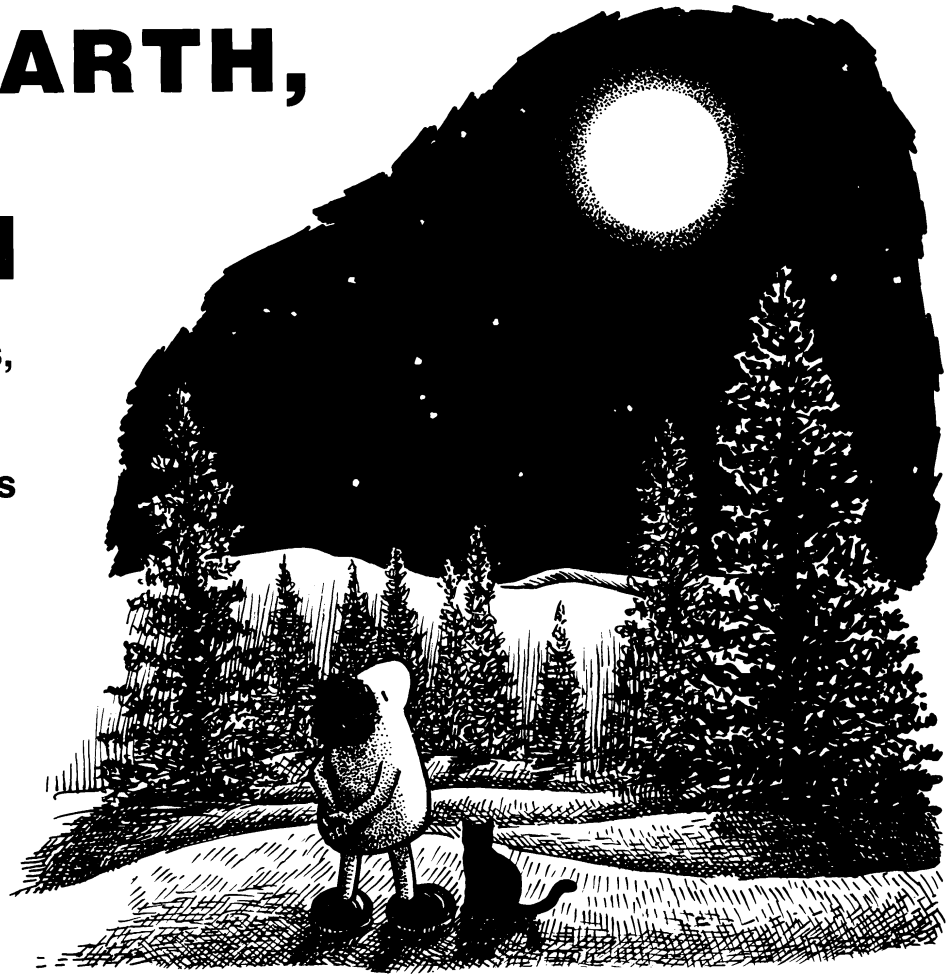
THE EARTH, MOON & SUN

with paper plates, bottles, tennis balls and simple things



SCIENCE WITH SIMPLE THINGS SERIES

Conceived and written by

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Illustrated by

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TOPS LEARNING SYSTEMS

10970 S. Mulino Rd.
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CONTENTS

PREPARATION AND SUPPORT

ACTIVITIES AND LESSON NOTES

SUPPLEMENTARY CUTOUTS

Gathering Materials

Listed below is *everything* you'll need to teach this module. You probably already have most items. Buy the rest locally, or ask students to bring recycled materials from home.

Keep this classification key in mind as you review what's needed:

general on-the-shelf materials:	*special in-a-box materials:*
Normal type suggests that these materials are used often. Keep these basics on shelves or in drawers that are accessible to your students. The next TOPS module you teach will likely utilize many of these same materials.	Italic type suggests that these materials are unusual. Keep these specialty items in a separate box. After you finish teaching this module, label the box and put it away, ready to use again.
(substituted materials):	*optional materials:
Parentheses enclosing any item suggest a ready substitute. These alternatives may work just as well as the original. Don't be afraid to improvise, to make do with what you have.	An asterisk sets these items apart. They are nice to have, but you can easily live without them. They are probably not worth an extra trip to the store, unless you are gathering other materials as well.

Everything is listed in order of first use. Start gathering at the top of this list and work down. The Teaching Notes may occasionally suggest additional *Extensions*. Materials for these optional experiments are listed neither here nor under *Materials*. Read the extension itself to determine what new items, if any, are required.

