Optics Laboratory

Measuring the wavelength of light with a rule.

The wavelength of visible light is very small, of the order of 400 nm to 700 nm. The aim of this experiment is to measure the wavelength of the red light from a helium-neon (He-Ne) laser using the diffraction of the light from the markings on a steel rule.

Diffraction gratings are often used in optical instruments in place of prisms to disperse light into it's component wavelengths. Diffraction gratings can be of either a transmission or reflection type. For reflection gratings they are classically made by ruling fine lines on to a reflecting surface. In order to get good dispersion of the incident light the line spacing needs to be of the order of the wavelength of the light to be dispersed. Thus it is quite common to find diffraction gratings with 600 - 1200 lines/mm.

However, even the periodic dark lines on a steel rule will act as a reflection diffraction grating and this property will be used to observe the diffraction pattern of a laser beam incident on to the surface of the rule (Figure 1). Using the fundamental grating equation

$$\sin\alpha + \sin\beta = 10^{-6} kn\lambda$$

where, α is the angle from the normal of the incident beam, β is the angle from the normal of the diffracted beam, k is the diffraction order, n is the line density (lines/mm), and λ is the wavelength of the light in nm. It is possible to calculate from the diffraction pattern the wavelength of the laser light.

Although the lasers used in these experiments have a low output power they can still cause damage to the eye. This is because the lens of the eye will focus ALL the light onto a very small spot on the retina and it will not then take very much power to cause a retinal burn. DO NOT LOOK DIRECTLY INTO THE BEAM AND DO NOT SHINE THE LASER AT OTHER PEOPLE.

For the experiment you will be given a laser, steel rule, screen and tape measure. Place the rule flat on the bench and prop the laser up so that it is striking the rule at a shallow angle. The diffraction pattern can then be viewed on the screen. Several dots should be visible. You first need to determine which is the zero order spot (k=0). How can you determine the wavelength of the laser light from the diffraction spots? See figure 2 for a clue.

Using the different diffracted spots measure the wavelength of the laser light and estimate the error in your measurements. How can you improve the accuracy of your measurements? Shine the laser on to the different line spacings on the rule. How does this affect the diffraction pattern? Calculate the wavelength of the laser using the different line spacings. Which give the best results?

The Wavelength of Laser Light
using a metal rule as a reflection diffraction grating

In this experiment you use a He-Ne laser which produces a red light which is diffracted off of the dark lines of the metal ruler as a diffraction grating. DO NOT LOOK DIRECTLY INTO THE BEAM OF THE LASER OR SHINE SHINE THE LASER AT OTHER PEOPLE.

You need to know that:

$$\sin\alpha + \sin\beta = 10^{-6}\,kn\lambda$$

where:

- α = the angle from the normal of the incident beam
- β = the angle from the normal of the diffracted beam
- k = the diffraction order
- n = the line density (lines/mm)
- λ = the wavelength of the red light (nm)

It is suggested that you take one 'quick' measurement to test the formula and if you obtain an answer in the right order proceed to design a good experiment.

Decide what are your variables, collect a suitable range of results plot a suitable graph and deduce an accurate value of the wavelength of the read laser light.

Figure 1. A schematic of the experiment

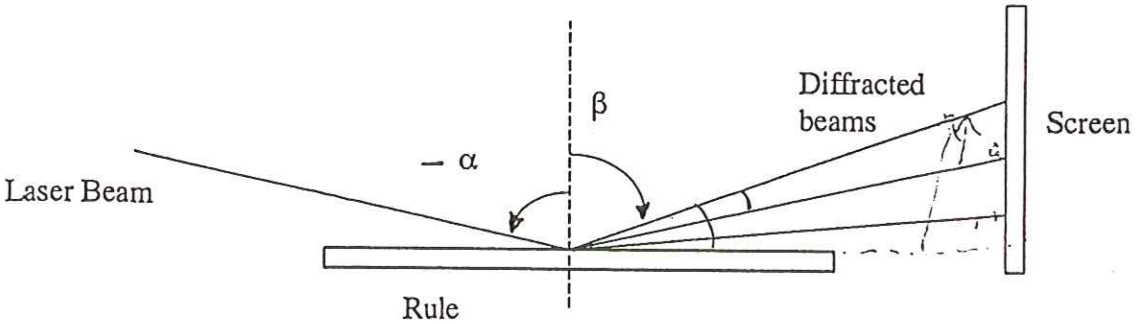
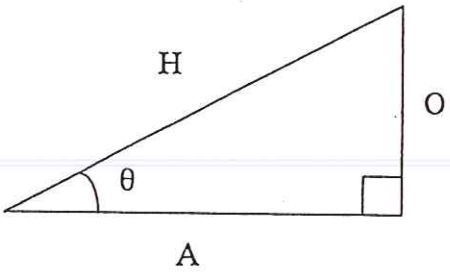


Figure 2. A tip for solving the problem



$\sin\theta = \frac{O}{H}$ and $H^2 = A^2 + O^2$