A simple diffraction experiment using banana stem as a natural grating

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A simple diffraction experiment using banana stem as a natural grating

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Abstract

A simple diffraction experiment was designed using banana stem as natural grating. Coherent beams of lasers with wavelengths of 632.8 nm and 532 nm that pass through banana stem produce periodic diffraction patterns on a screen. The diffraction experiments were able to measure the distances between the slit of the banana stem, i.e. $d = (28.76 \pm 0.295) \times 10^{-6}$ m for a laser with a wavelength of 632.8 nm and $d = (26.62 \pm 0.002) \times 10^{-6}$ m for a wavelength of 532 nm. Therefore, banana stem could be used as an easily obtained and low cost grating for diffraction experiments.

Introduction

Diffraction has become an important subject in physics. An interesting property of waves when they pass through an obstacle matter with a narrow slit is that they experience deflection. Water waves that pass through a slit will produce circular waves that spread out greatly due to the water waves deflected by the slit [1]. A similar phenomenon can be easily observed in sound waves with wavelengths in the order of meters that undergo deflection when they pass through an obstacle matter. This is because of various gaps in the order of wavelength sound such as a cave, shutters, blinds, ventilation etc. Meanwhile, we rarely see the phenomenon of diffraction of light in our daily lives because the wavelength of light is in the order of ~380–700 nm, while obstacles are always greater than the wavelength of light itself.

A simple experiment to observe the diffraction of light waves is by using instruments such as lasers as a light source, grating as an obstacle with multiple narrow slits and a screen as a medium to capture the periodic diffraction pattern. Grating becomes an essential tool in the diffraction experiment because of its role as an obstacle matter with the provision that the slit size is smaller than the wavelength of the light to obtain a periodic diffraction pattern perfectly. Lack of knowledge on the obstacle matter that could be used as a grating causing subject diffraction was not demonstrated to the students so the phenomenon of light diffraction was not taught in practice. The important advantage of the physics experiment's aim is to show a real physics phenomenon with simple tools, that are inexpensive and easily obtained so that they can reconstruct individually at home [2–4]. In this paper, we make a simple diffraction experiment using grating from banana stem. The experiment is easy to create and operate, so experiments can be conducted in


(a) (b)

Figure 1. (a) Banana plant and (b) a thin sheet of banana stem.

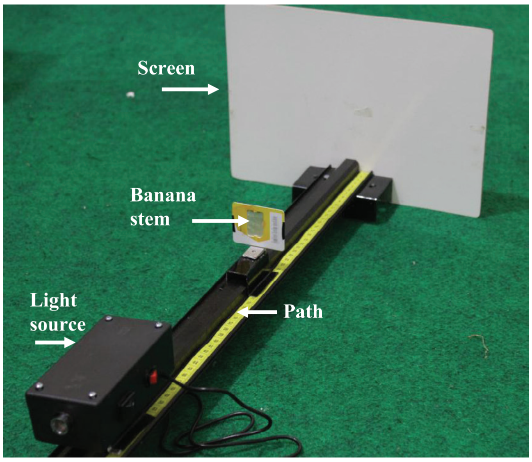

Figure 2. The instruments of the diffraction experiment using banana stem.

classrooms or students' home without demanding any assistance.

Method

Simple diffraction gratings from banana stem were made by using thin sheets on the outer portion of the stem that had dried from banana plant. The thin sheets of banana stem that were used as grating is shown in figure 1. The instruments and materials from the diffraction experiment such as laser, screen, and grating from banana stem were arranged as shown in figure 2. Laser beams used for the diffraction experiment have wavelengths of 632.8 nm (red) and 532 nm (green). A sheet of banana stem could be used as a diffraction grating if the periodic diffraction patterns are formed on the screen. This simple observation can be used to show properties of light that experienced a deflection when travelling through an obstacle with a narrow slit and can also be used to determine the distance between gratings of the banana stem.

