LAB 13: OPTO-MECHANICS AND OPTICAL ALIGNMENT

…..AN INTRODUCTION

Background

The terms "opto-mechanics" and "optical alignment" mean many different things to optical and mechanical engineers. In general, however, these terms describe the hardware and techniques used to establish the geometrical relationships between components in an optical system, as specified by the opto-mechanical design of the system—to within specified limits called tolerances. Examples of what is meant by "geometrical relationships between components…" might include the following:

- establishing the optical axis of the system in relation to the mechanical housing
- co-aligning an 'alignment' laser beam along this axis
- holding optical components (lenses, mirrors, prisms, cube beamsplitters, optical fibers, optical filters, detectors, etc.) in specified x-y-z locations and at specified angles

In your senior year, you will learn the theory, physics, and engineering behind 'real-world' opto-mechanics and optical alignment, by taking some of the following courses:

OPTI 421	"Introductory Optomechanical Engineering"
OPTI 421L	"Introductory Optomechanical Engineering Laboratory"
OPTI 423	"Optomechanical Design and Analysis"
OPTI 423L	"Optomechanical Engineering Laboratory"
OPTI 424A	"Optical System Engineering"

In this lab, you have the opportunity to use the optical hardware you are familiar with to perform a variety of simple, yet useful, optical alignments. The techniques learned will be useful in your upcoming lab classes, and potentially in a research lab, internship, or full-time job. To put this lab in the context of OPTI 201L and 202L, most/all of the optical alignment in any particular experiment was done before you did the lab. This was done to save time, but admittedly optical alignment could have been required as part of most, if not all, of the labs. This lab is designed to fill that gap, and to provide you with an introduction to opto-mechanics and simple optical alignment techniques.

Pre-Lab Questions:

(1) Think of some of the experiments you did where alignment was important to the experiment (and where it was done before you did the lab). Describe 3 such situations:

(2) Design a way to co-align 2 laser beams, so that they travel along the same optical path, acting as one ray of light. (This technique is often used to co-align a visible laser beam with an infrared laser beam, making the alignment of the infrared beam through the optical system much easier.)

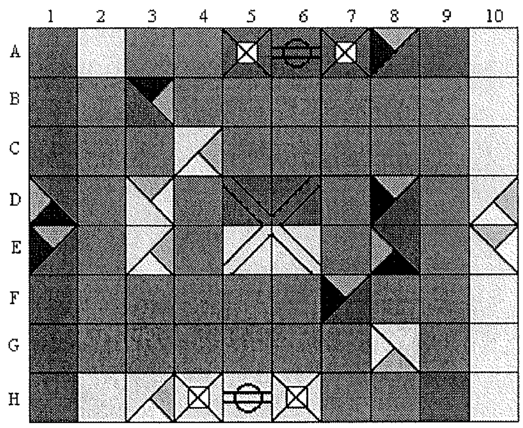
In particular, design 2 solutions:

(a) when the 2 laser beams are parallel to each other.

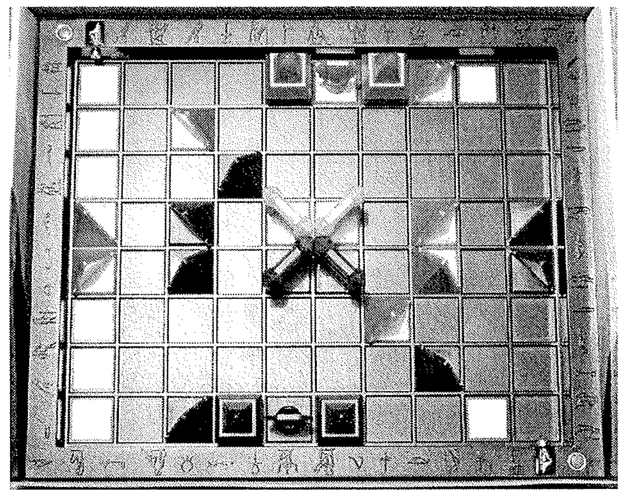
(b) when the 2 laser beams are at 90° to each other.

You may use any type and number of optical components, but <u>both designs must use at least 1cube beamsplitter</u>. Provide a drawing for each of your solutions.

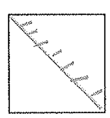
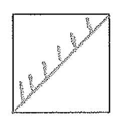
(3) The game of "Khet" uses a grid-of-squares playing board, mirrors set at 45° to the grid lines, and 2 laser beams. The goal is to maneuver your laser beam around the board, by reflections from the mirrors, until it hits your opponents target. The following picture shows a Khet board, with various mirrors angled at 45°.

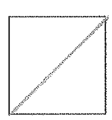


Opening position in the Classic Set-up

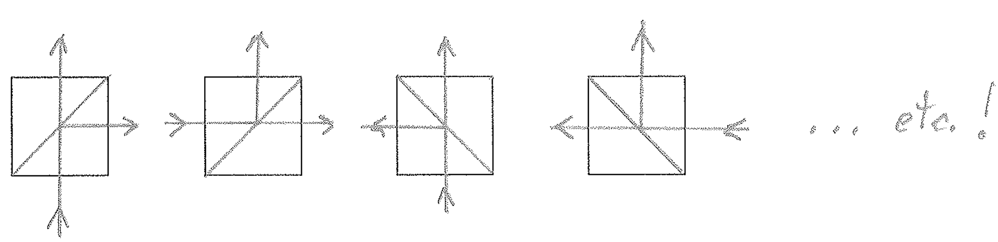


In this problem, you are to devise your own "version" of Khet, using mirrors and/or beamsplitters (all angled at 45° to the grid lines) to hit each of the dots, at each corner of the board. Your goal is to do this using the fewest number of mirrors and beamsplitters!

