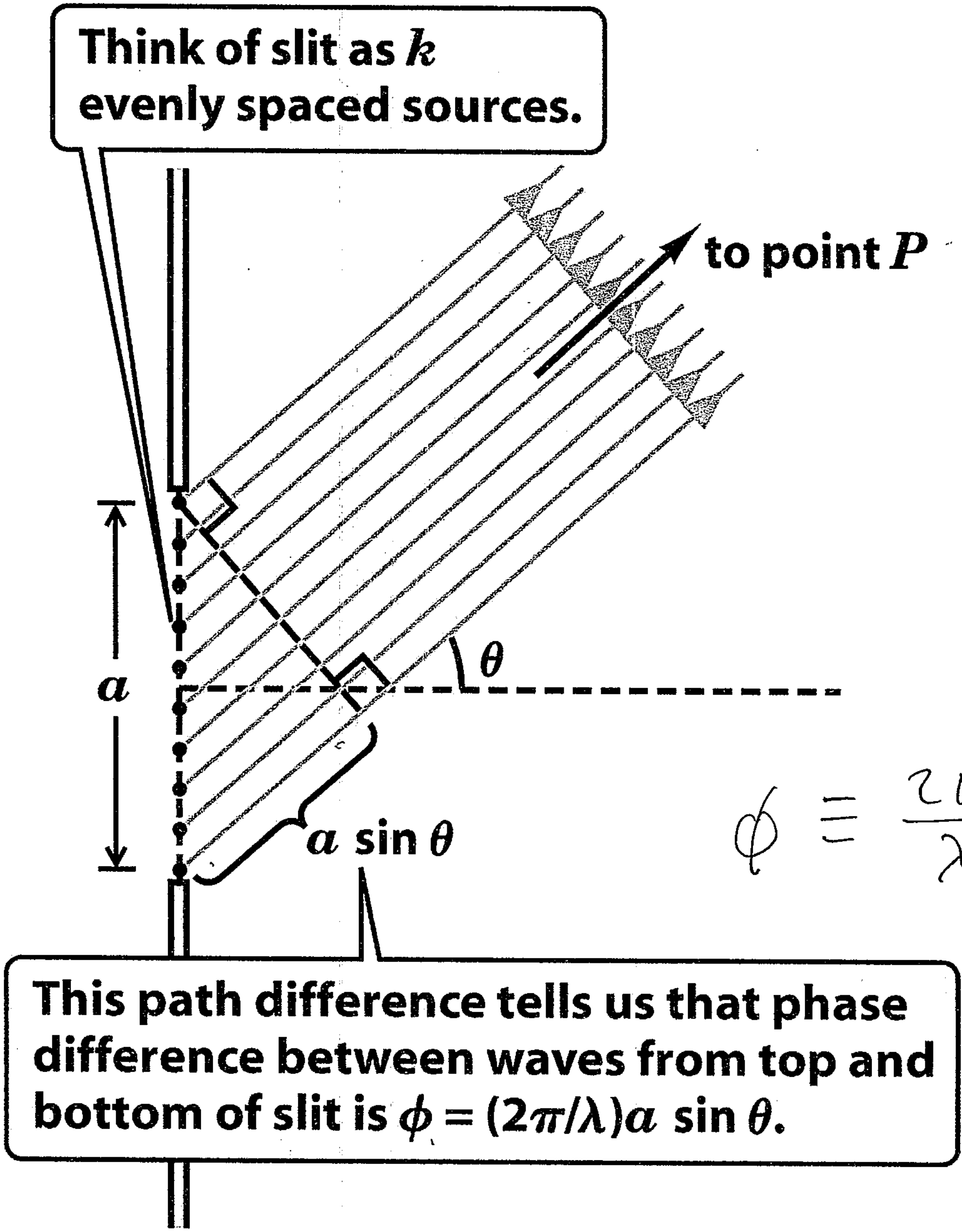
2^{nd} minimum



$a\sin\theta = m\lambda$

m^{th} dark spot

Figure 35-32 Physics for Engineers and Scientists 3/e



