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Determining Hair Thickness using the Light Diffraction Method: Verification of the Seven Times Sliced Hair Phenomenon

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Abstract

Light or optical spectrum is a part of electromagnetic radiation and has several electromagnetic wave properties; one of them is undergoing diffraction. Diffraction or light bending occurred when a light went through a narrow gap. By utilizing that principle, it was proven that a piece of hair could be assumed as a single gap, so the thickness of a piece of hair could be determined, which lead to the explanation of the phenomenon of a piece of hair sliced seven times. As a tool, the used sim cardholder is used to put hair using adhesive tape. Then the sim card is placed between the light source and the screen. The light source used is a red laser with a wavelength of 660 nm. Hair is placed in two positions: horizontally and vertically. Hair that is laid horizontally will create a vertical light-dark pattern, and hair that is placed vertically will form a horizontal light-dark pattern. The dark and light patterns on the screen are measured using a ruler according to the order of each pattern that is formed. The hair thickness measurement results using a red laser with a wavelength of 660 nm obtained hair thickness of d = (0.01146 ± 0.00019) cm for hair that is placed horizontally and d = (0.01151 ± 0.00011) cm for vertically placed hair. This data has more or less proven that there is potential to "split" the hair into sections, but it has not been proven that the hair can be split into seven parts, so there is still a chance to prove it.

Keywords: diffraction, single slit, wavelength, light.

1. Introduction

Light is an electromagnetic wave that has a very small wavelength. Generally, light has an amplitude, a wavelength, and a velocity. If light travels through a medium, its speed will change. In this hair measurement research, the light source used is laser light because the laser light can be seen directly by the eye and has coherent and monochromatic waves. In addition, the laser beam has a high intensity and is difficult to diffuse. Hair is generally so thin that it is impossible to measure it with a ruler.

Diffraction is the deflection of a wave when it passes through a small gap. The diffraction process makes it appear as if the slit is a circular light source. When the gap size is reduced, the spread of the wave will increase. Like waves, the light will also undergo diffraction when it passes through a small gap. (Giancoli, 2011:991).

When there are two or more slits, the intensity pattern on the screen is a combination of the single-slit diffraction pattern and the double-slit interference (Tipler,2004:1093). The formula used to determine hair thickness is:

$$d\ sin\theta = m\lambda \qquad (1)$$

2. Experiments Procedure

Before experimenting, all tools and materials must be prepared in advance: hair, blank sim card holder, adhesive tape, red laser, screen, and measurer.

First, stick a strand of hair on the sim card horizontally and place the sim card between the light source and the screen. Then, determine the distance between the hair and the screen (L). After that, ignite the red laser that radiates through the hair. Observe and measure the dark and light patterns formed on the screen. Lastly, do the same method on the hair that is pinned vertically on the sim card holder. For the arrangement of tools and materials, it can be seen more clearly in Figure 1.

Figure 1. Tools and materials

3. Result and Discussion

To determine hair thickness, the data for sin θ and m are required. Sin θ can be obtained from the measurement of the distance between the center of the light with the order (P) divided by the distance of the gap or hair to the screen (L). Then find the hair thickness (d) using the formula below:

$$\frac{m\lambda}{sin\theta} \qquad (2)$$

Where λ is the laser's wavelength, m represents the orde, d represents the thickness of the hair.

TABLE 1. The result of horizontally laid hair

L(cm)	m	P(cm)	sin θ	d (cm)
250	1	1,5	0.006	0,011
	2	2,8	0.0112	0,01178
	3	4	0.016	0,01238
225	1	1,3	0,00578	0,01142
	2	2,5	0,01111	0,01188
	3	3,7	0,01644	0,01204
200	1	1,3	0,006	0,011
	2	2,5	0,01225	0,01077
	3	3,7	0,0185	0,0107
175	1	1	0,00571	0,01156
	2	2	0,01143	0,01155
	3	3	0,01714	0,01155
150	1	0,8	0,00533	0,01238
	2	1,7	0,01133	0,01165
	3	2,5	0,01667	0,01187
125	1	0,7	0,0056	0,01178
	2	1,6	0,0128	0,01031
	3	2,3	0,0184	0,01076

Table 2. The result of vertically laid hair

L (cm)	m	P (cm)	sin θ	d (cm)
250	1	1,4	0,0056	0,01178
	2	2,9	0,0116	0,01138
	3	4,1	0,0164	0,01207
225	1	1,3	0,00578	0,01142
	2	2,5	0,01111	0,01188
	3	4,2	0,01647	0,01202
200	1	1,15	0,00575	0,01148
	2	2,25	0,01125	0,01173
	3	3,4	0,017	0,01165
175	1	1,1	0,00628	0,01051
	2	2	0,01143	0,01155
	3	3,1	0,01771	0,01118
150	1	0,9	0,006	0,011
	2	1,7	0,01133	0,01165
	3	2,6	0,01733	0,01142
125	1	0,7	0,0056	0,01178
	2	1,45	0,0116	0,01138
	3	2,2	0,0176	0,01125