Results and discussion

The results showed the periodic diffraction pattern of grating from banana stem that formed on the screen, as shown in figure 3. The coherent light of the laser with wavelengths of 632.8 nm and 532 nm which pass through the banana stem entirely could produce periodic diffraction patterns on the screen. This simple observation showed that banana stem can be used as a diffraction grating. However, the periodic diffraction pattern that formed on the screen was not clear. It was estimated to be due to the arrangement of fibers not being entirely organized with the relatively same distance, thus causing the light waves that pass through the banana stem to be scattered. The structure of the banana stem consists of fibers that are arranged with narrow distances and can be regarded as multiple slits within the grating. Laser light waves that pass through a banana stem will produce secondary waves with the same wavelength of the source of the incident wave. This principle was introduced by Huygens to explain the phenomenon of wave diffraction.

Bright spots on the screen formed by the secondary waves experience a constructive interference. Whereas the secondary waves also experience a destructive interference that causes dark spots to form on the screen. Bright spots on the periodic diffraction pattern occured when:

$$d \sin \theta_n = n\lambda \quad (1)$$

where d is the distance between the slits, λ is the wavelength of light, θ_n is the angular displacement from the central bright spot to a bright spot of order n. A simple schematic of the diffraction experiment is shown in figure 4.

Angular displacement from the central bright spot to a bright spot of order n is quite small, so the distance between the slit from equation (1) can be estimated to become linear equation (2).

$$d = n\lambda \frac{L}{y_n}$$
$$d = \frac{n\lambda}{\tan \theta} \quad (2)$$

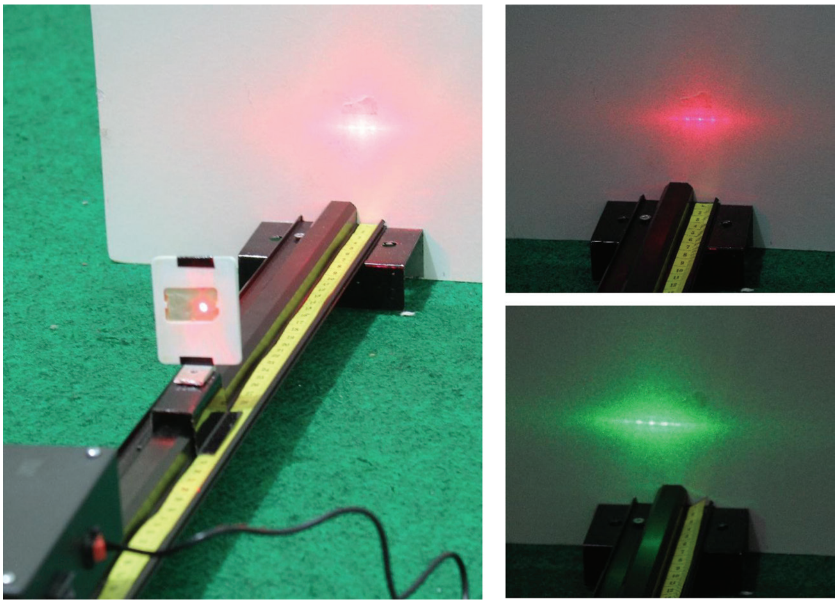

Figure 3. The periodic diffraction pattern produced from a banana stem grating.

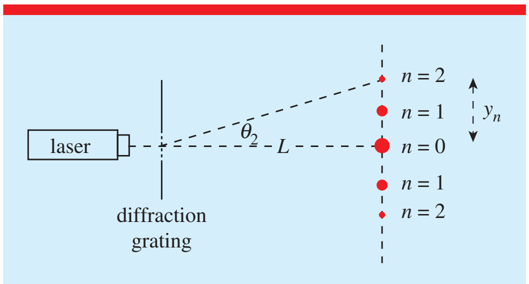

Figure 4. A schematic of the diffraction experiment.

Table 1. The relationship between L and y_n.

