Lesson 2

SHADOWS

OBJECTIVES:

* To familiarize students with the main features of the Sun's apparent motion across the sky in the course of one day.
* To teach students the cardinal points.

GRADES: 4 and up.

SCHEDULING:

A sunny day is required to carry out this all-day activity. Start out with the class discussion, and set up the experiment. Then go on with your ordinary schedule, but send students out in pairs, throughout the day, to record the shadows. Wait till the next day to hold a discussion and draw conclusions from the experiment.

PREPARATION:

Read the description of the activity carefully, and pick out an appropriate place to do the experiment.

MATERIALS:

For a gnomon (shadow stick), use:

* A 9" stick on a styrofoam stand

Tape it to a 3'x3' sheet of paper, which is itself taped to a 3'x3' masonite board (see figure 2-1)

You will also need:

* A watch or clock
* Markers
* Masking tape

* A good compass

CLASS DISCUSSION:

Show the class the gnomon, and ask them to predict the motion of its shadow during the day.

* How does the Sun move across the sky?

* Where does it rise? Where does it set?

* How does it get from here to there?

* Which way is North? East? West? South? * Imagine yourself at home, looking out a certain window. Point in the direction you would be facing. (Some students have a strong intuitive sense of direction, and can do this without hesitation.)

* Which way do shadows point?

* When are shadows long? When are shadows short?

* At what time is there no shadow at all?

* At what time is the Sun exactly overhead?

Remember that this discussion is intended only to raise the questions investigated by the experiment, not to answer them. Accept all your students' answers without judging their correctness. The less the students worry about saying "something stupid", the more they will participate in the discussion, and the more curious they will be about the outcome of the activity.

Tell the students that to evaluate the ideas that came up during the discussion, they will record the shadow of the gnomon many times in the course of the day, and that they will finish the discussion the next day.

WARNING:

Never look directly at the Sun. You may damage your eyes permanently. The same applies to your students. Make sure they understand this.

STUDENT SHEET:

* The Sun

ACTIVITY:

Start out by synchronizing the watches or clocks that are to be used.

The basic setup is illustrated in Figure 2-1. The gnomon should be on the southern part of the sheet (this will allow the shadows to land entirely on the sheet). The sheet should be on a piece of masonite (or other flat board), to facilitate drawing on the paper. Place the whole setup in a location that gets sunlight throughout the school day.

Show the students how a slight motion of the gnomon affects the position of the shadow. Therefore emphasize that it must not be touched during the course of the day. (In fact it is preferable to keep it out of the way of playground games and other potential disturbances.) Use chalk to mark the position of the paper on the ground (paint if you are to repeat the eperiment on another day). The orientation of the paper should remain absolutely constant during the whole experiment. Using a good compass, find and mark the direction of magnetic North.

Outline the position of the gnomon's base on the paper. The gnomon should remain exactly in the same position during the whole experiment. Masking tape can be used to hold it in place. The surface beneath the setup should be as flat and

horizontal as possible.

Tell the students to mark the outline of the top of the gnomon's shadow, and write the time of day next to it (Figure 2-2). Send groups of students out to repeat this every twenty to thirty minutes, and every ten to fifteen minutes around midday. Allow the students to make more frequent observations if they want.

By the end of the day, you will have a record of the shadow's movement. Save it. If you want to repeat the experiment on another day, try to place the setup in exactly the same orientation, and the gnomon in the same place so that comparisons of the records are meaningful. However, be aware that changes in the tilt of the gnomon dramatically affect the length of the shadow.

CONCLUSIONS:

The next day, hand out the student page "THE SUN". The students should find it relatively easy to answer the questions.

Post the gnomon shadow records in a visible place in the classroom. Discuss the ideas that were raised in the DISCUSSION above, and those on the student sheet.

At this point, you can be more of a guide in helping the students make sense of the information they gathered. Don't rush or force conclusions, but reinforce the correct comments made by the students, by repeating and rephrasing the best formulations.

