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Lecture 34

Interference

constructive interference

$$R = d \sin \theta = n \lambda \quad ; \quad n < \frac{d}{\lambda}$$

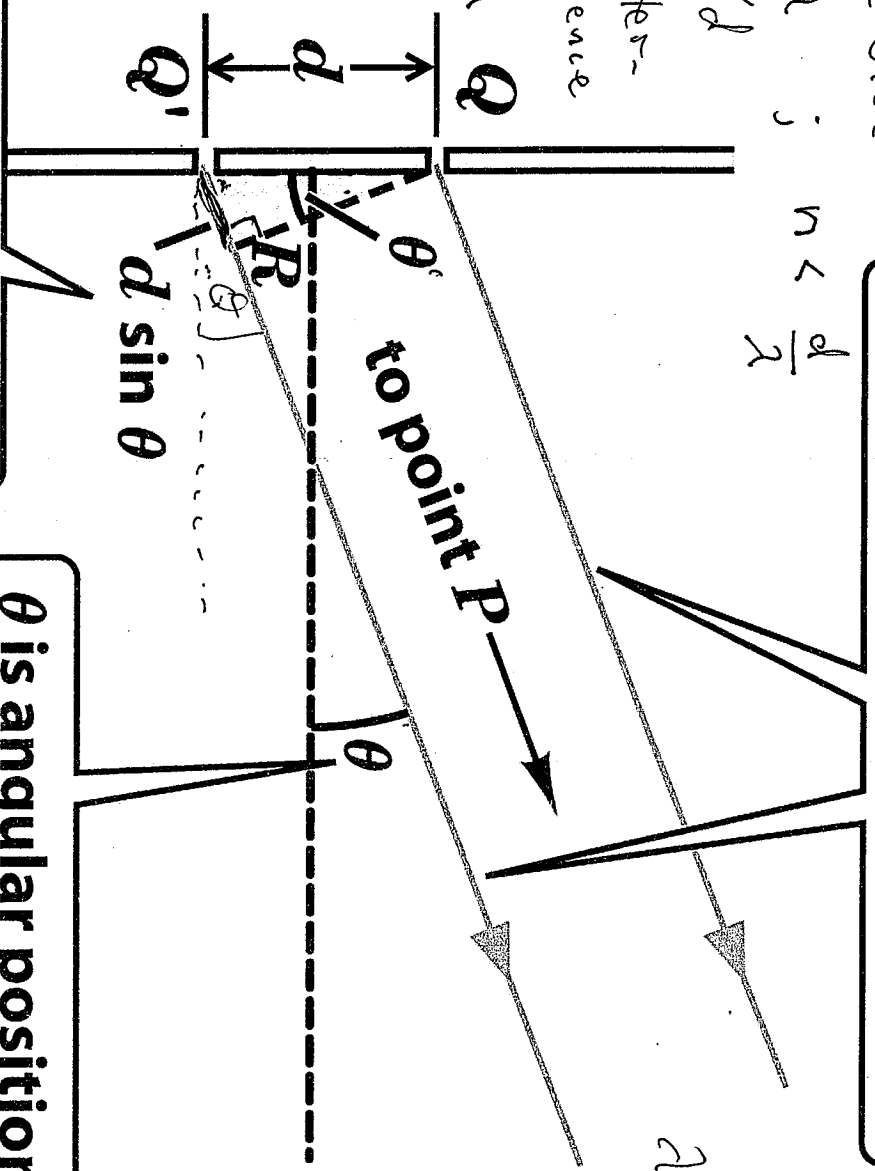
$$\sin \theta = n \lambda / d$$

destructive interference

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

$$n + \frac{1}{2} < \frac{d}{\lambda}$$

**For a faraway point P, rays from slits are nearly parallel.**



**$d \sin \theta$  is path difference to P.**

**$\theta$  is angular position of point P with respect to midline.**

$$\lambda = \text{wave length}$$

$$\lambda = \frac{c}{f}$$

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# Projecting Constructive & Destructive Interference of a screen.

constructive:  $n\lambda = d \sin \theta_n$ ;  $\tan \theta_n = \frac{y_n}{L}$ ;  $n < \frac{d}{\lambda}$   
 if  $\frac{d}{\lambda} < n$ ;  $n\lambda \approx d \sin \theta_n$ ;  $\theta_n = \frac{y_n}{L}$   $\therefore n\lambda = d \frac{y_n}{L}$