Needed quantities depend on how many students you have, how you organize them into activity groups, and how you teach. Decide which of these 3 estimates best applies to you, then adjust quantities up or down as necessary:

$Q_1/Q_2/Q_3$

- **Single Student:** Enough for 1 student to do all the experiments.
- **Individualized Approach:** Enough for 30 students informally working in pairs, all self-paced.
- **Traditional Approach:** Enough for 30 students, organized into pairs, all doing the same lesson.

KEY: general on-the-shelf materials; (substituted materials); *special in-a-box materials*; *optional materials

$Q_1/Q_2/Q_3$

- 1/1/1 pkt of steel pins, 1 inch long — see teaching notes 5
- 1/1/1 spool of thread
- 1/15/15 scissors — high quality scissors recommended for activity 14
- 1/15/15 magnets — the ceramic magnets sold by TOPS are suitable
- 1/35/35 small baby food jars or equivalent
- 1/1/1 water source — a large pitcher is suitable
- 3/35/35 straight plastic drinking straws — not wide milk shake straws
- .1/1/1 cup oil-based modeling clay
- 5/62/62 index cards, 4 x 6 inches
- 1/10/15 rolls clear tape — best if you can write on it
- 1/1/1 *roll clear tape, adhesive on both sides
- 1/10/15 rolls masking tape
- 1/1/1 pencil sharpener
- 3/75/75 generic paper plates — see notes 20
- 1/30/30 medium-sized washers, 3/4 inch (19 mm) outside diameter
- 1/8/15 textbooks
- 1/15/15 wristwatches
- 7/60/110 medium cans of equal diameter (paper towel or gift wrap tubes) — see notes 10
- .5/7/7 quarts dry gravel or sand
- 3/3/3 full-sized newspaper sheets
- 1/8/15 meter sticks
- 1/8/15 *hand calculators
- 1/2/2 rolls adding machine tape
- 1/3/6 paper punch tools
- 1/5/15 U.S. nickels or equivalent-sized coin
- 1/5/15 orange crayons or marking pens
- 1/1/1 roll waxed paper
- 2/30/30 rubber bands — thick ones work best
- 1/1/1 aluminum foil
- 1/1/1 roll kite string (heavy thread or dental floss)
- 1/8/15 clipboards (books)
- 2/30/30 *tennis balls, new or used*
- 2/10/30 batteries, dead or alive — size D are best
- 1/5/15 flashlights
- 1/15/15 Ping-Pong balls
- 3/45/45 paper clips
- 1/1/1 *roll black tape — electrical, vinyl or cloth*
- 3/45/45 *glass pop or beer bottles of equal height*
- 1/5/15 cardboard milk cartons, quart or larger
- 1/5/15 *canning rings, regular size
- 1/1/1 *calendars for this year and probably the next — see notes 20*

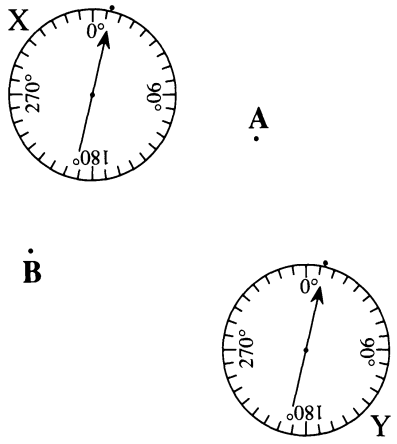
Review / Test Questions

Photocopy both pages of test questions. On a separate sheet of blank paper, cut and paste those boxes you want to use. Include questions of your own design, as well. Crowd all these questions onto a single page for students to answer on another paper, or leave space for student responses after each question, as you wish. Duplicate a class set and your custom-made test is ready to use. Use remaining questions as a review in preparation for the final exam.

activity 1 A

Use thread or a straightedge.

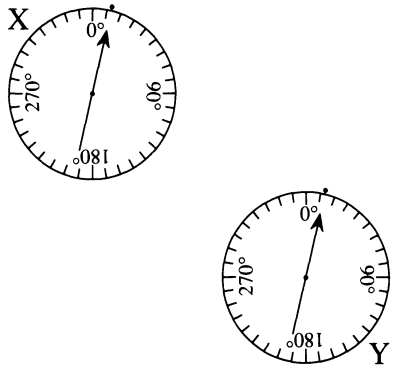
Both compass pins are properly aligned, each to its dot (magnetic pole). What are the azimuths of points **A** and **B** from compasses X and Y?



activity 1 B

Use a straightedge.