The following conclusions may be reached as a result of

the lesson:

* Between sunrise and sunset, the Sun travels across the Southern sky, from East to West (left to right).

* Shadows point in the direction opposite to where the Sun is. They are longer in the morning and evening, and shorter at midday.

Also, make sure that the students have a clear knowledge of the cardinal points.

COMMENTS:

* For more on this activity, see DAYTIME ASTRONOMY (Elementary Science Study, Webster / Mcgraw Hill)

* The following are alternative gnomons for the experiment:

.A flag or tether ball pole (use chalk to mark the shadow)

.A golf tee, glued to an 8 1/2x11 sheet of paper, on an 8 1/2x11 piece of stiff cardboard

.A thumbtack, poking through an index card

The shadow of a larger gnomon (say a flagpole) moves faster and allows more accurate readings. The records of the shadow of a 9" gnomon can conveniently be seen by the whole class. On the other hand, smaller gnomons allow children to have their own individual gnomon and record.

* It is commonly believed that there is no shadow at noon, because the Sun is exactly overhead. This only happens below the tropics -- this will be discussed in Lesson 19.

* If some students want to use the gnomon and its shadow record sheet as a sundial, encourage them to try it. However they will probably find that this kind of a sundial becomes inaccurate

after a few days. This can serve to interest the students in the seasonal variations in the Sun's path (which will be discussed in Lessons 6, 7, 8, 19 and 20), and in the design of sundials.

* It is especially interesting to do the gnomon experiment on or near the dates of the Solstices (December and June 21) and one of the Equinoxes (March or September 21). Differences in the shadow's path are most dramatic between those dates.

* It is interesting to compare compass North to "gnomon North". Keep in mind that inexpensive compasses are often inaccurate, and that good compasses point to Magnetic North. The DAILY PLANET ALMANAC features a map showing magnetic declination, the difference in degrees between magnetic and actual North. "Gnomon North" is true North.