In Table 1, the L (distance between hair and screen), m (orde), P (the distance of the light center of order m), and d (hair thickness) are shown. This table also shows how far L or how far L (the distance between the hair and the screen) is, the resulting hair thickness will remain the same. The hair thickness produced using a red laser is d = (0.01151 ± 0.00011) cm with a relative error of 0.96% based on this experiment.

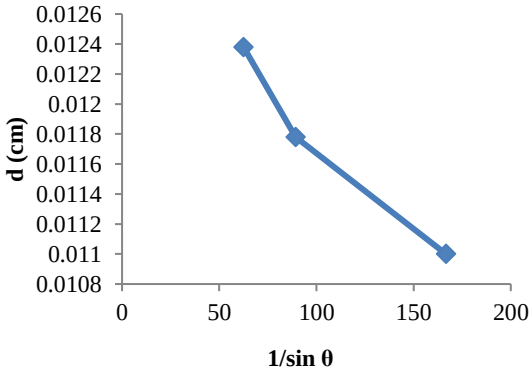

Figure 2. The relationship between 1 / sin θ and d at L = 250 cm

Table 2 shows L (distance between hair and screen), m (order), P (the distance between the center light and orde m), and d (hair thickness). This table also shows that no matter the distance between the hair and the screen, the resulting hair thickness data remains the same. Based on this experiment, the thickness of the hair produced using a red laser is d = (0.01146 ± 0.00019) cm with a relative error of 1.66%. From equation (1) a graph can be made between m / sin θ and d. This graph can be seen in Figure 2. Figure 2 shows that d (hair thickness) is proportional to the orde and wavelength but inversely proportional to sin θ.

From equation (1) a graph can be made between m / sin θ and d. This graph can be seen in Figure 3.

In the experiment, hair that was placed horizontally and vertically had almost the same hair thickness value or d. The hair placed horizontally will form a vertical dark and light pattern on the screen, while the hair placed in a vertical position will form a horizontal light-dark pattern on the screen.

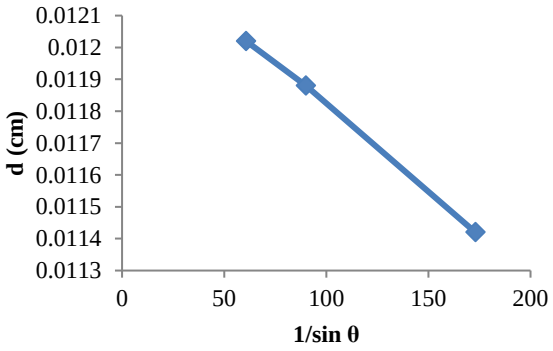

Figure 3. The relationship between 1 / sin θ and d at L = 225 cm

After discovering the thickness of the hair from this experiment, it can be said that hair has a function like a gap that can cause light to be diffracted.

The number of gaps can be calculated from the number of diffraction points. This means that how many gaps the hair has can be found out. Dengan persamaan dibawah ini dapat diketahui celah yang dimiliki oleh rambut:

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

For hair that is horizontally pinned, a grid is produced, namely N = 87.26 lines per cm. From this data, it can be concluded that the number of gaps in horizontal hair with a hair thickness of 0.01146 cm is 7.614 gaps and rounded to 7 (seven) gaps. As for the vertical hair, N = 86.88 lines per cm. Similarly, the number of gaps in the hair will be 7,548 and rounded to 7 gaps. Thus, it can be determined that the hair can be "split" into seven.

4. Conclusion

From experiments to determine hair thickness using a red laser, it can be concluded that:

1. Hair thickness can be found using equations:

$$d = \frac{m\lambda}{\sin\theta}$$

2. The hair thickness obtained is d = (0.01146 ± 0.00019) cm for hair that is installed horizontally and d = (0.01151 ± 0.00011) cm for hair in a vertical position.
3. Hair that is pinned horizontally will form a vertical dark light pattern on the screen, while hair that is pinned in a vertical position will form a horizontal light-dark pattern on the screen.
4. The thickness of the hair obtained is not affected by how far L is or the distance between the hair and the screen.
5. Hair has seven gaps, and this proves the phenomenon of hair being split seven.

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