UNIVERSITY OF WOLLONGONG IN DUBAI

LAB REPORT 8

INTERFERENCE AND DIFFRACTION

Subject: PHYS143 (DB123) Physics for Engineers.

Group Members:

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Interference and Diffraction

Interference

Interference is when 2 or more waves collide with each other in the same medium. If the 2 waves are in phase, they will add constructively and a bright spot will be observed on the screen. They add up to produce a larger wave. If they are out of phase, they will add destructively and a dark spot will be observed. The waves cancel each other out. In both cases, the resulting wave depends on the waves phase and amplitude.

IN PHASE AND OUT OF PHASE:

2 waves are said to be in phase when their crests or troughs cross the same point at the same time.

2 waves are said to be out of phase when the crest of one wave and the trough of the other wave cross the same point at the same time. Their phase angles in this situation differ by 180^0 or π radians.

Two slit interference

2 slits are placed by a distance d form each other. Light from a light source such as a laser hits the 2 slits and travels towards the screen which is placed a distance L from the slits. The light from the 2 slits travel to different distances. This light travels at an angle (θ) from the central maximum and is shown at a point P on the screen. The light from the bottom slit travels more than the light from the top slit. This extra path difference is shown by $\delta = d \sin(\theta)$. This also leads to a phase difference $(\Phi) = 2\pi\delta/\lambda$. Phase differences that are a multiple of 2π gives us constructive interferences while an odd multiple of π gives us destructive interference. The equation for constructive interference is $d \sin(\theta) = m\lambda$.

The equation for destructive interference is $d \sin(\theta) = (m+1/2)\lambda$

Multiple slit interference

Instead of 2 similar slits, this case has multiple identical slits and each are separated by the same distance d and the same effect takes place. The equation for the constructive interference is $d \sin(\theta) = m\lambda$.

Diffraction

The bending of waves as they pass through a small aperture or around an obstacle in their path is referred to as diffraction. Waves of all types, such as light, sound, and water waves, can exhibit diffraction. The degree of diffraction depends on the size of the obstacle or aperture and the wavelength of the wave. Diffraction becomes particularly important when the wavelength of the wave is much larger than the size of the obstacle or aperture. Diffraction is a fundamental principle in wave optics that is utilized in various applications, including the construction of optical instruments like lenses and telescopes.

EXPERIMENT 1

Purpose

The goal of this experiment was to find the number of CD tracks per centimetre by measuring the distance of the laser beam above the screen and measuring the distance between the dots shown on the screen.

Hypothesis

It is expected if a laser beam is passed through a DVD/CD which is at an angle of 45^0 to the horizontal, it will diffract and produce bright fringes on the screen placed on the optical bench. It may also produce dots which are in a circular manner.

Materials used

- Laser
- Screen/Paper
- CD/DVD
- Ruler
- Optical bench

Procedure

1) Set up the experiment in a dim room by connecting the laser beam at one end of the optical bench.
2) Then place a screen or paper on the optical bench.
3) Measure the distance (L) between the screen/paper and the laser beam.
4) Hold the CD/DVD and turn on the laser beam such that the laser goes onto the CD/DVD.
5) The CD/DVD must be at an angle of 45^0 to the horizontal.
6) Observe the dots that are shown on the screen/paper.
7) Measure the distance (w) between 2 dots using a ruler.

Data and calculations

For CD

L = 0.055 m

w = 0.035 m

d = Lλ/w = $(0.055*650*10^{-9})/0.035$

d = $1.02143*10^{-6}$ m = $1.02143*10^{-4}$ cm

Number of CD tracks per cm = 1/d

= 9790

For DVD

L = 0.055 m

w = 0.1 m

λ = $650*10^{-9}$ m

d = Lλ/w = $(0.055*650*10^{-9})/0.1$

d = $3.575 * 10^{-7}$ m = $3.575 * 10^{-5}$ cm

Number of DVD tracks per cm = 1/d

= 27972

Observation

When experimenting with the CD, only 2 dots were observed while with the DVD, multiple dots were observed in a circle manner since it has more tracks per cm than a CD.

