Optical Techniques in Experimental Physics
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Introduction

The REU this summer did not focus on a single project, but was comprised of many different experiments with a common theme. Working on multiple projects provided the opportunity to learn a variety of optical techniques used in solving complex problems in physics. A few of the experiments will be presented here.

Attenuation of a Fiber optic in oil

The purpose of this test was to determine the attenuation of an optical fiber immersed in crude oil for an extended period of time. The attenuation would be the result of "hydrogen darkening", which occurs when free hydrogen atoms bind to the SiO2 in the fiber and form an OH group that absorbs light passing through the fiber. Three different fibers were used during the test: a plastic fiber, a silicon fiber that was not stripped and a silicon fiber that was stripped of its cladding. Each of these was placed in the oil while light from a laser diode passed through it to a power meter. The test lasted six days and the data obtained is shown below.

![Figure 1: Power readings of the plastic fiber over the six days.](image1)

![Figure 2: Power readings of the fiber with cladding over the six days.](image2)

![Figure 3: Power readings of the fiber with no cladding over the six days.](image3)

From Figure 1, it is apparent that the plastic fiber had some attenuation over the six days. The jump in the middle was the result of the fiber being accidentally moved one day during the test, but even after it was moved the fiber continued to have power loss. The unstripped fiber did not have any noticeable attenuation during the period. The stripped fiber did show some power loss but nothing substantial.

![Figure 4: Measurement of the spot size.](image4)

![Figure 5: The spot size of the laser versus the distance from the germanium lens.](image5)

Focal point of a Germanium lens

For this experiment a plano-convex germanium lens was tested to find the focal point when used with a CO2 TEA laser. A CO2 laser operates at 10.6 microns wavelength which is in the infrared and readily transmitted through germanium. The lens was damaged on the plane side due to an earlier high power laser test, so it had to be refinished. The process of refacing the lens consisted of sanding down the back with (first) a 240 grit carbondum sandpaper until the damaged part was removed, then sanding it again with 500 grit sandpaper until the scratches became uniform. The final step was to finish the lens with a diamond based compound until there were no scratches on the back of the lens. After the lens was repaired, it was set up in front of the laser. Then after turning on the laser the lens was aligned directly in the path of the beam. The spot size of the laser was taken at 12.7mm distance increments from the lens- starting at 38.1mm. The focused spot was allowed to expose laser printing paper and the diameter of the spot was measured.

![Figure 6: Pressure reading for each object.](image6)

Fiber Transmission Attenuation with Pressure

This test was to observe fiber attenuation with pressure applied to a fiber at different locations. For the test, four different objects were placed on the fiber. Two of the objects were standard weights and the other two were magnets with different field strengths. The fiber had light from a diode laser directed through it and a sensor with a power meter on the other end of the four meter cable. The power measurements were taken in 15.24cm intervals along the fiber- starting at the end with the laser.

![Figure 7: regular fiber](image7)

![Figure 8: regular fiber with splice](image8)

![Figure 9: Attenuated fiber](image9)

![Figure 10: Attenuated fiber with splice](image10)

![Figure 11: regular fiber with screw](image11)

![Figure 12: regular fiber with plate](image12)

For each of the above charts the power is measured in milliwatts. From the data above, it appears that 500 degrees Celsius does not attenuate the power in fibers very much for any of these circumstances.

Fiber Optics in High Temperatures

This experiment was designed to measure how much attenuation occurred when a fiber is exposed to a high temperature environment of approximately 500 degrees Celsius. Only a short section of the fiber was placed under a heat gun for the duration of the test. A diode laser was directed through one end of the fiber and the other end terminated into a sensor with a power meter that was interfaced with a computer. Readings were taken four times a second for the duration of the test. There were a few different scenarios in which different types of fiber (or different parts of the fiber) were placed at the outlet of the heat gun. The following situations were used: a regular fiber, a splice of two regular fibers, an attenuated fiber, a splice between a regular fiber and an attenuated fiber, a regular fiber with a screw pressing down on it, and finally a regular fiber being pressed between two plates.

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Glucose Sensor

For this project, the goal was to build a sensor that would indicate how much glucose is in a sample at any given time. This required a visible red laser and an infrared laser with appropriate photovoltaic sensors (one of which had a polarizer on it). There was a polarizer placed on the laser side of the sample as well and it could be oriented so as to obtain a maximum reading for the two different polarizers. Then the difference between the two sensor readings was measured. Labview® was used for much of the data taking during the entire process. The experiment is currently in its final stages and soon it will be proposed for solving a wide variety of problems.

Very little attenuation occurred in the case of the objects being placed on the fiber, but as the objects were moved farther down the fiber the power was attenuated more.

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