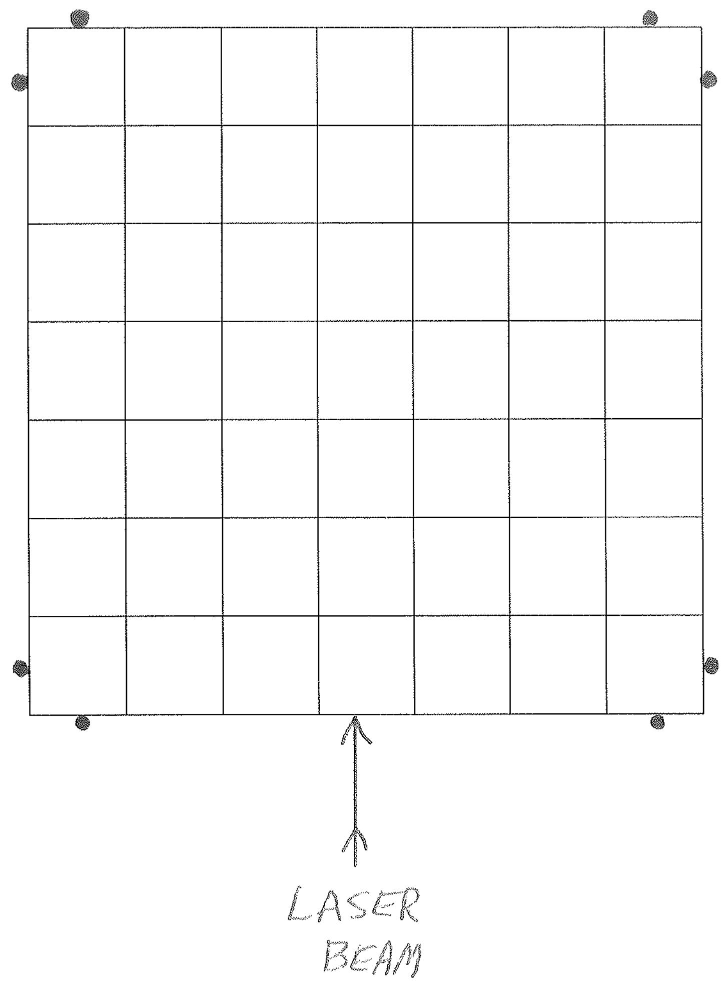
Draw a mirror as either  or 

Draw a beamsplitter as 

Note: A beamsplitter can be used in a number of ways:



On the following "game board" draw all of your mirrors, beamsplitters, and the ray paths to show that your laser beam actually hits all 8 dots!


LASER
BEAM

Lab Exercises:

Use the "table of parts" to perform the following tasks:

(1) Align the optical axis of the alignment microscope so it is 7" above the optical rail, and bore-sighted along the center of the rail (i.e. so that the optical axis of the microscope is parallel to the center-line of the rail).

Q1 Describe the hardware and procedure you used to accomplish this.

Q2 How did you ensure that the microscope was bore-sighted along the center of the rail?

(2) Use the alignment microscope to position a white light source/diffuser/pinhole aperture at this same height and on the axis of the optical rail.

(3) Use the alignment telescope and Xerox copy lens to produce a collimated beam from this pinhole.

Q3 How do you know that the beam is collimated?

Q4 How do you know that the collimated beam is parallel to the optical rail?

Q5 Describe the hardware and procedure you used to accomplish this.

(4) Align the positive lens (provided) in the collimated beam, so the focal point coincides with the center point of the crosshairs in the microscope. Align the lens in such a way that no coma or astigmatism is introduced.

Q6 Describe the hardware and procedure you used to accomplish this.

CR1 ● Show this alignment to your TA for credit!

Remove the light source, copy lens, and positive focusing lens from the rail.

(5) Position 2 pinhole apertures at this same reference height, also centered on the rail. Use clip holders mounted on rail carriers to do this.

(6) Align the red He-Ne laser beam down the center of the optical rail, at the reference height (now defined by the 2 pinhole apertures). Use the magnetic base and tip/tilt mount that already hold the laser to do this. When successful with this step, the beam should pass through both apertures (placed close to, and far away from, the end of the laser).

CR2 ● Show this alignment to your TA for credit!

(7) Position one of the shorter optical rails on the table, so that it is at a right angle to the longer rail. (Locate the end of the short rail near the 300mm mark on the long rail, and leave enough room between them so that a rail carrier can slide along the longer rail.) Using a penta prism and one of the apertures, align the short rail to be at exactly 90° to the longer rail, and then bolt the short rail to the table.

Q7 Describe the procedure you used to accomplish this.

(8) Replace the penta prism with a plane mirror, held in a tip/tilt mirror mount. Align the laser beam so it travels down the center of the short rail, at the reference height defined by the aperture. At the same time, align the beam so it is parallel to the top of the optical table.

CR3 ● Show this alignment to your TA for credit!

(9) Position the green He-Ne laser at the end of the short rail. Align the beam to be down the center of the rail, at the reference height defined by the aperture. Use the magnetic base and tip/tilt mount that already hold the laser to do this. When successful with this step, the beam should pass through the aperture as it is slid back and forth along the short rail.

CR4 ● Show this alignment to your TA for credit!

(10) Use a cube beamsplitter to co-align both the green and red laser beams down the center of the long rail. When successful, you will see a yellow(!) beam along the rail. (Due to the way our eyes perceive color, "adding" (by overlapping) red light and green light gives us the sensation of yellow—even though there is NO yellow light present.)

CR5 ● Show this alignment to your TA for credit!