The Masters School
Mr. Alex Rawson
Physics

Name: ______________________________

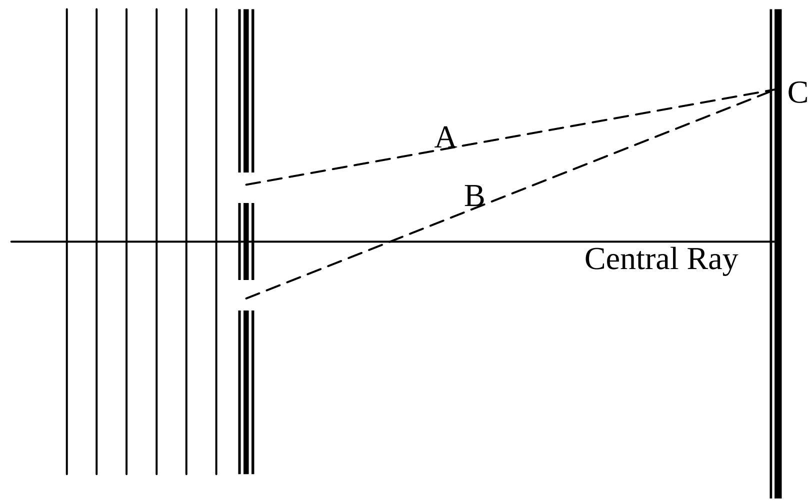
Date: ______________________________

Section C D F

Diffraction I: Double Slit Geometry

Let's imagine, geometrically, how a double slit may create constructive and destructive interference. You can clearly see that in the diagram below, ray A is shorter than ray B. If A and B were waves, can you see that wave A has a shorter distance to travel than wave B? Therefore wave B would be in a different "phase." Let's assume that wave B had to travel one full extra wavelength, and at point C, A and B were "in phase" because B had gone one full wavelength more than A. This would mean that they would constructively interfere, and a spot of light would shine.

Looking onto the next page, if A and B were both pointed at the central ray, do you see that they would again create constructive interference? This point, along the central ray, is called the central maxima. (See figure 16-9 on pg 603)
The first point above the central maxima that waves A and B would constructively interfere is called the "First Order Maxima," denoted by **m**.

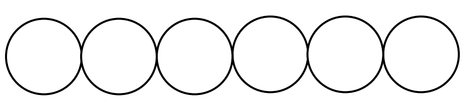


There is a way to calculate where the points of constructive interference, or maxima, would occur.