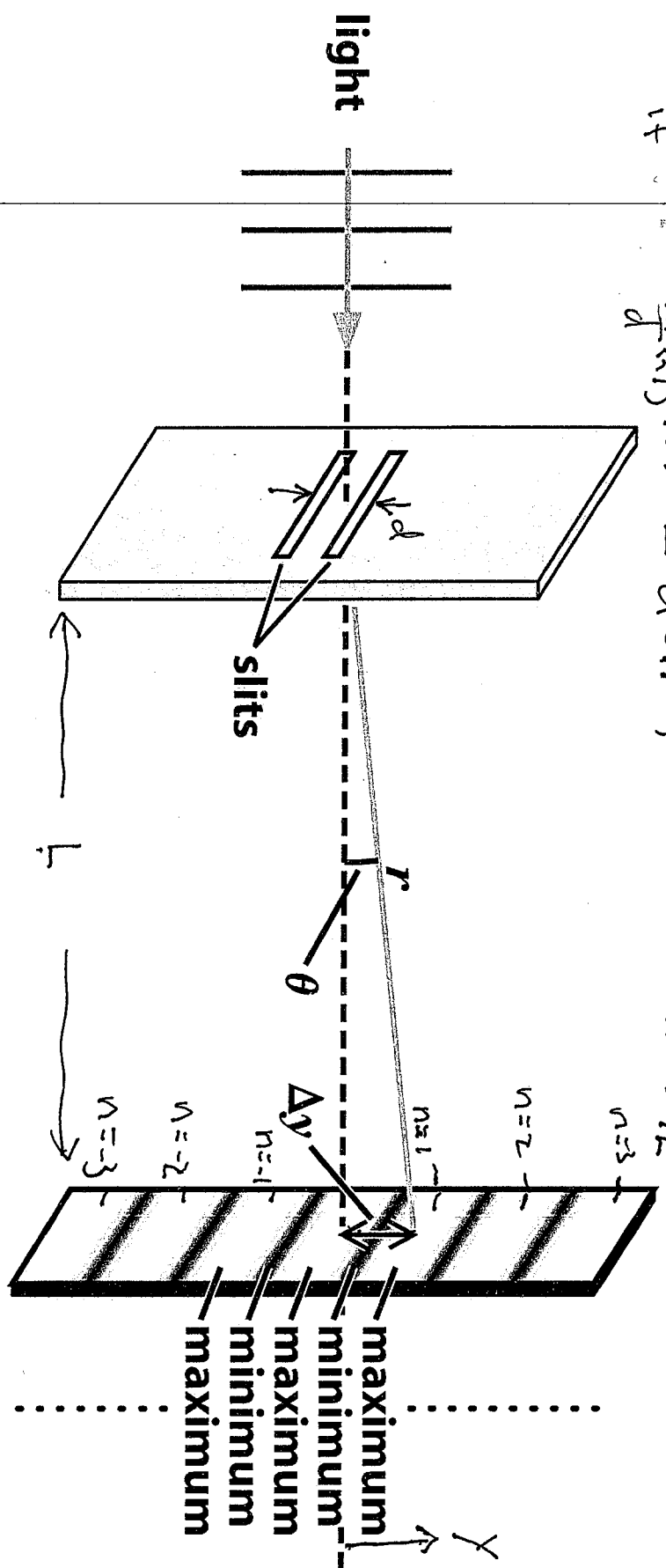
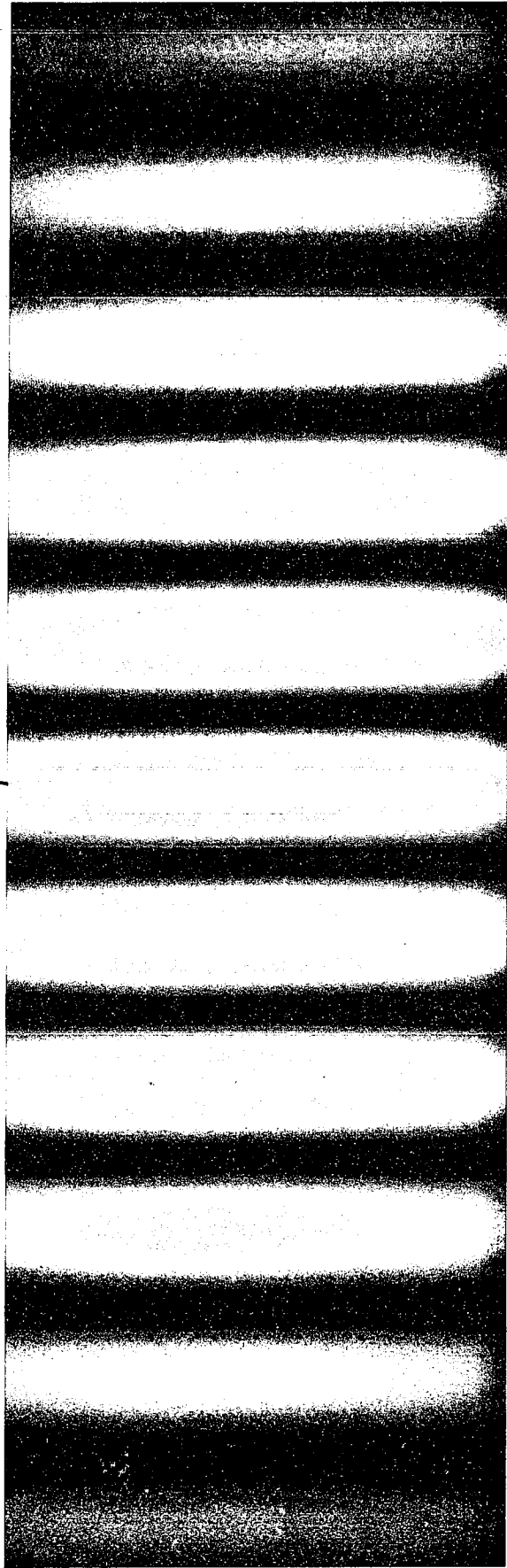
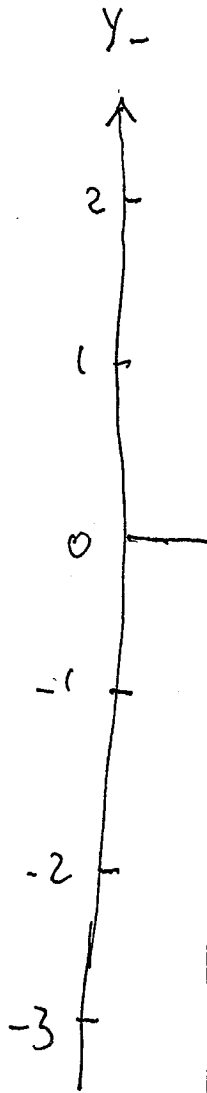


