PHYSICS 125 EXPERIMENT NO. 1
MEASUREMENTS USING TRIGONOMETRY AND VECTORS

In this experiment, we will perform a variety of measurements which require trigonometric calculations. Trigonometry is necessary for solving most problems involving more than one dimension. We will perform distance measurements using triangulation, application of similar triangles, and also express coordinates in the lab room by means of vectors.

A. Equipment

1 Meter Stick, 2 Protractors, Several paper clips.

B. Method

Triangulation is the procedure wherein one measures the position of a remote object by measuring the direction of the object from two known reference points. We will construct an instrument for triangulation measurement using two protractors and a meter stick and use this instrument to measure distances across the lab room. Additionally, we will measure the height of the room using the similar triangles created by the shadow of a meter stick.

Finally, we will express positions and features in the room in terms of unit vectors.

C. Procedure

I. Angular Width.

1. A horizontal line is drawn on the chalk board. When viewed from any distance, this line subtends a certain angular opening. Stand approximately 5 feet from the chalk board. Have your lab partner measure the exact distance.

2. Hold a piece of paper at arm's length and mark the "length" of the line as viewed by your eye. Have your partner measure and record the distance from your eye to the paper.

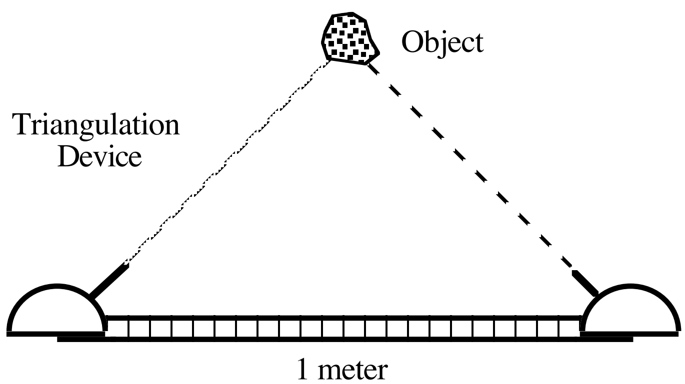
3. Calculate the angular width of the line as viewed from this position and calculate the length of the line from your measurements of eye-to-hand and eye-to-chalk board distances. Be certain to include an estimate of the uncertainty in your measurements.

4. Repeat steps 1-3 for distances of approximately 15 feet and 30 feet.

Q1. Which of your measurements of the line length has the smallest uncertainty and why?

II. Triangulation.

1. Make a surveying instrument (shown below) from the meter stick, protractors and paper clips. This instrument measures with a baseline of one meter.



2. Stand a known (measured) distance from the chalk board. Measure the angle of a mark on the far wall of the lab room as viewed from each end of the meter stick.

3. Calculate the length of the room using the appropriate trigonometric relations.

Q2. What could be done to improve the accuracy of your measuring instrument?

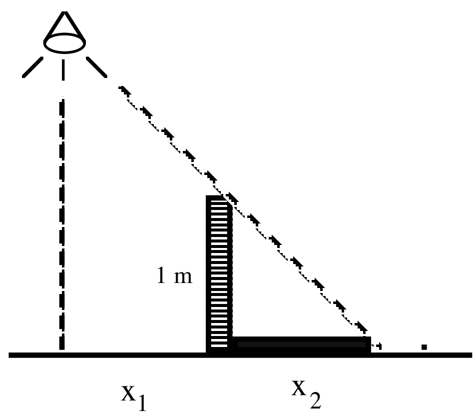
4. Repeat this measurement to determine the width of the room.

III. Method of Similar Triangles.

1. A bright lamp has been positioned near the ceiling at the front of the lab room. Determine the position on the floor which is directly below the lamp by holding your meter stick such that it casts no shadow.

Q3. What is the best way to hold the stick to make it level?

2. Move the stick to one side so that it casts a shadow as shown below. Measure the position of the stick and the length of the shadow.



3. Calculate on the basis of similar triangles the height of the lamp.

IV. Vectors.

1. We will impose a coordinate system on the lab room. Take the origin of the coordinate system to be that corner which is at the back of the room, at floor level, and on your left as you enter the lab. The +x direction is to your right (as you enter the lab). The + y direction is toward the chalk board, and the + z direction is upward. Draw a sketch of the room, labeling the origin as well as the **i**, **j**, and **k** directions.

2. Using your results from earlier parts of this lab, express the vector from the origin to the corner of the room located to the right of the chalk board and at the ceiling in component form (using **i**, **j**, and **k** unit vectors). Calculate the magnitude of this vector.

3. Using your results from earlier parts of this lab, express the vector from the origin to the corner of the room located to the right of the chalk

board and at the floor in component form (using **i**, **j**, and **k** unit vectors). Calculate the magnitude of this vector.

4. Calculate the angle between the vectors found in steps (2) and (3) of this part of the lab by calculating the dot product of the two vectors.

5. Check your calculation in step 4 using the Pythagorean theorem and your measurements. Show and annotate all steps of the calculation.

6. Ask your TA for a vector (each class member will get their own vector) which specifies the position of one of the laboratory stations.

Q4. Which lab station is at the position described by your vector? Justify your response based upon your measurements of the room.