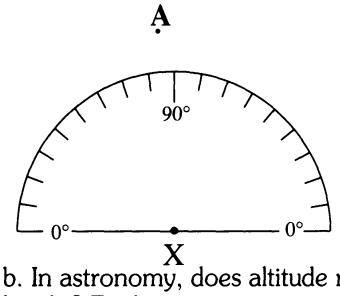
A treasure is buried at an azimuth of 78° from compass X, and 355° from compass Y. Mark its location with a circled dot.



activity 2 A

Use thread or a straightedge.

a. Find the altitudes of points **A** and **B** from point X.



b. In astronomy, does altitude refer to height? Explain.

activity 2 B

A clock is hanging on the wall so that 12 points straight up. Imagine you are a fly resting at its center.

a. What clock numbers are on your horizon? at your zenith?

b. What is the altitude of number 2? Number 11? Number 4?

activity 1-3

Use your compass and quadrant to answer this question.

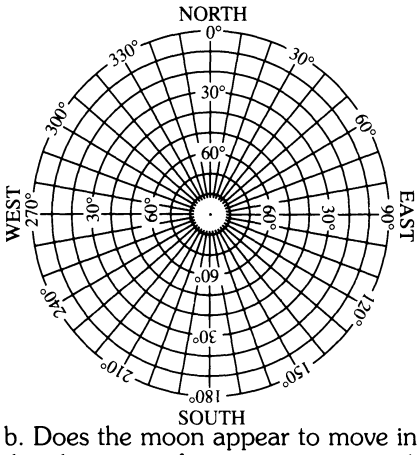
a. Measure the azimuth and altitude of your room's wall clock from where you sit. Express its position as an ordered pair: (azimuth, altitude)

b. Will other students sitting in other parts of the room get the same reading? Explain.

activity 3-5 A

a. Graph this table of moon positions taken over a period of 1 week. Use an arrow to show which way the moon is moving.

TIME	DATES	COORDINATES (Azimuth, Altitude)
7:30 pm	5 OCT	(151°, 27°)
	6 OCT	(136°, 26°)
	8 OCT	(111°, 16°)
	9 OCT	(100°, 15°)
	10 OCT	(89°, 6°)



b. Does the moon appear to move in the direction of your arrow over 1 night? Explain.

activity 4-5 A

Give either the azimuth *or* the altitude for these sun positions:

a. The sun is on your horizon.

b. Your shadow has an azimuth of 40°.

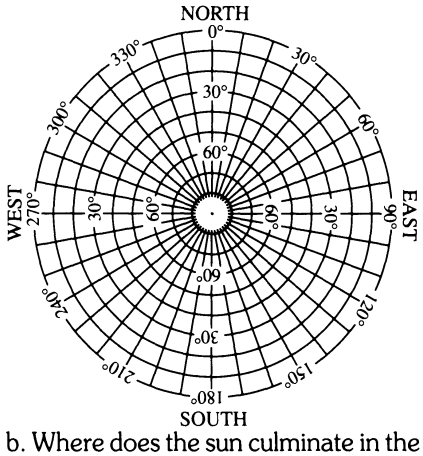
c. The sun is shining, but you cast no shadow.

d. The sun culminates lower than your zenith.

activity 3-5 B

a. Graph this table of sun positions taken over a period of 1 day. Use an arrow to show which way the sun is moving.

TIME	COORDINATES (Azimuth, Altitude)
8:00 am	(92°, 32°)
10:00 am	(116°, 56°)
12:00 noon	(182°, 68°)
2:00 pm	(240°, 52°)
4:00 pm	(268°, 32°)



b. Where does the sun culminate in the sky? Does it cross your zenith?

activity 4-5 B

Describe how the sun appears to move across the sky during this time of year. Does it pass straight overhead? Explain.

activity 5-7

Use your measuring triangle.

A vertical 8 meter pole casts a 5 meter shadow on level ground.

a. Draw the pole and its shadow to scale 100 times smaller than actual size.

b. Is the sun's azimuth less than 45°? Explain.

c. If the shadow has an azimuth of 215°, what is the azimuth of the sun?

activity 6-7 A

a. Make a scale drawing of this page that is 1/10 actual size.

b. Calculate the length of its diagonal without measuring this test paper directly. Explain how you did this.

activity 8

How can you make a telephone pole and a pencil have the same *apparent* size?