Figure 35-17b Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

destructive:  $(n + \frac{1}{2})\lambda = d \sin \theta_n$ ;  $\tan \theta_n = \frac{y_n}{L}$ ;  $n + \frac{1}{2} < \frac{d}{\lambda}$

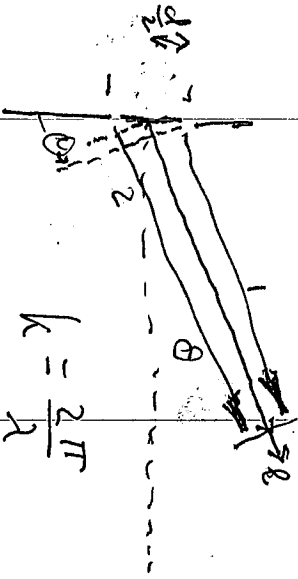
if  $\frac{d}{\lambda} < n + \frac{1}{2}$ ;  $(n + \frac{1}{2})\lambda \approx d \sin \theta_n$ ;  $\theta_n = \frac{y_n}{L} \therefore (n + \frac{1}{2})\lambda \approx d \frac{y_n}{L}$

Handwritten mark



Brightness  
of Screen  
from 2-slit  
experiment

Figure 35-17a Physics for Engineers and Scientists 3/e  
Courtesy of Chris C. Jones



$$l_1 = l - \frac{d}{2} \sin \theta$$

$$l_2 = l + \frac{d}{2} \sin \theta$$

$$E = E_0 \cos(\omega t - kl - \frac{kd}{2} \sin \theta)$$

$$+ E_0 \cos(\omega t - kl + \frac{kd}{2} \sin \theta)$$

**intensity**  $= 2 E_0 \cos(\omega t - kl) \cos(\frac{kd}{2} \sin \theta)$

$$I(k) \propto \underbrace{4 E_0^2 \cos^2(\omega t - kl) \cos^2(\frac{kd}{2} \sin \theta)}_{= 2 E_0^2 \cos^2(\frac{kd}{2} \sin \theta)}$$

