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Using a Diffraction Grid to Measure the Wavelength of a POF Laser

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ABSTRACT
The research has been carried out to determine the wavelength of the POF laser using a diffraction grating. The diffraction grating used consists of three kinds of grid constants, namely 100 lines/mm, 300 lines/mm, and 600 lines/mm. Furthermore, the variation of the distance between the grid and the screen with a length of 40 cm, 60 cm, and 90 cm is carried out. The results showed that the wavelength of the POF laser light was between 664.07 nm-728.31 nm and the red monochromatic light source obtained the interference pattern of light on the screen as well as red monochromatic light. Based on the results of the research, it can be proven that the wavelength obtained from the use of a diffraction grating to measure the wavelength of the red laser is close to the wavelength value of 664.07 nm.

INTRODUCTION

A laser is a coherent, unidirectional, and nearly monochromatic light source [1] [2][[3]. Laser is an abbreviation of Light Amplification by Stimulating Emission of Radiation which means the light is amplified through a triggered emission process [4] [5] [6] [7]. There are several types of lasers depending on the laser medium used, such as solids, liquids, gases, and semiconductors. The solid-state lasers consist of Ruby lasers, Ti:S lasers, and Nd: YAG lasers, while gas lasers consist of He Ne lasers and CO2 lasers [8] [9]. Dye and diode lasers are liquid and semiconductor lasers [10]. In addition, there are also known as POF lasers, which are laser beams usually monochromatic and coherent light as a result of the emission of light from many atoms [10] [11] [12]. LASER stimulates molecules to amplify light and emit light at certain wavelengths to produce a narrow beam of radiation [8] [13]. LASER rays are electromagnetic waves that can undergo reflection, refraction, interference, deviation, dispersion, diffraction, and polarization [14] [15] [16]. LASER with low intensity can be found easily in the market.

Diffraction is a phenomenon that can only be explained by the light model as a wave [13] [17] [18] [19] [20]. Light passing through a narrow slit will form a diffraction pattern in the form of light and dark bands on the screen [19] [21] [22]. The distance between the bright bands is affected by the wavelength of light (λ), the slit width (d), and the distance between the slits and the screen (L) [19] [23] [24] [25]. The relationship is shown by Equation 1.

$$d.sin\theta = n.\lambda \quad (1)$$

where n is the n^{th} dark pattern. The distance L is much larger than the slit width d (L >> d), so we can use a small angle approximation, sin = tan = y/L. Therefore.

$$d.\left({}^{y}/_{L}\right) = n.\lambda \quad (2)$$

Diffraction is an event of spreading waves that propagate through narrow gaps or sharp edges [31]. In the event of diffraction, a diffraction grating is known, a diffraction grating is a tool used to measure wavelengths consisting of many narrow slits with the same distance on a flat surface. Rays that are perpendicular to the diffraction grating can be seen in Figure 1.

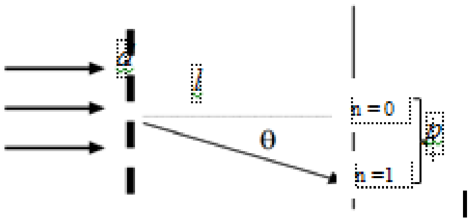

Fig 1. D*iffraction Grating in Diffracted Light* [31]

In Figure 1, the black arrow indicating the light source (rays) entering through the diffraction grating is depicted with a dotted line. After light enters the diffraction grating, the light will spread out to form diffraction orders. The diffraction order (n=0) which is in the center is also called the central light, while the light which is to the left and right of the central light is called the diffraction order 1. In the figure, the diffraction order 1 is denoted by n (n=1). The angle formed between the central light to the diffraction order (n) is denoted by θ.