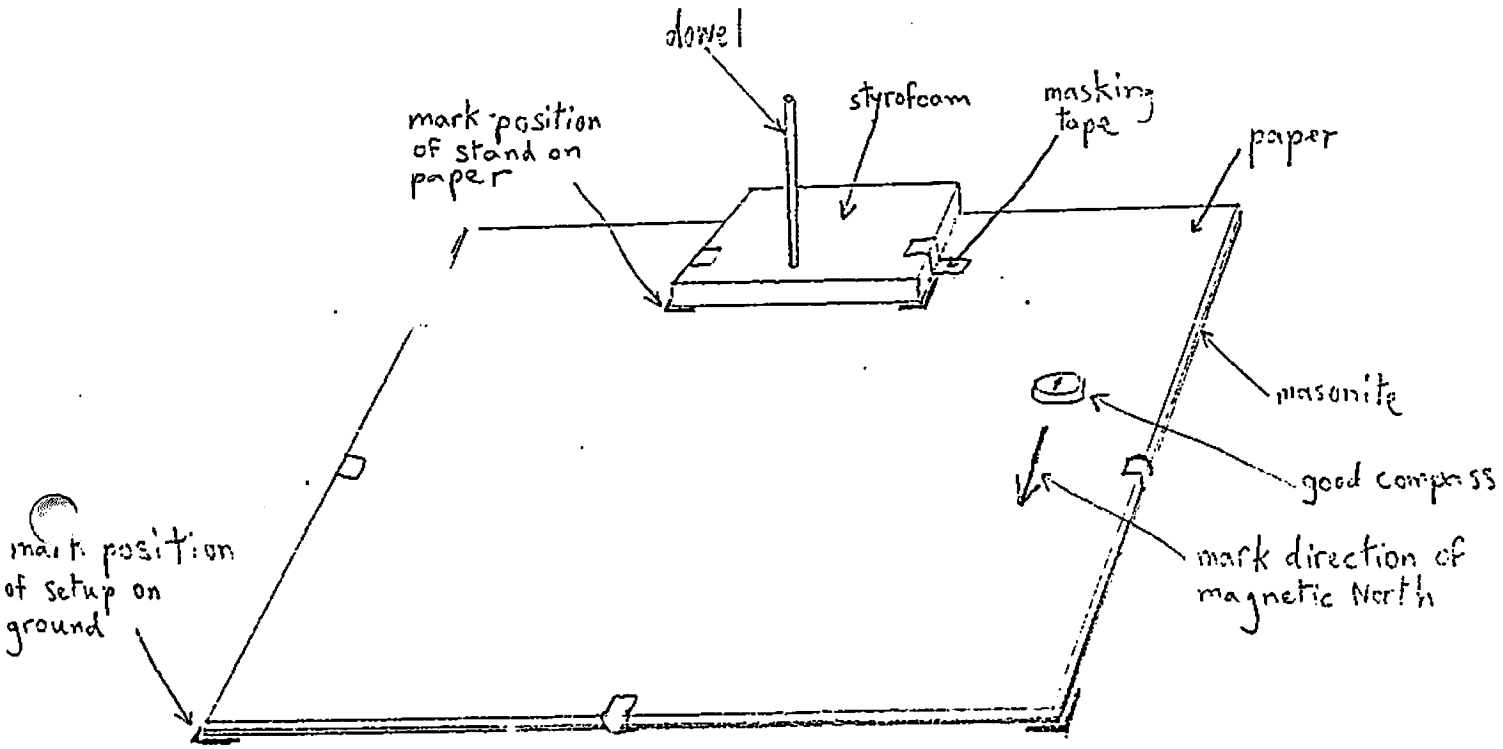
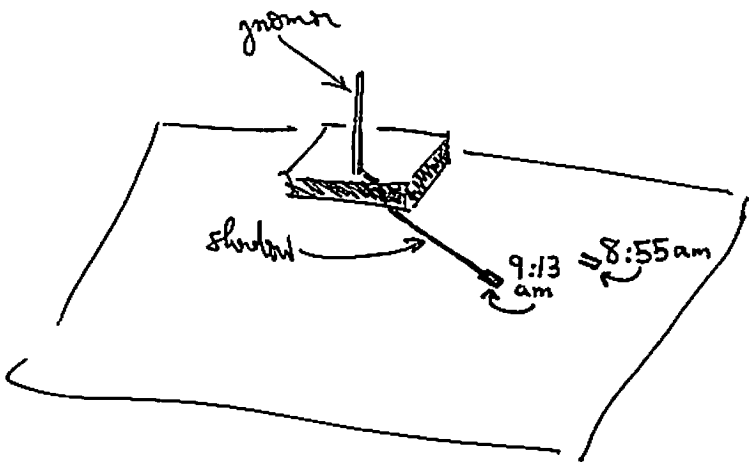

dowel
styrofoam
masking tape
paper
mark position of stand on paper
masonite
good compass
mark position of setup on ground
mark direction of magnetic North

Fig 2-1

Fig 2-2.



THE SUN

1. Fill in all the directions on the compass below. Some have been done to get you started. (Fig. 1)

2. The gnomon (pronounced know-mon) is the world's oldest scientific instrument. It is a vertical stick. By watching and measuring its shadow, people learned about the Sun's motion in the sky.

* When the Sun is low, the gnomon's shadow is (short, long).
* If the gnomon's shadow is short, the Sun is _____.
* When the Sun is in the East, the shadow points _____.
* If the shadow points North West, the Sun is _____.
* When the Sun is South South East, the shadow points _____.

3. Around what time of day are shadows shortest?

* At that time, which direction do they point to?

4. These pictures were taken (facing South) (a) at sunrise, (b) in the middle of the morning, (c) at midday, (d) in the afternoon, and (e) in the evening. Unfortunately, they have been mixed up. Under each one, write the correct letter (a-e). (Fig. 2)

WARNING: NEVER LOOK DIRECTLY AT THE SUN. YOU COULD DAMAGE YOUR EYES PERMANENTLY.

Fig 1 :

Fig 2 :