$$\text{max} = \frac{kd \sin \theta}{\lambda} = n \pi$$

$$\text{or } \sin \theta / \lambda = n$$

$$\text{min } \frac{kd \sin \theta}{\lambda} = (n + \frac{1}{2}) \pi$$

$$\text{or } d \sin \theta / \lambda = n + \frac{1}{2}$$

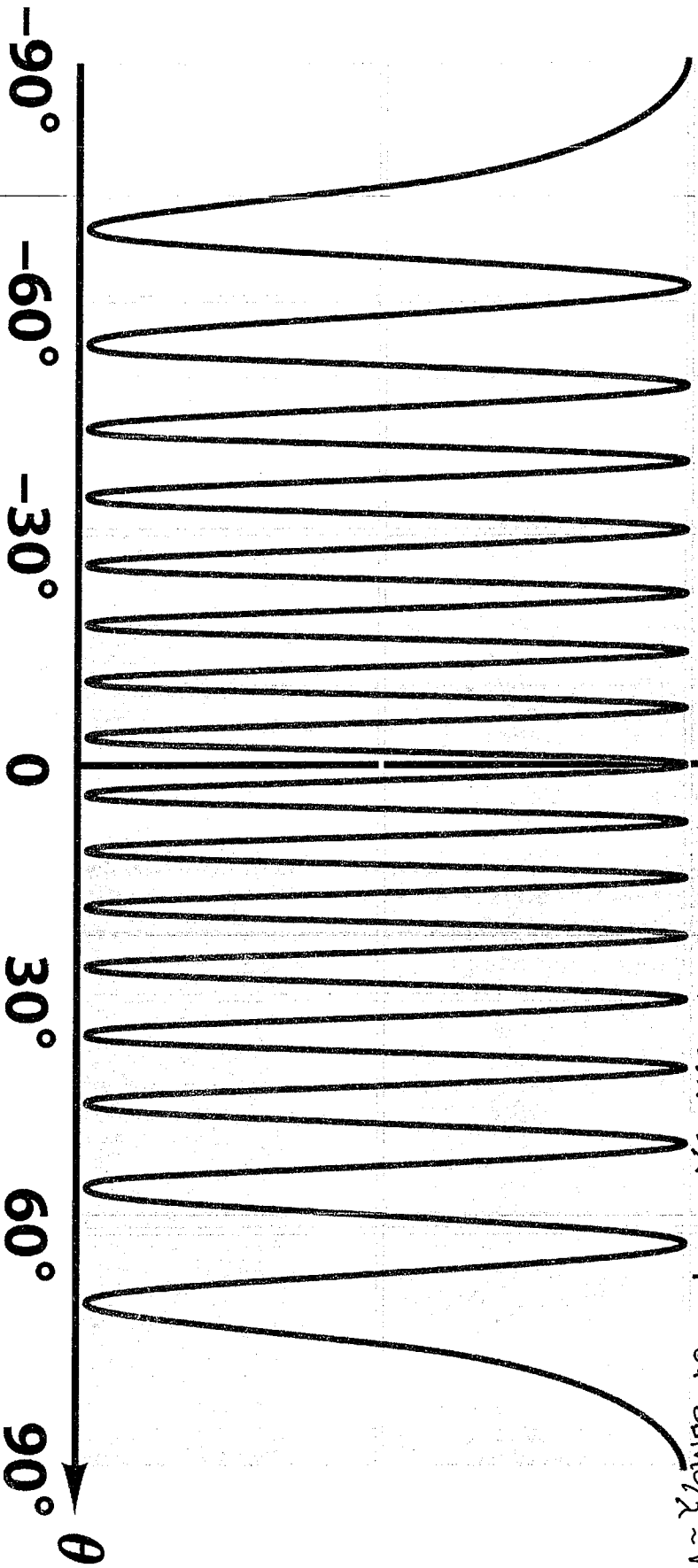


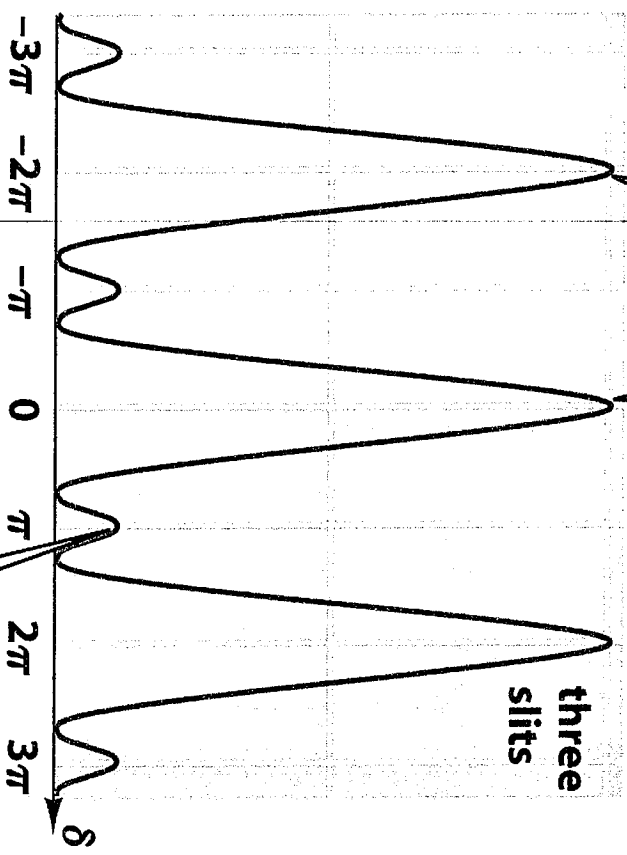
Figure 35-19 Physics for Engineers and Scientists 3/e  
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3 - slits