Distance of grating L (m)	Distance of bright spots y_1 ($\times 10^{-2}$ m)	
	$\lambda = 632.8$ nm	$\lambda = 532$ nm
0.3	0.7	0.6
0.4	0.9	0.8
0.5	1.2	1.0
0.6	1.4	1.2
0.7	1.6	1.4
0.8	1.8	1.6

The results of the diffraction experiments are shown in table 1. Experiments were performed to change the variable spacing of the grating to the screen (L). By using analysis of linear equations in the graph in figure 5, the distance between slits for a laser with a wavelength of 632.8 nm is $d = (28.76 \pm 0.295) \times 10^{-6}$ m with a percentage error of about 1% and for a wavelength of 532 nm is $d = (26.62 \pm 0.002) \times 10^{-6}$ m with a percentage error of about 0.01%; the present method offers very good accuracy. The distance between slits from the diffraction experiments are relatively similar.

Periodic diffraction patterns that are formed on the screen are a result of interference and secondary waves with highest intensity at the zeroth order, and the intensity will decrease in the next

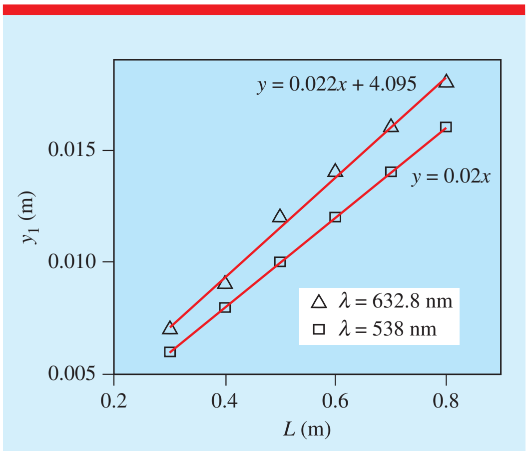

Figure 5. Graph analysis of the diffraction experiment results with laser wavelengths of 632.8 nm and 532 nm.

(a)

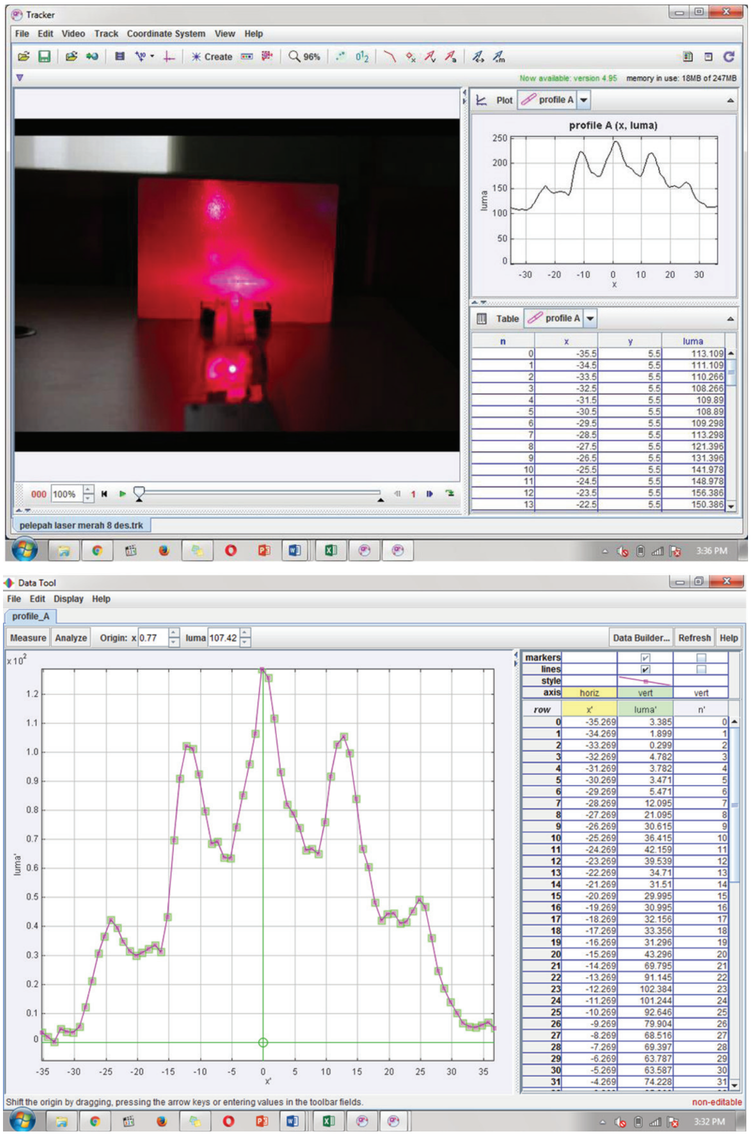

Figure 6. The results of periodic diffraction pattern analysis on *Tracker* (top) and spectrum intensity as a function of position *x* with relation to the zeroth order (down) using gratings: (a) banana stem and (b) glass.

