

How far away is that flagpole? Set your sights on a very distant reference object and compare where the flagpole is in relation to that distant reference object. Then move to a new observing position and again compare where the flagpole is in relation to the distant reference object. The apparent change in position is the flagpole's "parallax". In this activity, your students use a parallax angle measuring device to determine distance.

### Materials

- Parallax Angle Measurer cut-out sheet—scale piece (1/student + 2 for the teacher; photocopy master on p. 39)
- Distance Measuring worksheet (1/student; master on p. 40)
- 6 to 10 sheets of construction paper, 8½" x 11", various colors
- Ruler or 8-1/2" x 11" sheet of paper (1/student)
- Scissors (1/student)
- Push pin (1/student)
- A bit of wine cork, eraser, wood, Styrofoam or other soft material, at least 1 cm thick, for a push pin to stick into (1/student)
- Five or six tape measures
- 2-3 rolls of tape
- Optional: Overhead projector and 3 sheets of acetate.
- Optional: Two or three tape measures

# Parallax—How Far Is it?

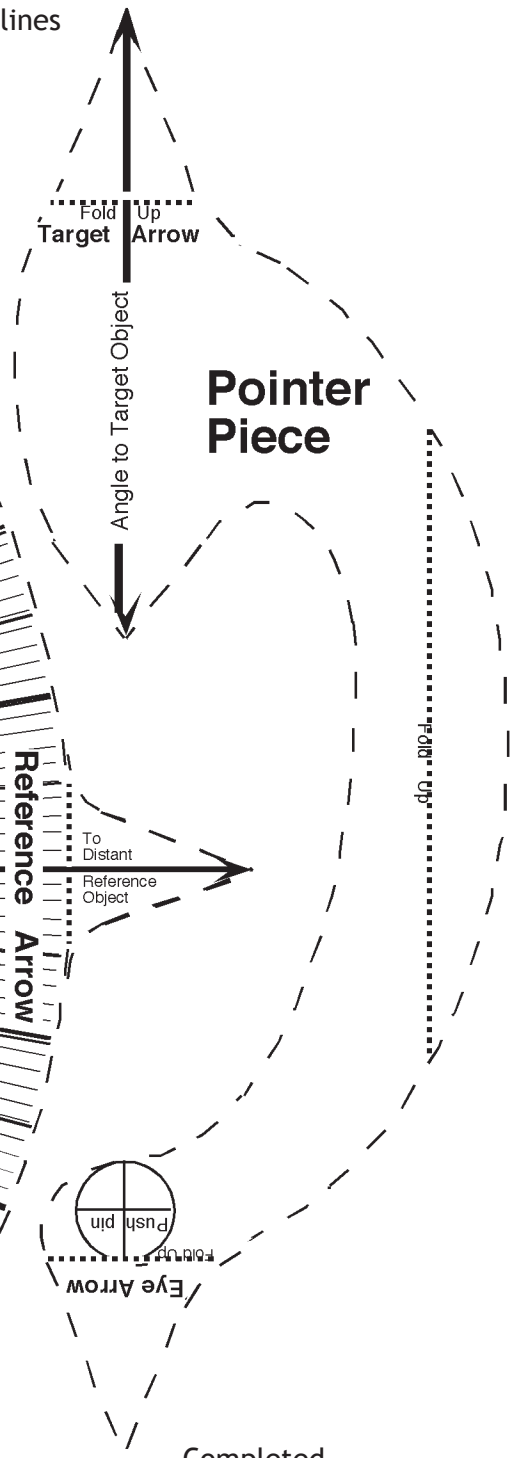