Multiple slits

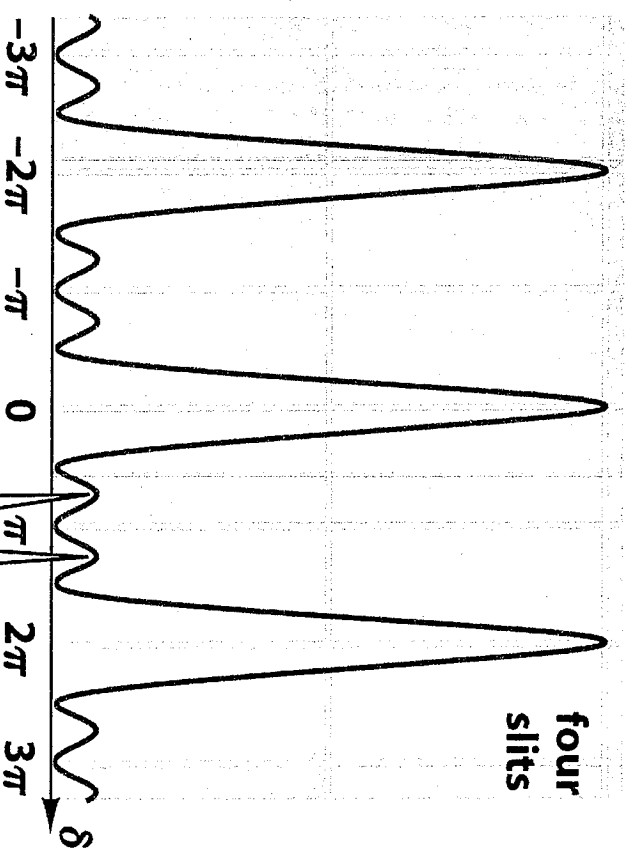
4 slits

(a) Between principal maxima, for three slits...



...there is one secondary maximum...

(b)  $I_{max} \propto N^2$  sharper slits



...and for four slits there are two secondary maxima.

Figure 35-27 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

Principal

but position of

Maxima

Get sharper maxima look the same

$d \sin \theta = n \lambda$

Diffraction Grating Bend  
 long wavelength light more than  
 short wavelength (opposite of refractive  
 light separation)