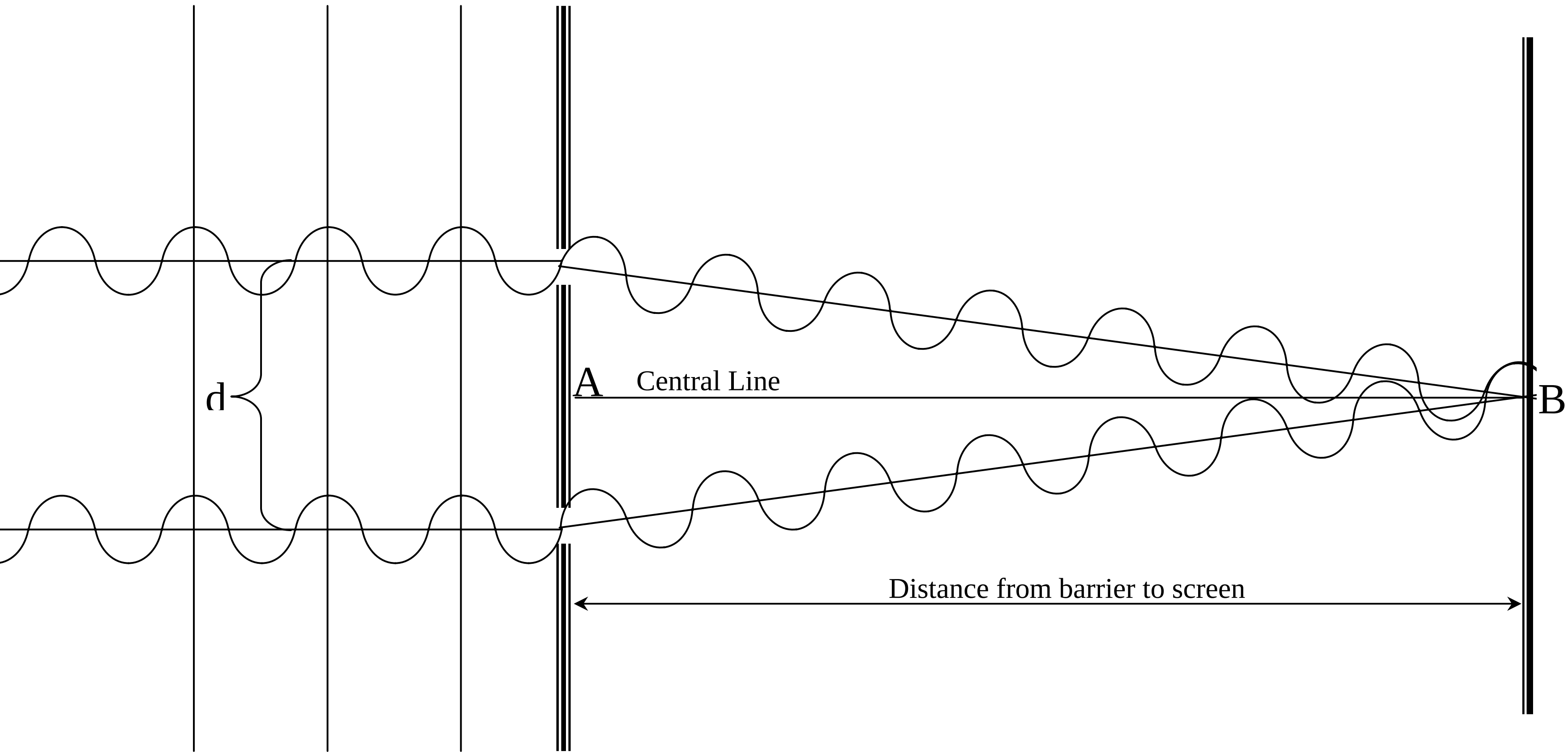
<u>Equation for Constructive Interference</u>
$d (\sin \theta) = m \lambda$

<u>Equation for Destructive Interference</u>
$d (\sin \theta) = (m + \frac{1}{2}) \lambda$

Go through the next few pages and complete all measurements.