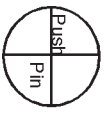
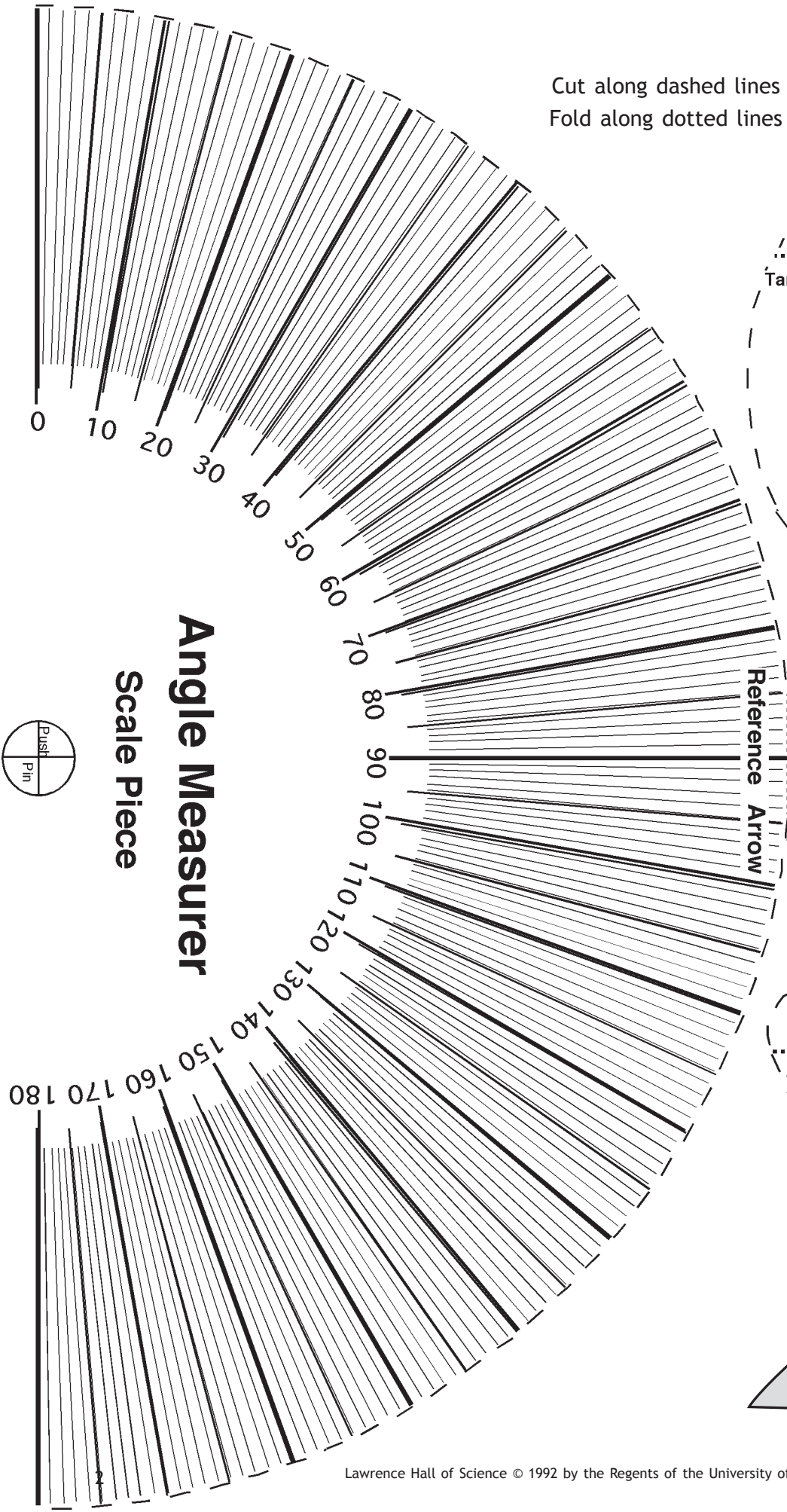
## Before Class

1. Make one photocopy each of "Angle Measurer" cutout sheet and "Distance Measuring" worksheet for each student. The angle measurer will work best if you photocopy onto cardstock, though regular paper works adequately.
2. Cut bits of material that the push pin can be stuck into. Wine corks, big pencil erasers, or Styrofoam can be sliced up with a sharp kitchen knife into pieces about 1 cm thick.
3. Assemble a demonstration angle measurer yourself, following the instructions in step 1 (below).
4. Make 6 to 10 cardboard targets out of different colored construction paper. The targets can be stick people figures, cones, or other shapes. Making each one a different color will allow students to distinguish them easily. Place the targets among the students' desks so that the targets extend well above the height of the desks, 30 cm (a foot) or so. The targets may be taped onto desks or hung from the ceiling.
5. Optional: Photocopy the cutout sheet and the worksheet onto clear acetate for pointing out parts on an overhead projector.