**Second and third orders overlap.**

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

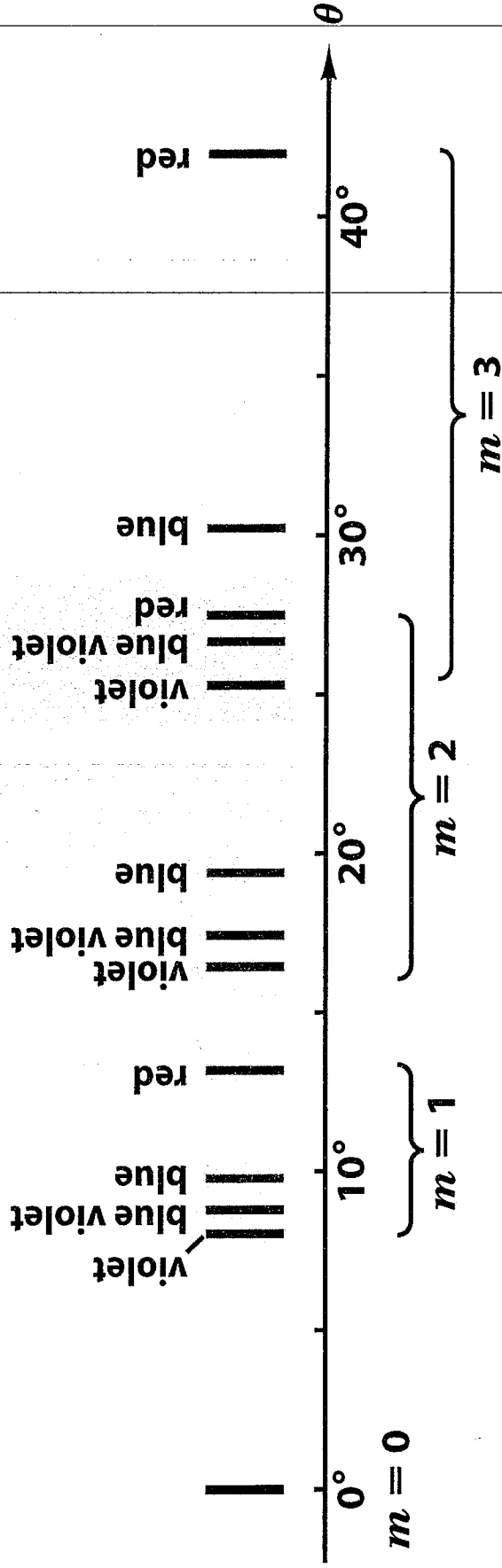


Figure 35-22 Physics for