$$\phi \equiv \frac{2\pi}{\lambda} a \sin\theta$$

Figure 35-35 Physics for Engineers and Scientists 3/e

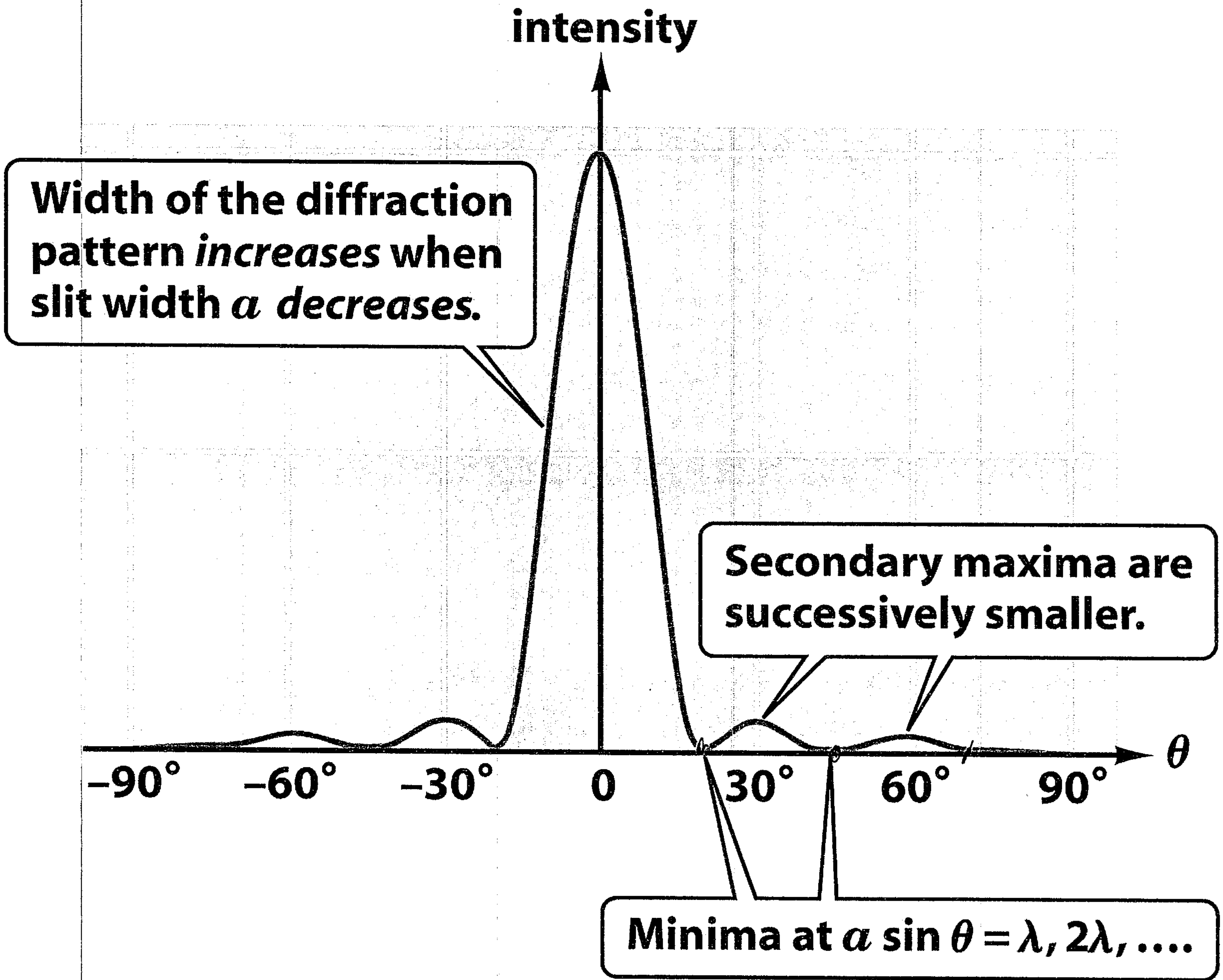


Figure 35-37 Physics for Engineers and Scientists 3/e