Conclusion

The purpose of this experiment was to determine the number of CD tracks per centimetre by measuring the distance of the laser beam above the screen and the distance between the dots shown on the screen. The hypothesis was that if a laser beam passed through a CD/DVD at an angle of 45 degree to the horizontal, it would diffract and produce bright fringes on the screen placed on the optical bench. The materials used included a laser, screen/paper, CD/DVD, ruler, and an optical bench. The procedure involved setting up the experiment in a dim room, measuring the distance between the screen/paper and laser beam, placing the CD/DVD at an angle of 45^0 to the horizontal, observing the dots on the screen/paper, and measuring the distance between the dots using a ruler. The observations indicated that only 2 dots were observed with the CD, while multiple dots were observed in a circle manner with the DVD, which has more tracks per cm than a CD.

Sources of error:

1) The angle may not be accurate due to human error
2) Parallax error when taking measurements.
3) The CD/DVD may be worn out.
4) The dots observed using the DVD where shaped in a circle so the value of w may not be accurate.

We learnt that a DVD has more tracks per cm than a CD as shown in the calculations above. If we were to repeat the experiment, we would make sure to take the measurements more accurately.

EXPERIMENT 2

Purpose

The purpose of this experiment is to measure the thickness of human hair by measuring the interference pattern created when a laser beam is shone through it.

Hypothesis

The hypothesis of the experiment is that by measuring the spacing of the interference bands created by a hair intercepting a laser beam, it is possible to determine the thickness of the hair.

Materials used

- Red laser beam
- Optical bench
- Screen
- Human hair
- Ruler
- Transparent holder

Procedure

1) Set up the laser beam to shine onto a screen L meters away on the optical bench.
2) Set up the hair in a transparent holder and fixate it on the optical bench.
3) Turn on the laser beam and allow it to intercept with the hair.
4) Observe the screen for a set of bands and adjust the hair until the dark and red bands are visible.
5) After obtaining the pattern, measure the space between the bright fringes (w) and the distance between the laser and the screen (L).

Data and calculations

$L = 0.89$ m

$w = 0.34$ cm $= 0.0034$ m

$\lambda = 650*10^{-9}$ m

$d = L\lambda/w = (0.89*650*10^{-9})/0.0034 = 170.15$ µm

Observations

The main observation in the experiment is the pattern of bright and dark bands produced when a laser beam is intercepted by a human hair. These interference patterns are caused by the interaction of light waves and hair. The main outcomes of the experiment were the observation of these interference patterns and the calculation of hair thickness. The thickness of the hair can be calculated by measuring the distance between the bands and using the equation $d = (L*\lambda)/w$. Where d is the hair thickness, L is the distance between laser and screen, lambda is the wavelength of the light and w is the space between the bands.

Conclusion

In this experiment, we intercepted a laser beam with a human hair to measure its thickness using light interference patterns. The experiment requires a laser pointer, a screen or wall, a ruler or measuring tape, and a dark and firm human hair. By setting up the laser pointer to shine on the screen from a distance of L from the screen and intercepting it with a hair, a pattern of bright and dark fringes can be seen on the screen. By measuring the space between the fringes and using a simple equation, the thickness of the hair can be calculated. This experiment provides a simple and effective method for measuring hair thickness. Upon intercepting the laser beam with a hair, a pattern of bright and dark bands can be seen on the screen. By certain adjustments to the hair, the dark and white bands become more visible. The space between the bands can be measured, and by using the equation, the thickness of the hair can be calculated.

Some sources of the error may include:

1) Variation in hair thickness along the length can give us inaccurate results.
2) Inaccurate measurements taken between the dark/bright fringes.
3) Inaccurate measurements of L.
4) Improper alignment of laser can cause errors in the interference pattern.

In conclusion, this experiment shows a simple yet effective method for measuring the thickness of human hair using light interference patterns.

The thickness of a hair can be calculated by intercepting a laser beam with it and measuring the distance between the resulting bright and dark bands on a screen. We learnt that as thickness increases, width between the bright fringes decreases. If we were to repeat this experiment, we would make sure to take measurements more accurately since a small difference can change the calculation values.