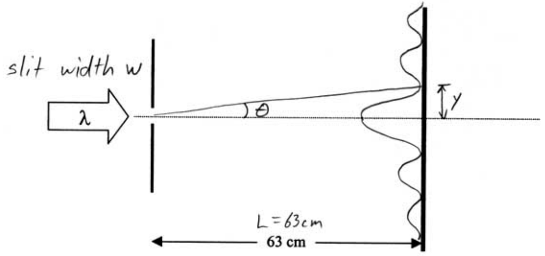
Your Name ____________

Practice Problem #11.1
Single Slit Diffraction



a) Light of 665 nm is incident on a single slit. Draw the expected intensity pattern above in a qualitative manner. That is, don't expect to draw it to scale. Show at least the first 3 bright fringes.

b) Indicate the "width" of the central bright fringe on your drawing. How would you calculate the width? Contrary to suggestion in the appendix, I define the "width" to be half the distance between dark fringes, Width = y

$\tan\theta = \frac{y}{L}$ $\sin\theta = \frac{\lambda}{w}$ $y = L\tan\left(\sin^{-1}\left(\frac{\lambda}{w}\right)\right) \approx \frac{L\lambda}{w}$ small angle approx.

c) If the width of the central bright fringe is 2.6 cm on the flat screen, what is the width of the slit?

$\theta = 2.36°$

$w = 16.13\,\mu m$

d) If the light had a wavelength of $\lambda = 425$ nm instead, now what would the width of the bright fringe be?

$y = 1.66$ cm

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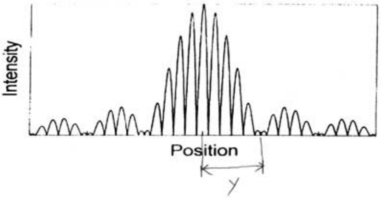
Practice Problem #11.2
Missing Order Problem

Light with wavelength λ = 625 nm is incident on two parallel slits with width W =1mm and spaced 5mm apart. The intensity pattern produced on a screen 2m from the slits is a combination of a single slit diffraction pattern and a double slit interference pattern - see picture to the right.



a) What is the condition for constructive interference in a double slit pattern? (Just write down the equation.)

$$\sin\theta = \frac{m\lambda}{d}$$

b) At what distance from the central bright fringe would the fifth order bright fringe from double slit interference occur?

$m = 5$ $\lambda = 625\times10^{-9}$ m $d = 5$ mm $L = 2$ meters

$\theta = 0.03581°$

$\tan\theta = \frac{y}{L}$

$y = 1.25$ mm

c) What is the condition for single slit dark fringes? (Just write down the equation.)

$$\sin\theta = \frac{m\lambda}{W}$$

d) At what distance from the central bright fringe would the first minima due to the single slit diffraction occur? Use the width given above.

$m = 1$ $W = 1$ mm

$\theta = 0.03581°$

$y = 1.25$ mm

e) Notice your answers for b) and d) are the same. Anytime this happens, the minima wins out and a missing order occurs. What m values for the double slit would be missing in this example?

$m_s = \pm1, \pm2, \ldots$

$$\frac{d}{w} = \frac{m_D}{m_S} = 5$$

$m_D = \pm5, \pm10, \pm15 \ldots$

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Practice Problem #11.3
Blackbody Effect

a) What is the surface temperature of Betelgeuse, a red giant star in the constellation of Orion, which radiates with a peak wavelength of about 970 nm? Now, repeat this calculation for Rigel, a bluish-white star in Orion, with a peak wavelength of 145 nm.

970nm: 2988°K

145 nm: 19,990°K

b) Assume that the tungsten filament of a lightbulb is a blackbody. Determine its peak wavelength if its temperature is 2900 K.

999.3 nm

c) Now, look at your answer to b) and comment on why this suggests that more of the lightbulb's energy goes into heat than into light. Why is this evident?

999.3 nm is infrared. (IR)

The bulb produces a lot of IR radiation, which is not useful visible light. It just heats things up, so a lot of the energy goes into heat.

Your Name ________________

Practice Problem #11.4
Photoelectric Effect Practice (direct from your textbook)

a) The work function for a sodium surface is 2.28 eV. What is the maximum wavelength (in nm) that an electromagnetic wave can have and still eject electrons from this surface?

$$KE_{max} = E_{photon} - W_0 = 0$$

$$\lambda = 543.8 \text{ nm}$$

b) An owl has good night vision because its eyes can detect a light intensity as small as 5.0×10^{-13} W/m^2. What is the minimum number of photons per second that an owl eye can detect if its pupil has a diameter of 8.5 mm and the light has a wavelength of 510 nm?

$$E_{photon} = 3.894 \times 10^{-19} \text{ J}$$

$$A = 5.674 \times 10^{-5} \text{ m}^2$$

$$\text{Intensity} = S = 5.0 \times 10^{-13} \frac{W}{m^2}$$

$$SA = P = 2.837 \times 10^{-17} \text{ W}$$

$$P = \frac{\text{Energy}}{\text{photon}} \cdot \frac{\text{\# photons}}{\text{sec}} \qquad \frac{\text{\# photons}}{\text{sec}} = 72.9 \frac{\text{photons}}{\text{sec}}$$ on average

c) A laser emits 1.3×10^{18} photons per second in a beam of light that has a diameter of 2.00 mm and a wavelength of 514.5 nm. Determine the average electric field strength and the average magnetic field strength for the electromagnetic wave that constitutes the beam. You will have to look back to Problem Solver unit #7 for part of this.

$$E_{photon} = 3.860 \times 10^{-19} \text{ J} \qquad A = \pi \times 10^{-6} \text{ m}^2$$

$$P = 0.5018 \frac{\text{J}}{\text{sec}}$$

$$S = 1.597 \times 10^{5} \frac{W}{m^2} = c\epsilon_0 E_{rms}^2$$

$$E_{rms} = 7.76 \times 10^{3} \frac{N}{C}$$

$$B_{rms} = 2.59 \times 10^{-5} \text{ T}$$

The "average" values of E and B are zero, though.