Student's Name: Student's Name:

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Lab day & time: __________________ Date: _________________

Diffraction (E8) – Data Sheets

Activity 1: Diffraction Pattern of a Single Slit. *(1.5 p.)*

Warning: **DO NOT LOOK INTO THE LASER BEAM!**

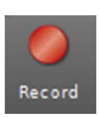
The laser beam will not hurt your hand, but if you look directly into the laser beam, it could be harmful to your eyes. Before you start, collecting data check the **initial settings**:

- Make sure that the data interface is turned on.
- The rotary motion sensor should be connected to the DIGITAL CHANNEL 1 (yellow plug) and DIGITAL CHANNEL 2 (black plug).
- The light sensor should be connected to the ANALOG CHANNEL A.
- The **red diode laser** should be turned on. The red light from the diode laser has the average wavelength λ_{red} = 670 nm.
- The aperture disk in front of the light sensor should be set to aperture slit #2, i.e., 0.2 mm wide. In other words, the laser light should go through the slit aperture #2.
- The "SINGLE SLIT SET" accessory disk should be located in front of the laser and set to a single slid with the nominal width $a_{nom.}$ = 0.16 mm.
- Set the "Gain" slide on the top of the light sensor to "1" (minimum sensitivity).

Diffraction pattern of a single slit with red light.

1.5. Measure the distance L between the disk with slits and the light sensor. It should be between 0.75 m and 0.90 m. Remember that for the red diode laser λ_{red} = 670 nm.

L = ______________ (m)

1.8. Click on the 

button. Initially, you should not see any data. **Slowly and steadily** move the light sensor from its initial position to make a 10 cm scan. Once you get to the point that is located at 5 cm from the center, but on the other side of the optics bench (y = +0.050 m), the data acquisition stops automatically. The whole scan should take ~30 seconds. You may get a smooth motion when instead of pushing the whole light sensor assembly you try to rotate the disk on the top of the rotary motion sensor. The direction of the sensor's motion is perpendicular to the light beam. That way, we get the graph of light intensity vs. position (in perpendicular direction to the beam). Without any slits we would simply observe a single bright spot in the center of the screen without any other patterns. When the computer finish collecting data points, move the light sensor back to the starting position. If computer does not start collecting data when you move the sensor, then try reversing direction of the motion (this could happen when the rotary motion sensor was accidentally installed upside down).

Once the laser beam goes through a slit (or a pair of slits), then it diffracts creating more complicated patterns on the screen. The light sensor measures the light intensity changes and sends that information to the computer for visual representation in form of light intensity graph. Using the intensity graph, we can perform quantitative analysis of the diffraction pattern, not just observe it.

1.9. You should see two graphs on the monitor. The upper graph shows the intensity of the light versus the position of the light sensor $I(y)$. The lower graph shows the log $(I(y))$. The log scale has one very important advantage. It shows more clearly, where the light intensity minima are located. The positions of the minima on the log scale are the same as it is for the linear scale. **Print** this graph #1.

1.10. Using the log $(I(y))$ graph measure the distance Δy_w between the first order diffraction minima (dark spots). Find the measured width w of the single slit. Remember that λ_{red} = 670 nm.

$a_{nom.}$ = 0.16 mm Δy_w = ______________ (   ) w = ______________ (   )

What is the percent difference between the measured value and the nominal width of the slit?

$$\Delta w = \frac{|w - a_{nom.}|}{a_{nom.}} \times 100\% = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_} \ (\%)$$

What is the ratio of the measured width of the slit to the wavelength of the laser light?

w/λ_{red} = ________________

What should happen to the diffraction pattern if we would reduce the w/λ_{red} ratio?
(*Hint*: see the Theory section)

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1.11. Gently rotate the "SINGLE SLIT SET" to get the laser light through the next slit with the nominal width $a_{nom.}$ = 0.08 mm. Check if the diffraction pattern spreads <u>horizontally</u>. Repeat the measurements (steps 1.7 – 1.10) for this wider slit. **Print** this graph #2. Remember that for the red laser λ_{red} = 670 nm.