The lattice consists of narrow slits with the same width for each slit. The width of the slit is denoted by d. If there is N in 1 cm of the lattice, then the width of the lattice gap can be calculated using equation 3 below. with the value of this lattice constant (N) namely 100 lines/mm, 300 lines/mm and 600 lines/mm

$$d = \frac{1}{N} \quad (3)$$

According to Kholifudin [26], light can experience diffraction if light can pass through a narrow gap. Light can pass through the slit if its wavelength is greater than the width of the slit. If a light with a wavelength λ passes through a narrow slit d, where d < λ, then the light will experience diffraction. Diffracted light can be detected by the deviation of the beam by θ from the original direction and the bright/maximum interference pattern will appear on the screen. The emergence of a lattice diffraction pattern has the same conditions as the occurrence of an interference pattern on a double slit, that is, if a maximum diffraction pattern occurs, it will be in phase and can be expressed in the equation:

$$d.\sin\theta = n.\lambda; n = 0, \pm 1, \pm 2 \quad (4)$$

If a minimum diffraction pattern occurs, it will be in phase opposite and can be expressed in the equation:

$$d.\sin\theta = \left(n - \frac{1}{2}\right).\lambda; n = \pm 1, \pm 2, \pm 3 \quad (5)$$

To determine the wavelength of light through a diffraction grating practicum, it can be determined using equation 6, namely:

$$\mathrm{d}.\sin\theta = \mathrm{n}.\lambda \ \text{ or } \ \frac{\mathrm{d_p}}{\mathrm{l}} = \mathrm{n}.\lambda \qquad (6)$$

LASER belongs to visible light and the LASER used for practicum is POF type LASER. LASER on the POF type has a wavelength ranging from 630-690 nm which belongs to the visible light range in the red color spectrum. LASER has several properties, namely: (1) Coherent light (at the same frequency), (2) Monochromatic light (one specific wavelength), (3) Concentrated LASER beam, (4) LASER beam has a very large intensity , much larger than other light sources. In order to produce an energy density that is the same as the energy density of a LASER, a hot object must have a temperature of 10^{30} K.

With the diffraction phenomenon, it is possible to calculate the wavelength of the POF laser, from the observations listed on the tool, the wavelength of the POF laser is around 630-700 nm [20][27][28], is this value by the results of the research? what is the wavelength of the POF laser by varying the diffraction grating of 100 lines/mm, 300 lines/mm, and 600 lines/mm? What is the wavelength of the POF laser by varying the distance from the grating to the L screen? In this paper, the results of these observations and research are described in more detail.

METHOD

This research used experimental method. The tools and materials used are screens, POF Laser, power supply, diffraction grating, precision rail, precision rail foot, and ruler. The tool setup is shown in Figure 2 with the experimental scheme in Figure 3.

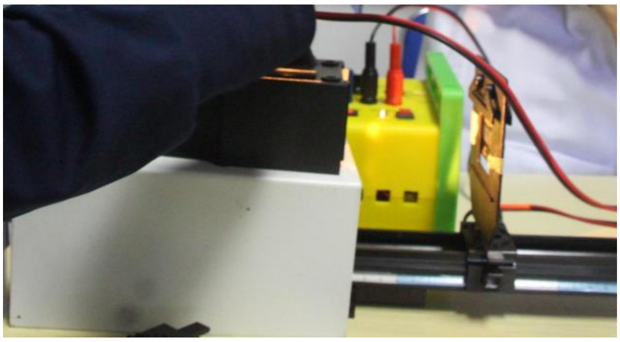

Fig 2. *Tool Set Up In Laser Diffraction Research*

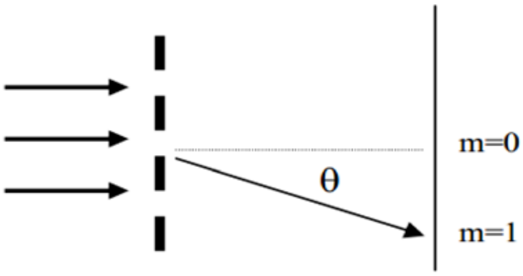

Fig 3. *Schematic in Experiment*

The diffraction pattern on the screen will be formed when the laser hits the grid. The next step is to mark the center light, pattern edge light 1, and pattern edge light 2 on both the right and left sides of the screen. The data is the result of measuring the distance between the center bright pattern to the edge of the bright pattern 1 and the distance between the center bright pattern to the edge of the bright pattern 2 which is formed due to the diffraction phenomenon, the display of diffraction can be seen in Figure 4 below.

Fig 4. *The Results of The Diffraction on The Screen Designed in This Research*

RESULTS AND DISCUSSIONS

In this study, different values of n have been varied, namely n = 1, n = 2 and n = 3. For n = 1, the POF laser wavelength can be obtained as shown in Table 1.