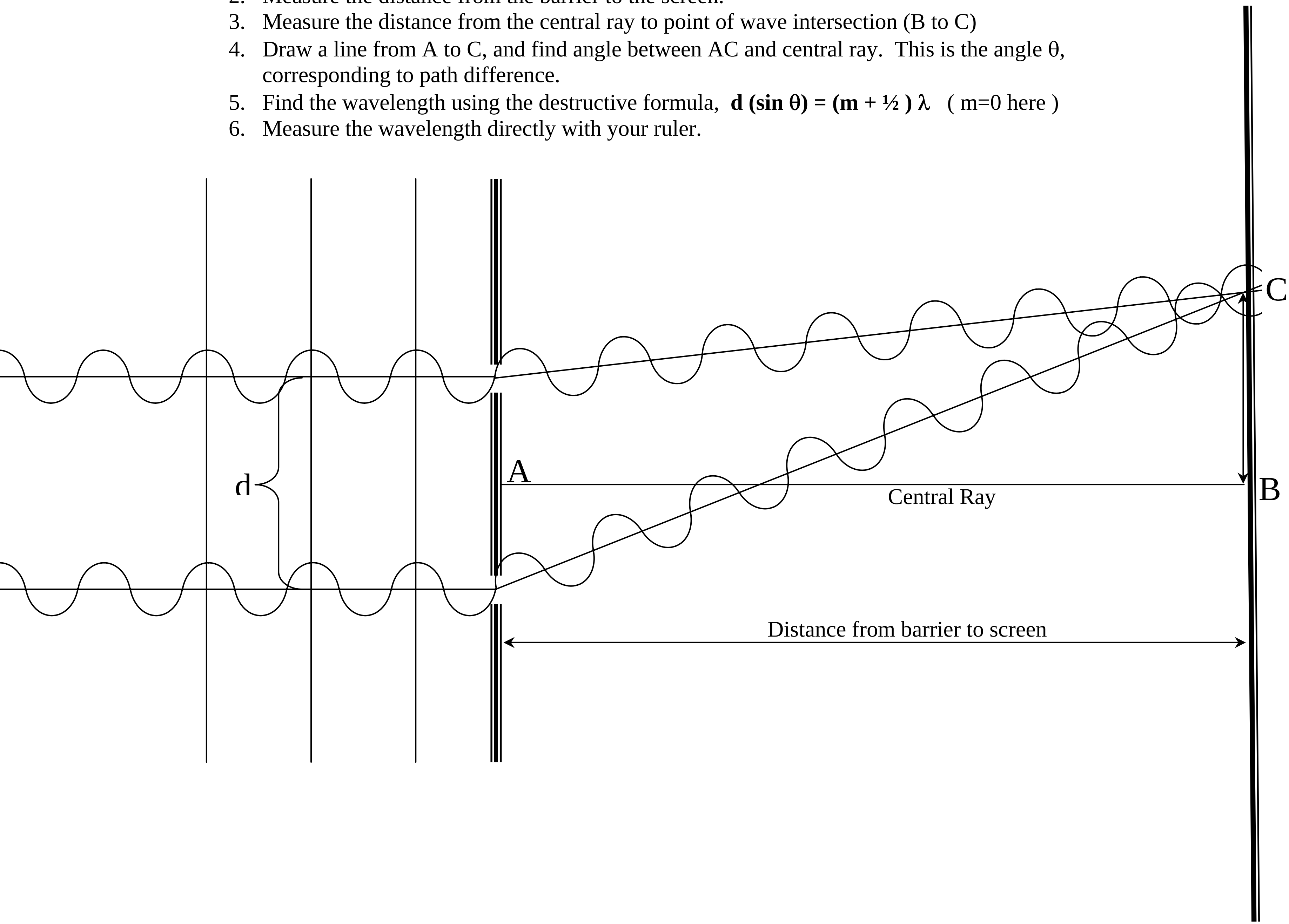


#1



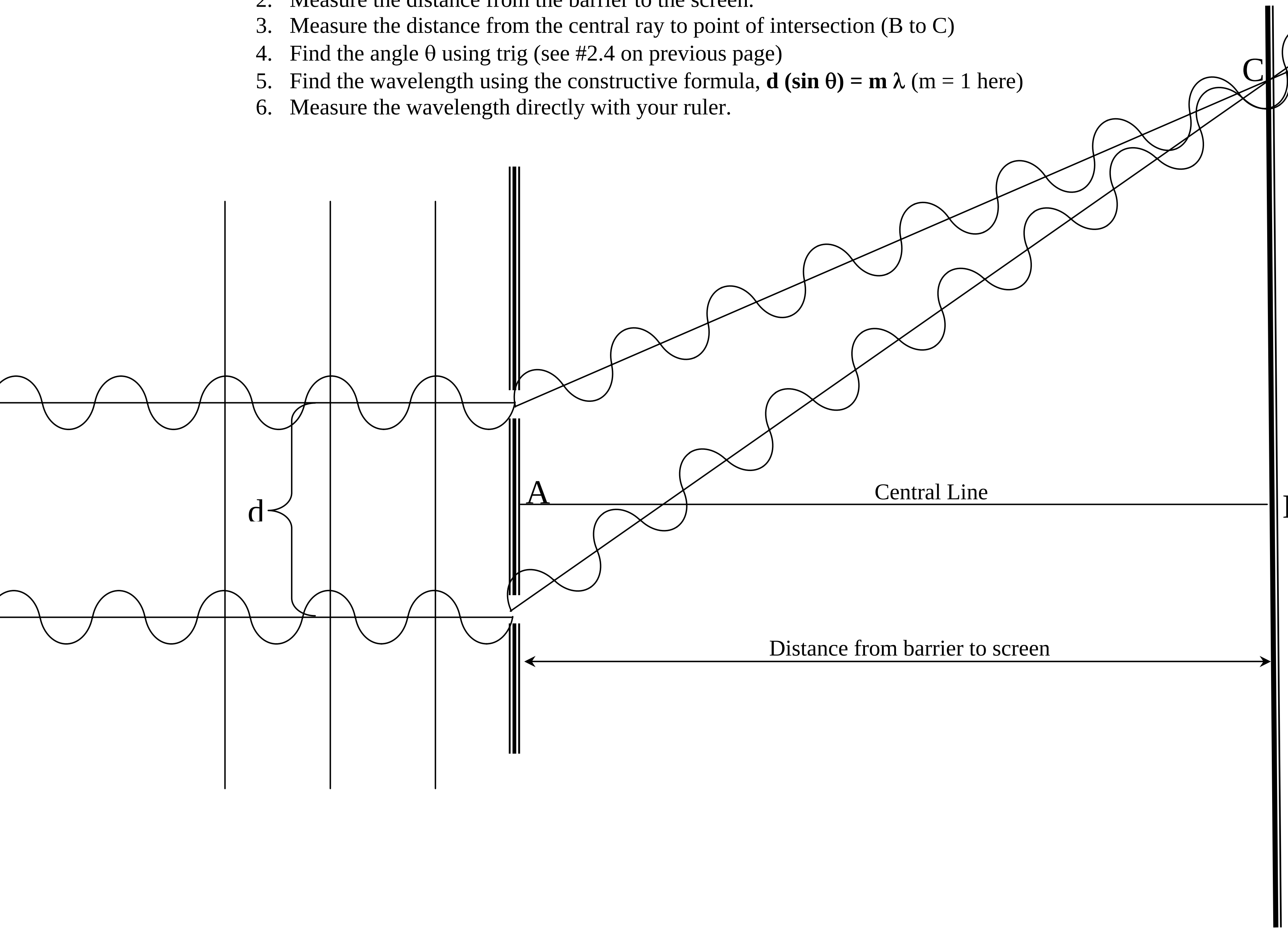
#2

1. Measure the slit width, d.
2. Measure the distance from the barrier to the screen.
3. Measure the distance from the central ray to point of wave intersection (B to C)
4. Draw a line from A to C, and find angle between AC and central ray. This is the angle θ, corresponding to path difference.
5. Find the wavelength using the destructive formula, **d (sin θ) = (m + ½) λ** (m=0 here)
6. Measure the wavelength directly with your ruler.



#3

1. Measure the slit width, d.
2. Measure the distance from the barrier to the screen.
3. Measure the distance from the central ray to point of intersection (B to C)
4. Find the angle θ using trig (see #2.4 on previous page)
5. Find the wavelength using the constructive formula, **d (sin θ) = m λ** (m = 1 here)
6. Measure the wavelength directly with your ruler.



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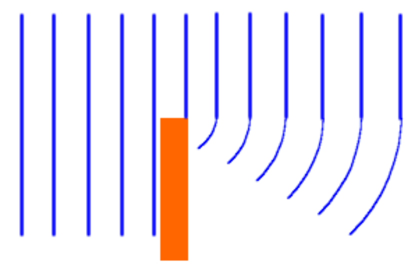
Diffraction and Interference

Introduction

We just finished looking at the properties of light being reflected off of a mirror, and refracted through lenses. Now we are going to look at the properties of waves as they travel through tiny holes and bend around those holes. This bending around objects is called diffraction, the main topic of Chapter 16.