1.12. $a_{nom.}$ = 0.08 mm Δy_w = ____________ ( ) w = ____________ ( )

$\Delta w = \dfrac{|w - a_{nom.}|}{a_{nom.}} \times 100\%$ = ____________ (%) w/λ_{red} = ______________

1.13. Gently rotate the "SINGLE SLIT SET" to get the laser light through the next slit with the nominal width $a_{nom.}$ = 0.04 mm. Check if the diffraction pattern spreads <u>horizontally</u>. <u>Change the "Gain"</u> slide on the top of the light sensor to "10". Repeat the measurements (steps 1.7 – 1.10) for this wider slit.

1.14. $a_{nom.}$ = 0.04 mm Δy_w = ____________ ( ) w = ____________ ( )

$\Delta w = \dfrac{|w - a_{nom.}|}{a_{nom.}} \times 100\%$ = ____________ (%) w/λ_{red} = ____________

Activity 2: Interference-Diffraction Pattern of Two Slits. *(1 p.)*

2.1. Remove the "SINGLE SLIT SET" accessory disk from the optics bench and replace it with the disk called "MULTIPLE SLIT SET". That one contains several "DOUBLE SLITS" as well as some other configurations of multiple slits.
Remember that for the <u>red laser</u> λ_{red} = 670 nm.

2.2. Measure the distance L between the disk with slits and the light sensor. It should be between 0.75 m and 0.90 m.

L = ______________ (m)

2.4. Gently rotate the "MULTIPLE SLIT SET" to get the laser light through the slit with the nominal width $a_{nom.}$ = 0.04 mm and the nominal separation between slits $d_{nom.}$ = 0.25 mm.

Check if the interference-diffraction pattern spreads horizontally. Change the "Gain" slide on the top of the light sensor to "10". Repeat the measurements (steps 1.7 – 1.10) for this pair of slits. **Print** this graph #3.

2.5. $a_{nom.} = 0.04$ mm $\Delta y_w =$ ______________ (   ) $w =$ ______________ (   )

$$\Delta w = \frac{|w - a_{nom.}|}{a_{nom.}} \times 100\% = \text{\_\_\_\_\_\_\_\_\_\_\_\_} \ (\%)$$

$d_{nom.} = 0.25$ mm $\Delta y_d =$ ______________ (   ) $d =$ ______________ (   )

$$\Delta d = \frac{|d - d_{nom.}|}{d_{nom.}} \times 100\% = \text{\_\_\_\_\_\_\_\_\_\_\_\_} \ (\%)$$

2.6. Is the distance between the first diffraction minima similar to that for the single slit with the same width? ($a_{nom.} = 0.04$ mm, Activity 1)

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2.7. Gently rotate the "MULTIPLE SLIT SET" to get the laser light through the next slit with the nominal width $a_{nom.} = 0.04$ mm and the nominal separation between slits $d_{nom.} = 0.50$ mm. Check if the interference-diffraction pattern spreads horizontally. Repeat the measurements (steps 1.7 – 1.10) for this pair of slits. **Print** this graph #4.

2.8. $a_{nom.} = 0.04$ mm $\Delta y_w =$ ______________ (   ) $w =$ ______________ (   )

$$\Delta w = \frac{|w - a_{nom.}|}{a_{nom.}} \times 100\% = \text{\_\_\_\_\_\_\_\_\_\_\_\_} \ (\%)$$

$d_{nom.} = 0.50$ mm $\Delta y_d =$ ______________ (   ) $d =$ ______________ (   )

$$\Delta d = \frac{|d - d_{nom.}|}{d_{nom.}} \times 100\% = \text{\_\_\_\_\_\_\_\_\_\_\_\_} \ (\%)$$

2.9. **Turn off the laser**. Restore the initial conditions, i.e., remove the holder with diffraction grating and attach the holder with the "SINGLE SLIT SET" at the distance of 0.90 m from the screen. Set the "Gain" slide on the top of the light sensor to "1" (minimum sensitivity).

Complete the lab report and return it to the lab TA.