Engineers and Scientists 3/e  
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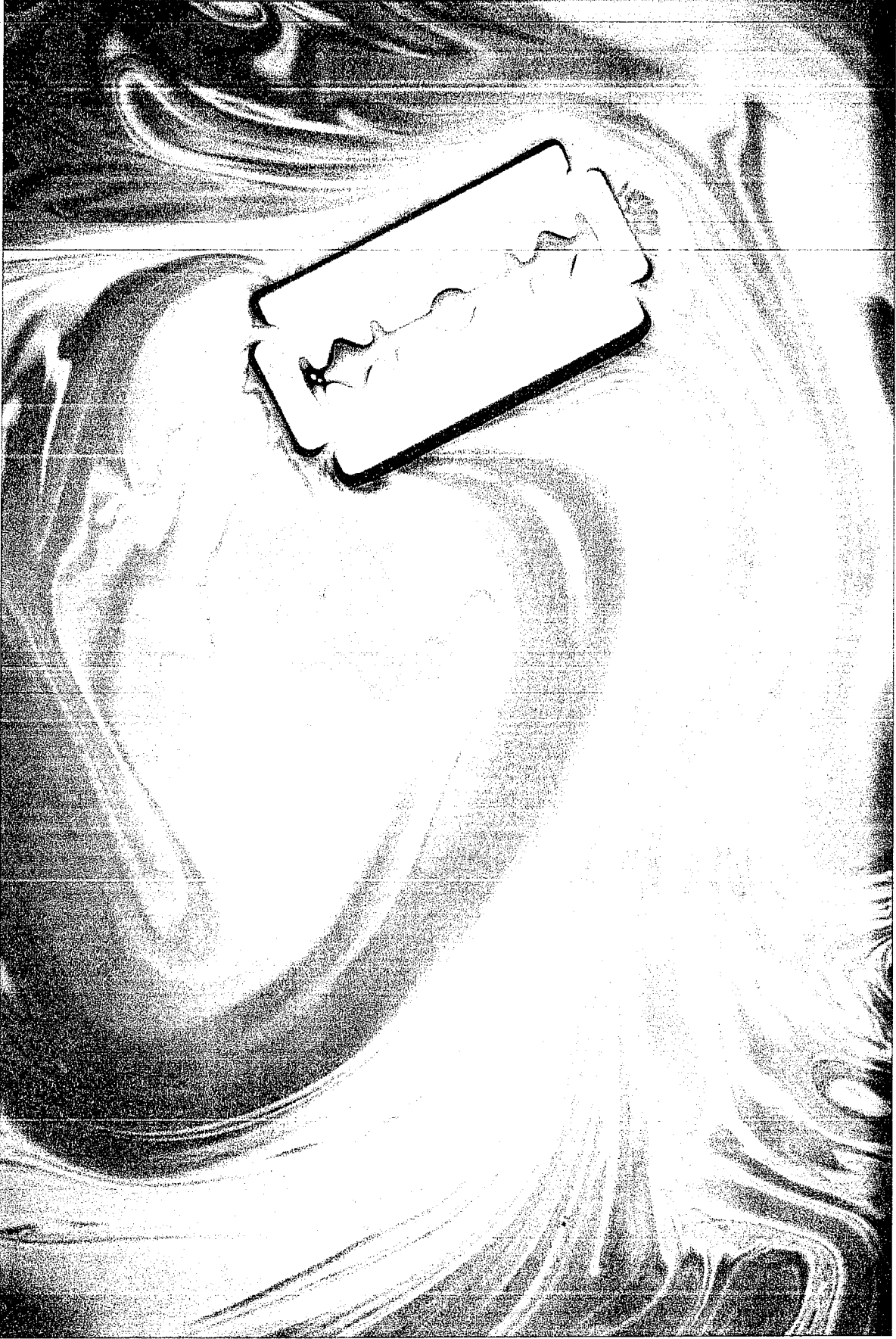
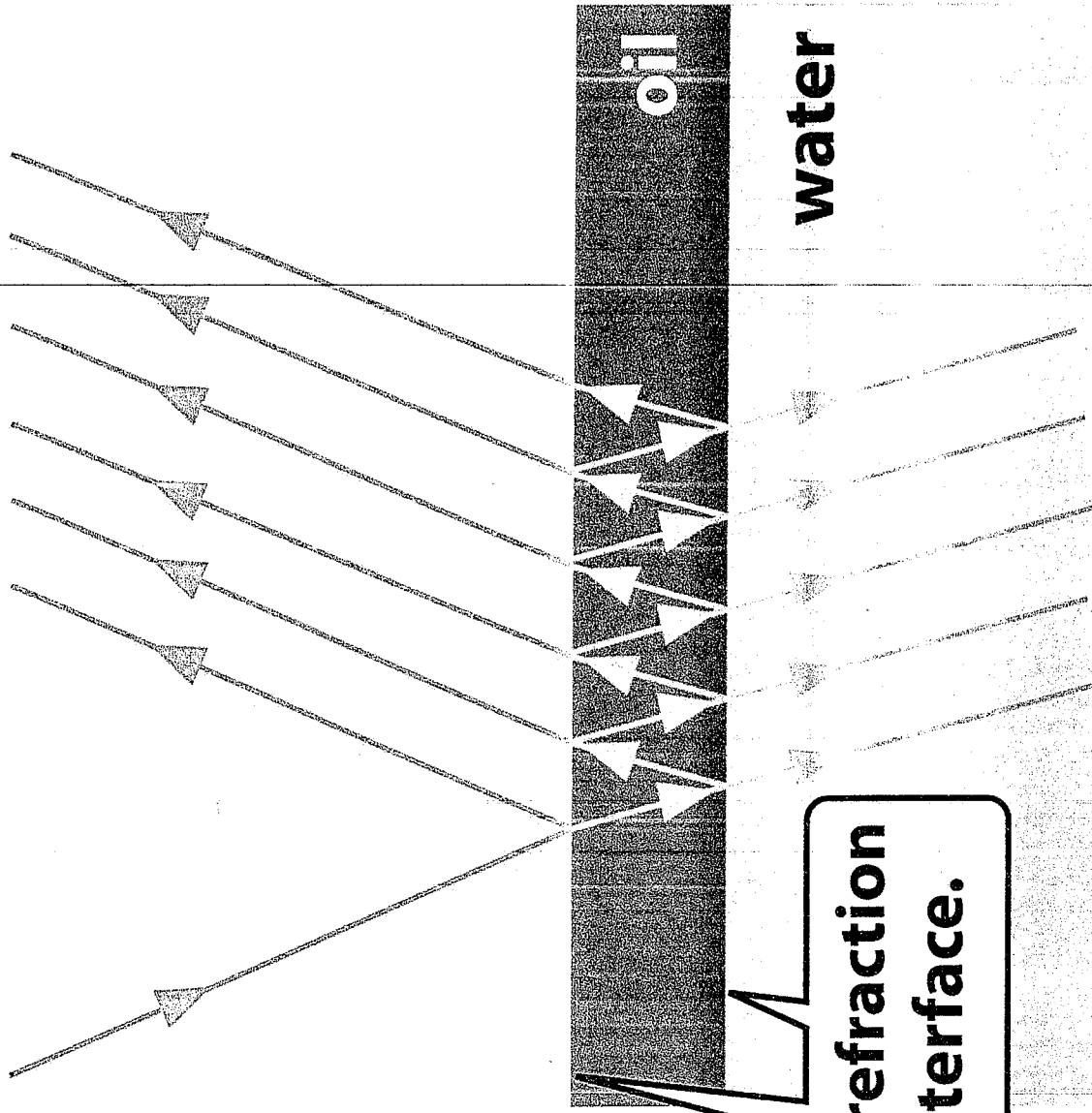