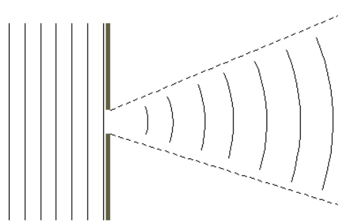
Refraction relates to when light travels through a medium, and the light slows down, thus bends. Diffraction is when light is bending around an object, yet the medium remains the same. Remember that light follows the same wave principles that we studied in chapters 12 and 13, in terms of interference, amplitude, and wavelength.

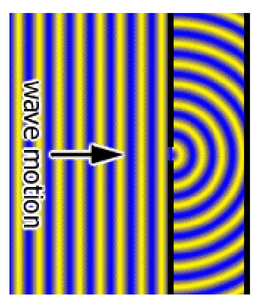
Different types of diffraction (bending)

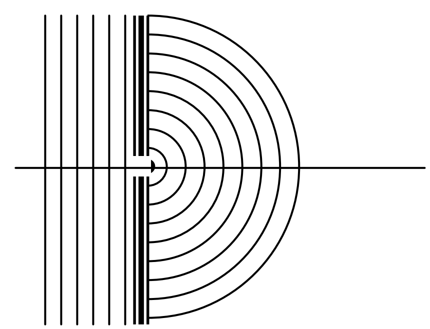


1. **Diffraction around an edge –** Imagine that the blue lines would be the crests of the waves, or the *wavefront* (we studied this in class; there is an image on pg 483). If the blue waves are traveling from left to right, see how above the red barrier, the blue waves continue straight. At the top of the red barrier, the waves bend down in a semi-circular shape. An animation can be seen by going to http://www.ngsir.netfirms.com/englishhtm/Diffraction3.htm

2. **Diffraction through a slit –** Imagine that the red barrier is now above and below, and a small opening allows the waves to travel through. This small opening we will refer to as a *slit*. The semi-circular wavefront from 1 would not only be on the lower half but also on the upper half, creating a full circular resulting wavefront. An animation can be seen by going to http://www.ngsir.netfirms.com/englishhtm/Diffraction.htm



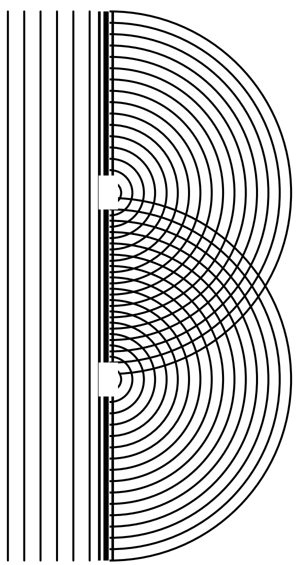




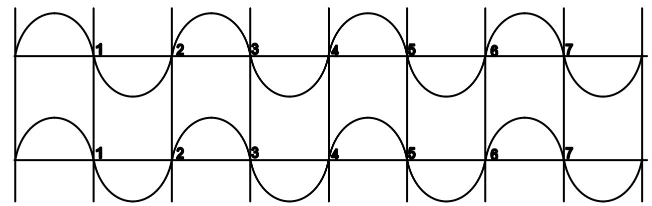
3. **Diffraction through 2 slits -** If we have 2 slits, then we will have 2 circular patterns emitted from the barrier. These two patterns will collide with one another, and constructive and destructive interference will occur. A good animation can be seen by going to http://www.ngsir.netfirms.com/englishhtm/Interference.htm
    a. *Constructive Interference* is when the crests of two waves overlap, and the amplitude is increased. Light will shine when there is constructive interference.
    b. *Destructive interference* is when the crest of one wave overlaps with the trough of another, and the two waves cancel out. No light will shine when there is destructive interference.
    c. The waves will not always be perfectly constructive or destructive however. The range of interference patterns is called the Phase Difference.

