Name ______________________ Section ____________ Date ____________

CONCEPTUAL PHYSICS	Activity

 Turn a mm into a μ to Find λ

Light Rules

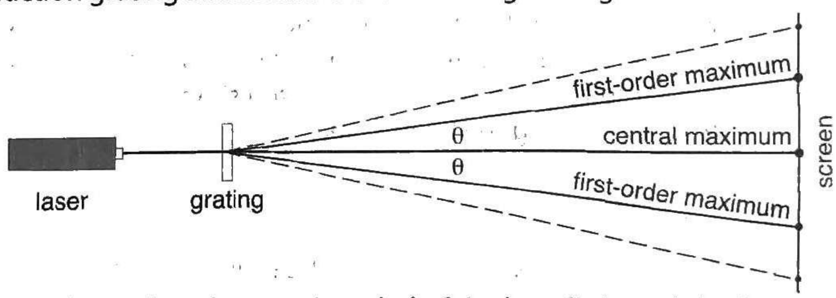
Purpose
To use simple geometry and simple equipment to determine the wavelength of laser light

Apparatus
laser with a known wavelength
metal ruler with an etched millimeter scale
metersticks or tape measure

Discussion
If you view a meterstick face on, at right angles to your vision, millimeter marks appear simply as millimeter marks. But if you view the meterstick at a grazing angle, not only does the meterstick appear foreshortened, but the markings on the ruler appear "squashed" in your line of sight.

Likewise for a laser beam reflecting at a grazing angle from the surface of a tilted meterstick. When the stick is tilted as shown in Figure 1 (Step 1), the millimeter marks appear to be 1/10 of a millimeter to the light beam. One millimeter is seen as 0.10 mm. Likewise for the raised millimeter marks of a metal or plastic ruler. With this grating spacing and the viewing screen far away, we can use the raised ridges of the ruler as a diffraction grating and measure the wavelength of light!

The diffraction pattern produced by a transmission or reflection grating is an interference pattern that produces very distinct maxima (bright spots of constructive interference).



The angle θ of the first-order maxima depend on the wavelength λ of the laser light and the line spacing d of the diffraction grating: $\lambda = d \sin\theta$. See Figure 29.18 and footnote 2 on page 550 of your textbook for a detailed discussion on the reason for the bright and dark zones.

Procedure
Step 1: Arrange a simple reflection. Shine a laser at a smooth (unmarked) section of the metal ruler, as shown in Figure 1. A reflected dot will appear on the wall or screen.

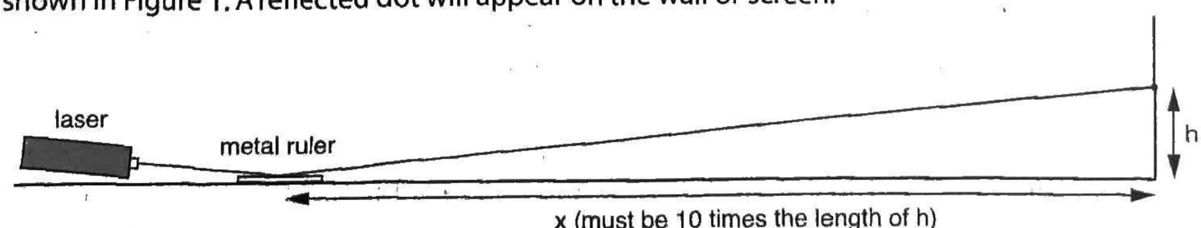


Figure 1. Specular Reflection

The laser beam's path has a slope of 1/10. That is, its height changes by 1 cm for every 10 cm that it travels forward.

The horizontal distance x must be 10 times the vertical distance h. Secure the laser once the configuration is correctly arranged. Record the distances x and h for your arrangement. Don't forget to include units! The ruler-to-screen distance L will be determined later.

$x =$ ______________________ $h =$ ______________________

Step 2: Move the ruler so that the laser beam strikes the etched millimeter marks. A diffraction pattern will now appear as shown in Figure 2.

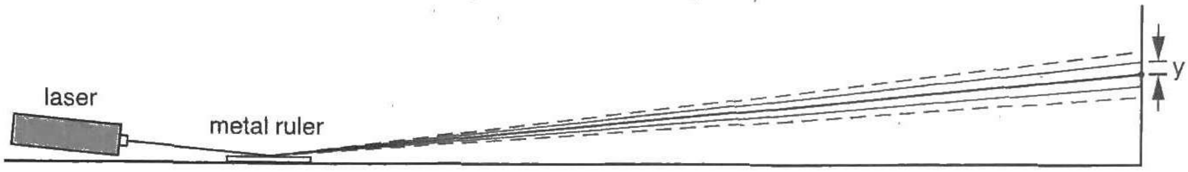


Figure 2. Diffraction

Step 3: Measure the distance y to the first-order maxima. The pattern of dots will be somewhat asymmetric due to the oblique angles used in the arrangement. To get a good value for the first-order maxima distance, do the following.

Measure the distance from one first-order maximum to the other. See Figure 3. Take this distance to be $2y$. Find y by dividing that distance by 2.

$2y =$ ______________________ $y =$ ______________________

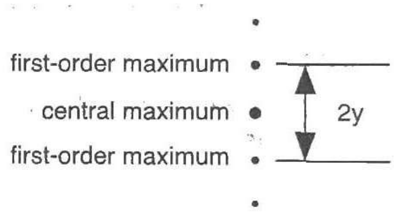


Figure 3. Maxima

Step 4: Record the wavelength of the laser in nanometers and in meters (use scientific notation).

$\lambda =$ ______________ nm = ______________________ m

Summing Up

1. Examine Figure 1. Since x is 10 times the length of h, can you see that the grating-to-screen distance L is ***essentially*** the same as the distance x? Record the value below. If you are concerned that this is an unwarranted simplification, determine the value of L from the values for x and h using the Pythagorean Theorem.

   $L =$ ____

2. Calculate the wavelength of the laser using $\lambda = d \sin\theta$.

   a. The value of $\sin\theta$ in the geometry of our skinny triangle can be taken to y/L.

   $\sin\theta = y/L =$ ____

   b. Multiply this result by d. Note that d is the foreshortened space between our etched millimeter marks. It's 1/10th of 1 mm, which is 10^-4 m

   $\lambda = d\sin\theta = dy/L =$ ____

   c. Express the wavelength to the nearest nanometer (nm).

   $\lambda =$ ____

3. Calculate the percent difference between this value and the accepted wavelength of the laser.

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