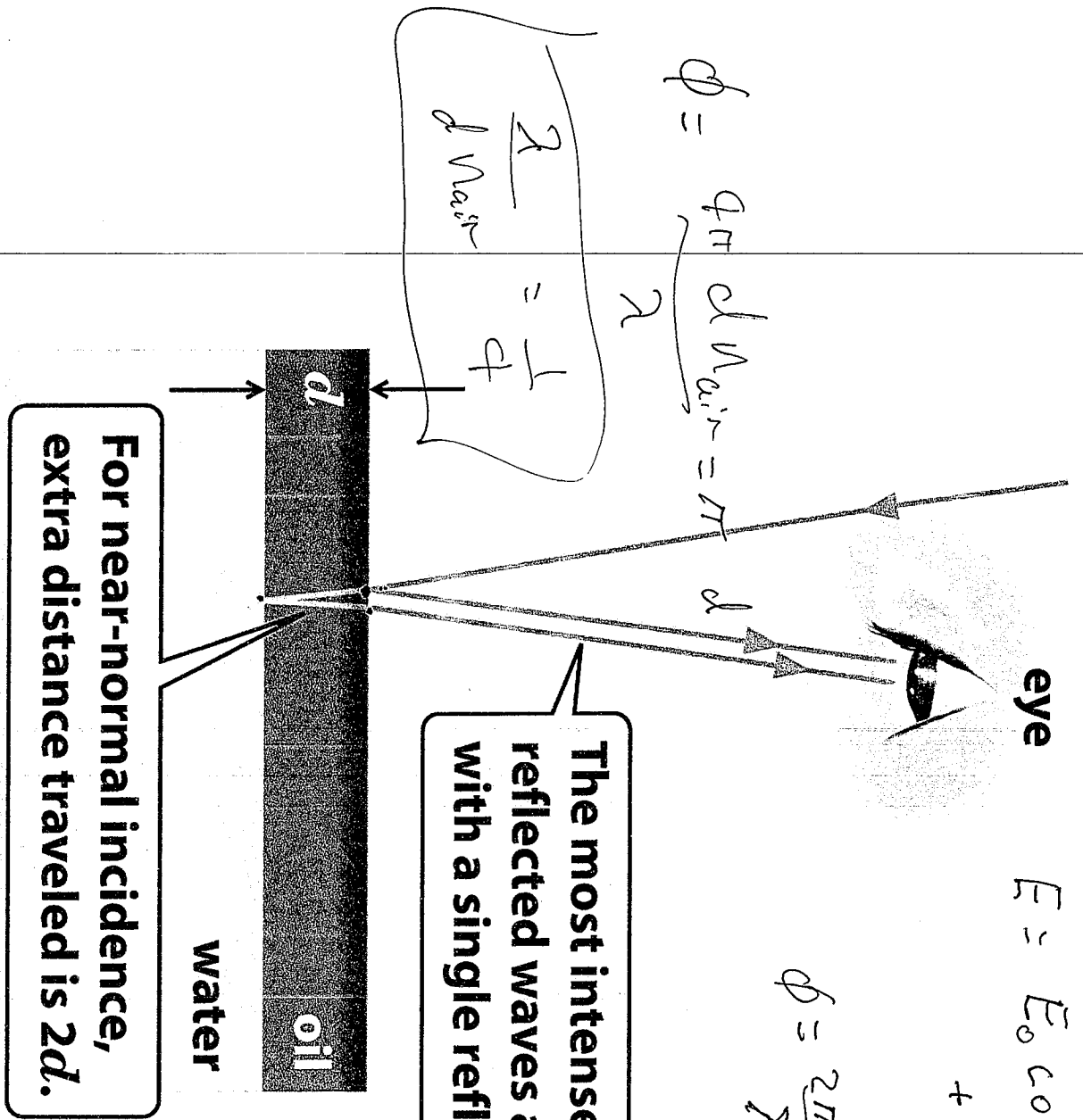
Figure 35-1 Physics for Engineers and Scientists 3/e  
Peter Aprehian/Photo Researchers, Inc.





**Reflection and refraction occur at each interface.**

Figure 35-2 Physics for Engineers and Scientists 3/e  
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$$E = E_0 \cos(\omega t - kd)$$

$$+ E_0 \cos(\omega t - kd + \phi)$$

$$\phi = \frac{2\pi(2d)}{\lambda_{oil}} = \frac{2\pi}{\lambda_{oil}} (2d) = \frac{4\pi d n_{oil}}{\lambda}$$

$$\lambda_{oil} = \frac{v_{oil}}{f}, \quad \lambda_{air} = \frac{c}{f}$$

The most intense reflected waves are those with a single reflection.

For near-normal incidence, extra distance traveled is  $2d$ .

$$\begin{aligned} \lambda_{oil} &= \frac{v_{oil}}{\lambda_{air}} \\ &= \frac{v_{oil}}{c/v_{oil}} \\ &= \frac{\lambda}{n_{oil}} \end{aligned}$$

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