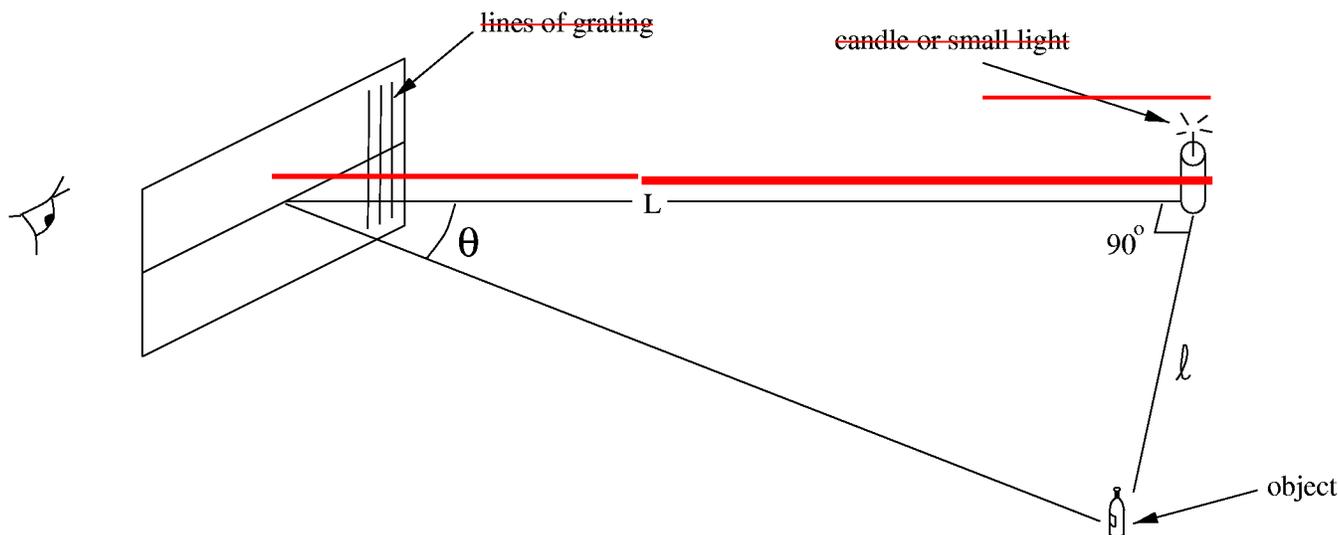


- ~~(d) What colors do you observe in the zero order spectrum?~~
- ~~(e) How many maxima do you see in red and how many in blue? Compare this with your predictions under b. (Use your filters to avoid confusion due to possible overlap of different colors from different orders.)~~
- ~~(f) Place an object a distance ℓ away from the candle (as in the figure below) until you see the red light of the first order maximum in the same direction as the object (use your red filter). Measure the distances L and ℓ . Calculate from this the angle θ (see figure). Compare your result with that under b.~~



- ~~(g) Observe the two first order spectra as before (grooves in grating vertical). Now rotate the grating about the vertical; you observe an increase in θ . Why?~~

~~Use your grating to analyze the various spectra of street lights. The mercury lights show a remarkable spectrum!~~

Problem 11.3

Diffraction, interference and angular resolution of 2-element interferometers.

Equation 36-9 holds all the “secrets” of diffraction and interference for single-slits and double-slits. This is true for the entire range of the electromagnetic spectrum. See e.g. figure 36-10c and 36-11. Consider two radio telescopes, each with a diameter of 100 ft, separated by 1 km.

- (a) Using only 1 of these telescopes, what would be the angular resolution at a wavelength of 21 cm?
- (b) Using both telescopes as an interferometer, what now would be the angular resolution? For simplicity, think of the diameter of the radio dishes as an approximate “slit-width”.

Problem 11.4

Destructive interference of sound.

Giancoli 36-55.

Problem 11.5

Resolving power of the human eye.

Giancoli 36-65.

Problem 11.3

Diffraction, interference, and angular resolution of 2-element interferometers.

(a) Giancoli Equation (36-10) (p. 897) gives the angular resolution of a single radio telescope of diameter 100 ft = 3048 cm at a wavelength of 21 cm:

$$\theta = \frac{1.22\lambda}{D} = \frac{(1.22)21}{3048} = 8.4 \times 10^{-3} \text{ rad} = 0.48^\circ \simeq 1700 \text{ arcsec} .$$

(1° = 3600 arcsec.)

(b) To determine the angular resolution of the pair of telescopes operating as an interferometer, we make an analogy to the double-slit experiment. The angular resolution will be set by the position of the first minimum in the diffraction/interference pattern described by Giancoli Equation (36-9) (p. 894). Since the effective “slit separation” of $d = 1 \text{ km}$ is much greater than the effective “slit width” of 100 ft, this first minimum will occur when the $\cos^2(\delta/2)$ factor first goes to zero:

$$\frac{\pi}{2} = \frac{\delta}{2} = \frac{\pi}{\lambda} d \sin \theta \implies \sin \theta = \frac{\lambda}{2d} = \frac{0.21}{(2)1000} = 1.05 \times 10^{-4} .$$

$\sin \theta \cong \theta$ for such small angles, thus we have

$$\theta = 1.05 \times 10^{-4} \text{ rad} = (6.0 \times 10^{-3})^\circ = 22 \text{ arcsec}$$

for the angular resolution—a big improvement.

~~**Problem 11.4**~~

~~*Destructive interference of sound.* (Giancoli 36-55.)~~

~~We can idealize this as a single-slit diffraction problem with sound waves instead of light waves. Our slit width is $a = 0.88 \text{ m}$ and the wave frequency is $f = 750 \text{ Hz}$. We'll take $v = 344 \text{ m/s}$ for the speed of sound in air. The whistle will not be heard clearly at the angular position(s) of minima in the diffraction pattern (Giancoli Equation (36-2), p. 889):~~

~~$$\sin \theta = m \frac{\lambda}{a} = m \frac{v}{fa} = m \frac{(344)}{(0.88)(750)} = (0.52)m .$$~~

~~The only non-zero integer m that yields a solution is $m = 1$ (for $\sin \theta \leq 1$ necessarily). So in an ideal situation, the whistle would go unheard at~~

~~$$\theta = \arcsin(0.52) = 31^\circ .$$~~