<u>Phase Difference – pg 599</u>

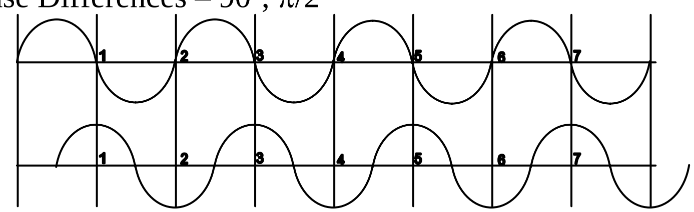
- "*in phase*" – when two waves have the same wavelength and the crests overlap. Thus they have constructive interference, amplitudes are added, and light shines.
- "*out of phase*" – when two waves have the same wavelength but the crest of one overlaps with the trough of another. Thus they have destructive interference, amplitudes cancel, and no light shines.
- Usually the different phases are explained by imagining that the wavelength simply began later, or *shifted* over.



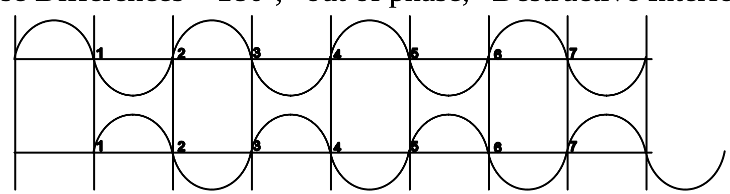
Phase Differences – 0^{o}, "in phase," Constructive interference