orders. The intensity of the periodic diffraction pattern from the banana stem grating can also be estimated by using *Tracker* [5–7], as shown in figure 6. The estimation results indicate that the intensity of periodic diffraction patterns from a banana stem have a spectrum with highest intensity at the zeroth order and the intensity decreases at the first and next order. The spectrum of the periodic diffraction patterns are approximately equal to the spectrum that is produced by a grating from glass. Therefore, banana stem can be used as a grating in the diffraction experiment.

(b)

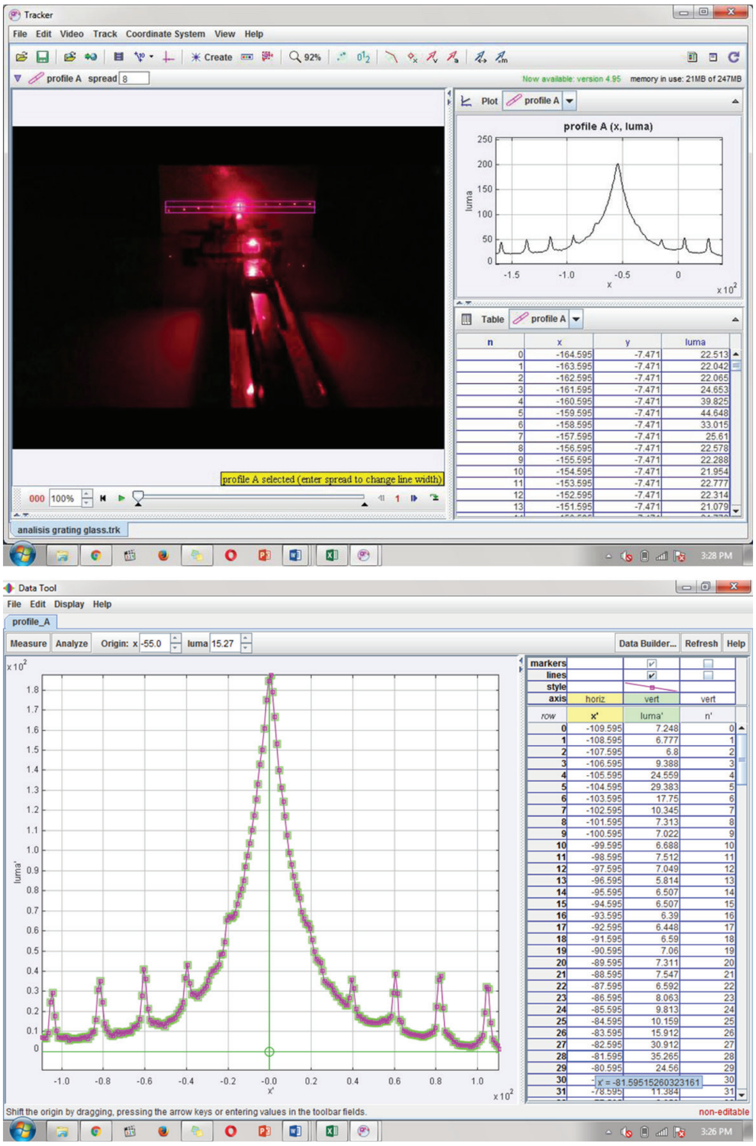

Figure 6. (*Continued*)

Conclusion

A simple diffraction experiment using banana stem as a grating has been successfully designed and tested. The periodic diffraction pattern formed when the coherent light beams from a laser pass through banana stem shows that the banana stem can be used as a grating. This study can show diffraction phenomenon with simple experimental tools and low costs using a natural grating.

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