OPTICS AND LASER PHYSICS LABORATORY #1
INTRODUCTION TO LASER LAB

Welcome to Miami University's Optics and Laser Physics laboratory. Before we begin our semester's journey, there are several basics that need to be understood. These include 1) laser safety, 2) methods of directing the laser beam, and 3) the control of laser power. These 3 areas will be explored in this first lab.

1) Laser Safety

Lasers are wonderful optical tools capable of emitting coherent radiation of many wavelengths, output powers, and pulse lengths. There is a lot of energy propagating in a small area. Because of this, one must always insure the safety of personnel in the laboratory. You will be issued laser safety goggles and are expected to wear these at all times. All people in the lab must obey these safety rules, so that no one person is injured.

BE AWARE OF EVERYONE'S SAFETY.

Find and WEAR SAFETY GOGGLES AT ALL TIMES in which the argon ion laser or dye laser are in operation -- YOUR EYES CANNOT BE REPLACED.

Never reposition any optical elements on the optics table unless you are sure that all goggles are in place over lab partners' eyes.

Be aware of the reflections from optics as you move them.

Use a white 3x5 card or other computer card provided to find the beam -- it will fluoresce when exposed to argon and dye wavelengths in the infrared and far red and the far red wavelengths are visible through the argon goggles.

Never expose your hands or skin to the laser beam.

Remove any jewelry that might reflect the laser beam to an unexpected place in the lab (watches are particularly troublesome).

The laser safety sign outside the lab will flash as soon as the heat exchanger is turned ON, but people entering the lab may not be as aware as they should be. If someone enters the lab, immediately close the shutter on the argon laser until the person has time to state his or her business and leaves OR until they put on a pair of goggles.

BE EXTREMELY CAUTIOUS WHEN OPERATING THE LASER.

4) Manipulation of the Laser Beam

In any optical experiment, the laser beam must be introduced to the equipment and samples under investigation. This is accomplished by manipulating the position of the beam via mirrors, lenses, beam splitters and other optical elements. Often the height of the beam is of great importance as is the relative levelness of the beam to the table top. The beam should be centered on any optical element place in its path unless one has a specific need to place it otherwise. (For instance, in-house dye lasers often have a portion of the laser beam close to the side of a mirror so that the pump beam and dye laser beam can co-propagate along a certain direction and then be separated.) The cleanliness of the optics is one factor which will determine the beam quality downstream. Dust particles can degrade the beam's intensity profile quite distinctly. In addition, the size and surface quality of the optics affects diffraction and optical clarity.

Common sense can be used for placement of most optical elements -- beam centered on mirror with angle of incidence equal to angle of reflection.

Predict a good method for aligning optics, such as lenses, mirrors, etc. by discussing and answering the following questions.

a) How do you know how high a mount must be?

b) How do you determine whether the optic is placed at normal incidence (perpendicular) to the beam?

c) How can you determine if your optical system is on-axis i.e. the components are all centered on the beam?

d) How would you position a detector to measure the beam power?

Under the direction of your instructor, set-up a simple experiment in which the output of the laser is sent through an iris diaphragm to a photodiode for power measurements. Several mirrors are provided for this task. The photodiode and iris diaphragm have been placed on the optical table by the instructor and <u>can not be moved</u>! Once you have the beam centered on the iris diaphragm and the detector's active area, place a lens in the system to insure the beam's spotsize is correct for the detector.

e) What must you consider when placing a lens in an optical system? Why?

f) Move your lens in the plane perpendicular to the beam. What happens to the beam?

g) How do you place a lens in the beam?

h) What should the beam's spotsize be on the detector and why?

3) Power Measurement and Control Techniques

There are several methods one can utilize in order to measure and control the output power of the lasers. This lab will concentrate on the use of PIN photodiodes for measuring power and the use of filters for controlling the laser beam's power. Filters may be of heat absorbing or reflecting variety. Either one will reduce the power of the laser beam.

3a) Use of detectors as power "meters".

Various detectors are available in the optics and laser physics labs. These include photomultiplier tubes (PMT), PIN photodiodes, and amplified photodiodes. Most of the lab work in this semester will utilize PIN photodiodes, but the Spectroscopy labs will use PMT's quite often. You can read about the details of photodiodes in your electronics textbooks. All of these detectors will provide the user with information on the power of the beam as well as temporal information about the change of the signal over time.

When used with low terminating resistance, 50 Ω, the time response of these instruments can be 10 picoseconds or less. Photodiodes are very helpful in the power ranges below which the analog meters operate (10^{-7} watts to 100 mW). PMT's are typically used in the sub-nanowatt range or they can be used to count individual photons. The PIN photodiodes output can be read with a voltmeter and the detector output is linear over a broad range of input light powers. The range of the diode is selected via a terminating resistor which is attached to the BNC/banana plug adapter. The larger the signal the lower the terminating resistance necessary. When the output of the photodiode is less than 18 volts, there is no saturation of the detector and the choice of terminating resistor is thus determined. The Thorlabs photodiodes have a 22 volt battery power source and must be turned OFF when not in operation.

Use of neutral density filters may be necessary to ensure that the detector is not saturated.

3b) Neutral Density Filters

The neutral density filters provided in this lab are absorbing filters, but one can obtain reflecting filters as well. The transmitted power of the beam can be determined by the following expression.

$$P_{Out} = P_{In}\ 10^{-ND}$$

Thus, if one were to place a filter with ND = 1.0 in a 100 mW beam, the transmitted beam would have a power of 10 mW. Likewise, a ND = 0.4 will cut the beam to about 39% of its original value.

Choose 5 neutral density filters with various values of ND. Measure the power of the beam, P_{in}, and then place the ND's into the beam and measure the transmitted power, P_{out}. Calculate the expected P_{out} and compare to the measured value. Discuss discrepancies in your lab write-up.

This is the introduction to the laser laboratory. You should be able to use photodiode detectors to make power measurements, be able to set-up an optical system and align it, and be able to control the power of the laser beam.You should also know where the laser safety goggles are, how to wear them, and what to do when someone enters the lab.

WEAR YOUR LASER SAFETY GOGGLES AT ALL TIMES

This cannot be stressed often or strongly enough -- laser safety is a MUST.