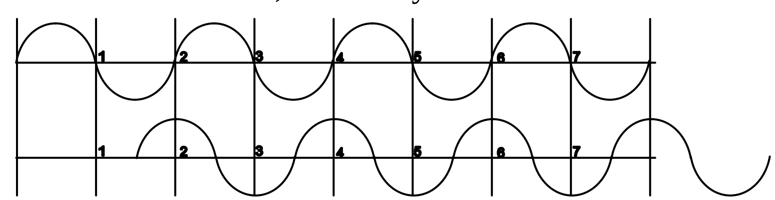
Phase Differences – 90^{o}, $\pi/2$

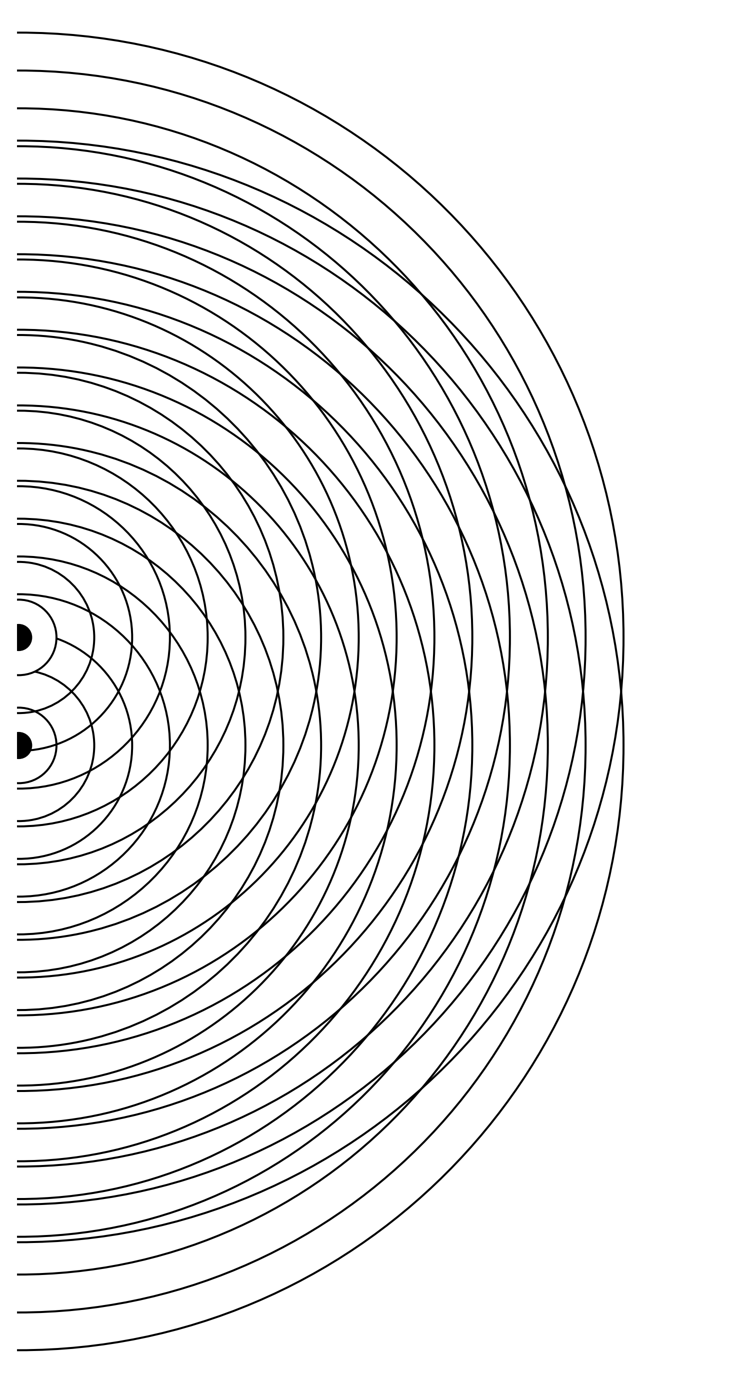


Phase Differences – 180^{o}, "out of phase," Destructive Interference



Phase Differences – 270^{o}, commonly referred to as $-\pi/2$





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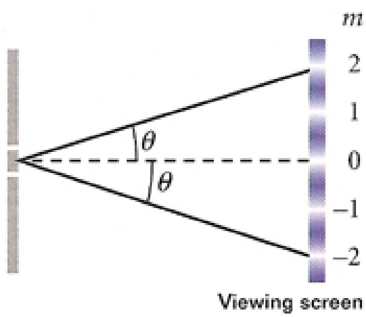

Figure 16-9
The higher-order ($m = \pm1, \pm2$) maxima appear on either side of the central maximum ($m = 0$).

SAMPLE PROBLEM 16A

ne second-order bright angle of 2.15° from the light.

5°

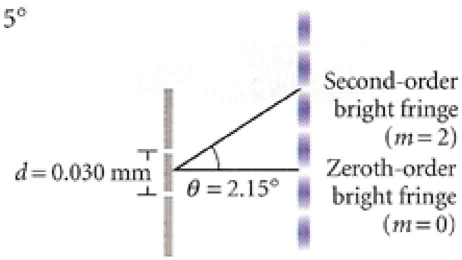

Diagram not to scale

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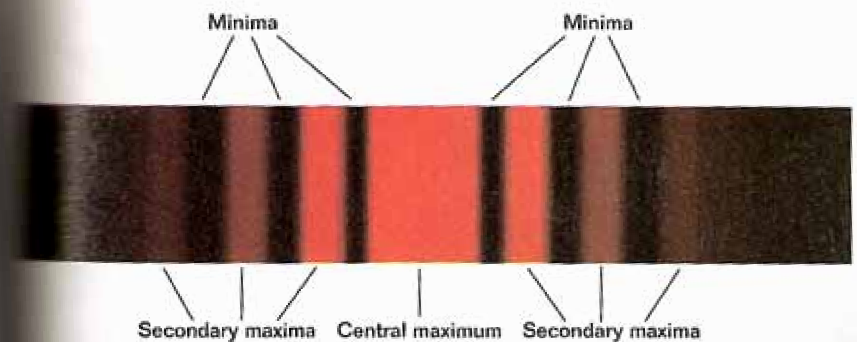
CALCULATOR SOLUTION

Because the minimum number of significant figures for the data is two, the calculator answer



16-14
ction pattern, the central maximum is twice as wide as
ndary maxima.