## In Class

1. Tell your students that they are each going to make a parallax angle measuring tool. Hand out the cutout sheets and scissors. Explain the following steps (pointing out parts on an overhead projector if you wish):
  - a. Cut out both pieces along the dashed lines.
  - b. Fold up all the arrows along the dotted lines: the **reference** arrow on the scale piece, and the **target** and **eye** arrows on the pointer piece. A ruler is helpful here.
  - c. Stick a pushpin through the "Pushpin" cross marks on the Pointer piece, the Scale piece, and then into the cork. The completed Angle Measurer should appear as in the figure on the cutout sheet and as your demonstration model. The pointer piece should be able to sweep along the angles of the scale piece.
2. Explain that each student is going to measure the distance from his or her desk to one of the colored targets in the room. A distant reference point will be the vertical line formed by the corner of the room farthest from the student. Ask each student to select a colored target object that is not too far from them, but in the general direction of the corner of the room that is farthest from them.
3. Have each student make a baseline by taping a ruler or sheet of paper onto

Cut along dashed lines  
Fold along dotted lines

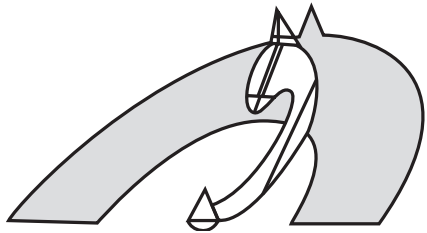


**Pointer Piece**

**Reference Arrow**

**Eye Arrow**

**Completed Angle Measurer**



# Distance Measuring

## 1

Target Angle 1		<input style="width: 95%; height: 25px;" type="text"/>
Target Angle 2	-	<input style="width: 95%; height: 25px;" type="text"/>
-----		
	=	<input style="width: 95%; height: 25px;" type="text"/>
Parallax Angle		

## 2

Parallax Angle	Distance in "Baselines"
1° .....	57.3
2° .....	28.6
3° .....	19.1
4° .....	14.3
5° .....	11.4
6° .....	9.5
7° .....	8.1
8° .....	7.1
9° .....	6.3
10° .....	5.7
11° .....	5.1
12° .....	4.7
13° .....	4.3
14° .....	4.0
15° .....	3.7
16° .....	3.5
17° .....	3.3
18° .....	3.1
19° .....	2.9
20° .....	2.7

Accuracy decreases with larger angles.

## 3

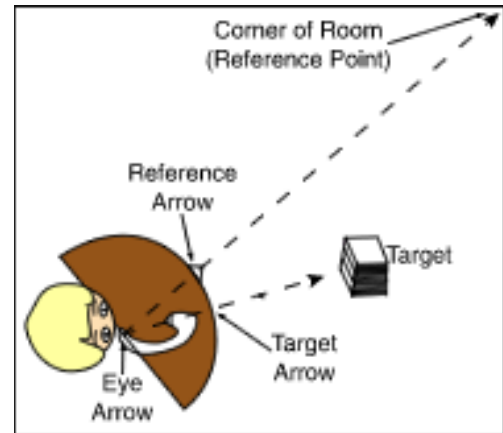
Distance in "Baselines"		<input style="width: 95%; height: 25px;" type="text"/>
Length of Baseline	<b>x</b>	<input style="width: 95%; height: 25px;" type="text"/>
-----		
	=	<input style="width: 95%; height: 25px;" type="text"/>
Distance to Object		

their desks. The baseline should be roughly perpendicular to the direction of the target and reference objects.