Table 1. The result of observing the POF Laser wavelength for n = 1

Grating	D(m)	L(cm)	Y(cm)	Lamda (nm)	Lamda average
100	10^{-5}	30	2	666.67	685.18
		60	4	666.67	
		90	6.5	722.22	
300	$3.3x10^{-6}$	30	6	660.00	678.33
		60	13	715.00	
		90	18	660.00	
600	$1.67x10^{-6}$	30	13	723.67	728.31
		60	26.5	737.58	
		90	39	723.67	

Table 1 and the calculation results, it can be seen that the wavelength of the POF laser obtained from the results of this study for the three types of grating used is in the range of 660.00 nm to 737.58 nm. For n = 1 using the three different types of grating, it can be seen that by using a grating of 100 lines/mm, the average wavelength is 685.18 nm. For a grating of 300 lines / mm produces an average wavelength of 678.33 nm. Meanwhile, the 600 line/mm lattice produces an average wavelength of 728.31 nm which tends to be larger than the wavelength obtained from the other two types of grating, but the results of this study are still in the order of the wavelength of the POF laser light.

Furthermore, observations and calculations of wavelengths for different values of n were carried out with other variations of n, namely n = 2, with the same type of lattice in Table 1 above, namely 100 lines/mm and 300 lines/mm, and 600 lines/mm, obtained the results of this study as shown in Table 2.

From Table 2 and the calculation results, it can be seen that the wavelength of the POF laser obtained from the results of this study for the three types of grating used is in the range of 660.00 nm to 720.50 nm. For n = 2, using these three different gratings, it can be seen that the 100 line/mm type grating obtained an average laser wavelength of 681.48 nm and by using a 300 line/mm lattice the average wavelength was 698.50 nm, Likewise, using a lattice of 600 lines/mm produces a wavelength of 678.82 nm, the results of this study are still in the order of the wavelength of the POF laser light.

Table 2. POF Laser Wavelength Observations for n = 2

Grating	D(m)	L(cm)	Y(cm)	Lamda (nm)	Lamda average
100	10^{-5}	30	4	666.67	
		60	8	666.67	681.48
		90	12.8	711.11	
300	$3.3x10^{-6}$	30	12	660.00	
		60	26	715.00	698.50
		90	39.2	720.50	
600	$1.67x10^{-6}$	30	36	668.00	
		60	75.5	700.47	678.82
		90	105	668.00	

Furthermore, observations and calculations of wavelengths for different values of n were carried out with other variations of n, namely n = 3, with the same type of lattice in Table 1 and Table 2 above, namely 100 lines/mm and 300 lines/mm and 600 lines. /mm. The experimental results are shown in Table 3.

Table 3. The Result of Observing the POF Laser Wavelength for n = 3

Grating	D(m)	L(cm)	Y(cm)	Lamda (nm)	lamda average
		30	6	666.67	
100	10^{-5}	60	12	666.67	666.67
		90	18.8	666.67	
		30	18	660.00	
300	$3.3x10^{-6}$	60	36	660.00	664.07
		90	55	672.22	
		30	-	-	
600	$1.67x10^{-6}$	60	-	-	-
		90	-	-	

The results in Table 3 provide an overview of the measured wavelength data for 3 types of a diffraction grating, using a 100 line/mm grating, the average laser light wavelength is 666.67 nm. For experiments using a grating of 300 lines/mm, the average wavelength of laser light was 664.07 nm and by using a lattice of 600 lines/mm the wavelength of laser light was unmeasured for n = 3 in this study. The average range of POF laser light wavelengths obtained in this study is still within the wavelength range stated in the literature, which is 630 nm - 700 nm, this indicates that the wavelength is by the reference color spectrum/spectrum of visible light or visible light [11,29], namely with a range of 630 nm – 700 nm in table 1 [11,23,30,31].

CONCLUSION AND SUGGESTION

Based on the research that has been done, it is concluded, among others, that the wavelength of the red laser light is on average in the range of 664.07 nm - 728.31 nm and the red monochromatic light source is the interference pattern of light on the screen as well as red monochromatic light. Research that uses a diffraction grating to measure laser wavelengths whose values are close to the values listed in the literature that red lasers have a wavelength of 664.07 nm.

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