4. Hand out a “Distance Measuring” worksheet to each student.
5. Tell them that they are going to measure the angle between the reference and target objects twice—one measurement at each end of their baseline. Explain the following procedure:
  - a. Put your Eye Arrow on one end of the baseline.
  - b. Line up your Eye Arrow, the Reference Arrow, and the reference point (farthest corner of the room). Emphasize that all three elements must line up as in a gunsight. Once reference corner is lined up with both the eye arrow and reference arrow, press the scale piece firmly to the desk with one hand, so that it does not move.
  - c. Now pivot the Target Arrow until it is in line with both the Eye Arrow and the colored target object, whose distance you are trying to measure. Again emphasize that all three elements must line up. Be sure you are holding the scale piece down firmly so that it does not move. Only the Pointer Piece should pivot.
  - d. Read the “Angle To Target Object” indicated on the scale and write that angle down on the worksheet in the space for “Target Angle 1.”
  - e. Move your angle measurer to the other end of your baseline. Then repeat steps (b) and (c) to measure the 2nd “angle to target object.” Write that angle down on the worksheet in the space marked “Target Angle 2.”
6. Draw on the chalkboard as you explain that the difference between their two measured angles is the **parallax** angle. Draw the baseline and the target object and show how they form a triangle. Label Target Angle 1 and Target Angle 2. Extend the sides of the triangle and label the parallax angle as shown in Figure A. Explain that they can calculate the parallax angle by subtracting the larger angle from the smaller angle.

Optional: Draw a dotted line through the target parallel to the baseline. Label angle 1 and angle 2, as shown in Figure B. Point out that Target Angle 1 is the same size as angle 1 and Target Angle 2 is the same size as angle 2. (In geometry, these are “corresponding” angles.) Sometimes it is easier for students to see why the parallax angle is the difference between angles above the dashed line than it is for them to see how the parallax relates to Target Angles drawn on the baseline.

7. Instruct your students to subtract the larger angle from the smaller angle (interchange the numbers if necessary) and write the answer in the space marked “Parallax Angle.”
8. The distance to the target is the height of the triangle and can be found in the table on the worksheet. The table lists distances in “baselines” so have your students find the distance corresponding to their parallax angle in the table and write that distance in the space marked “Distance in Baselines.”
9. Have the students write in the length of the baseline in the space marked



### Parallax Angle

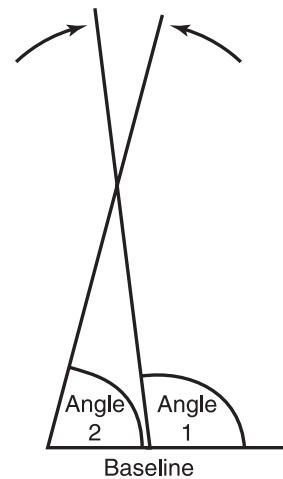


Figure A

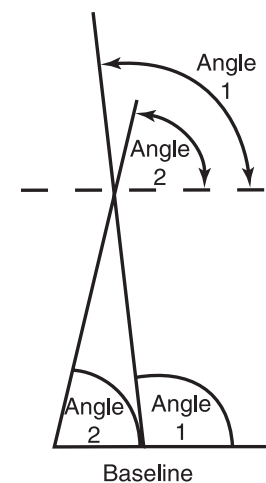


Figure B

“Length of Baseline.” If they used a standard ruler, the baseline is 30 cm. If they used the length of a standard sheet of paper, the baseline is 28 cm.

10. Finally, the students can calculate the distance to their target object by multiplying the “Distance in Baselines” by the “Length of the Baseline.” Have them enter the answer in the space marked “Distance to Target Object.” If you have tape measures, students can check their answers by direct measurement.

## Going Further

### Alternate Calculation Method I

You may opt for students to do a graphical calculation (draw a scale drawing):

Steps 1-6 above are the same except that in step 4, do not hand out a “Distance Worksheet.” Have students record their angles on paper.

7. Use a protractor and ruler to make a scale drawing of the baseline, Target Angle 1 and Target Angle 2 with appropriate scale, e.g. 1 mm = 1 cm. Demonstrate this on an overhead transparency if possible.
8. Find the point where the angles intersect and measure the scale distance to the object.

### Alternate Calculation Method II

If your students are studying trigonometry, the Distance to the target (D) is related to the Parallax angle (a) and the Baseline (B) by the trigonometric relationship (tangent),  $D = B \div \tan(a)$ .

## How Far is That Flagpole?

Your Parallax Measurer can be used to find really far away distances outdoors by measuring off baselines of several meters or more.