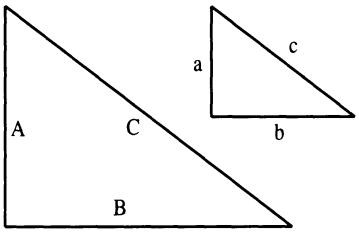
activity 8-9 A

Using these numbers, write *four* true statements comparing the size of the earth, moon and sun and the distance between them: 3.5, 30, 108.

Review / Test Questions (continued)

activity 6-7 B

Use your measuring triangle.
Show that these triangles are proportional.



activity 8-9 B

a. How many earths fit across the sun?
b. How many moons fit across the earth?
a. How many moons fit across the sun?

activity 8-10

Do the moon and sun have the same apparent size? The same real size? Explain.

activity 8-11

Suppose the moon were reduced to 2 mm in diameter, about the size of a pinhead. At this scale...
a. Calculate the earth's diameter in mm.
b. Calculate the sun's diameter in cm.
c. Calculate the distance between them in meters.

activity 9

Relate the view of a basketball from a distance of 30 basketball diameters to a view of the earth and the moon.

activity 9-10 A

What apparent size would the earth and sun have as seen from the moon?

activity 9-10 B

To project a sun image of 1.0 cm in diameter, how long would you have to make your pinhole projector?

activity 10

How would you build a device to safely view an eclipse of the sun?

activity 10-11

From what distance should you view a basketball for it to have the same apparent size as the sun?

activity 12 A

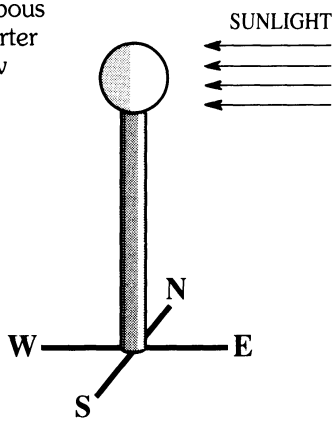
a. If the moon were an umbrella and the earth were your head, how would you demonstrate an eclipse of the sun?
b. Is this a scale model?

activity 12 B

Half the earth is always in sunlight and half is in shadow.
a. Is this true for the moon as well?
b. If so, why does the moon sometimes appear as a thin crescent?

activity 13 A

A volleyball "moon" is balanced on a post, illuminated by a rising sun. Where should you stand to see a model of these moon phases?
a. crescent
b. gibbous
c. quarter
d. new
e. full



activity 13 B

List 8 moon phases in the moon cycle in the correct order.

activity 14 A

Circles of latitude on the earth differ in size, while circles of longitude all have the same size. Why is this so?

activity 14 B

Three principle circles divide a globe of the earth into equal halves:
a. Which is calibrated in degrees north and south?
b. Which is calibrated in degrees east and west?
a. Which is calibrated in months of the year?

activity 14 C

Order these earth belts by size from largest to smallest: tropic of cancer, arctic circle, equator.

activity 15 A

How should you align an earth globe to model the current alignment of the real earth and sun?

activity 15 B

A ring of twilight surrounds our globe that separates night from day.
a. Where do people on this ring see the sun?
b. Do you live on this ring?

activity 15-16

In which direction does the sun *appear* to move across the sky? Does it really move this way? Explain.

activity 16-17

What causes earth's changing seasons? Give an example.

activity 17 A

a. Where is the Tropic of Capricorn? Why is it important?
b. Where is the Arctic Circle? Why is it important?

activity 17 B

Name 4 important astronomical events that mark the beginning of each new season in the year. How does earth's north pole tilt with respect to the sun at these points in time?

activity 18 A

Most people believe that the earth rotates full circle (360°) from 12 noon to 12 noon. How far does it really rotate? Explain.

activity 18 B

Is 24 hours of star time the same as 24 hours of solar time? Explain.

activity 3, 19

Which way does the moon *appear* to move? Which way does it *actually* move? Explain.

activity 19

A full moon is just rising on the horizon.
a. Where will you see it in 1 hour? Why?
b. Where will you see it in 24 hours? Why?

activity 20 A

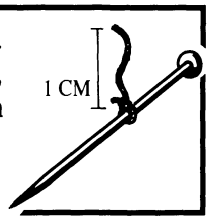
A lunar calendar has months that alternate between 29 days and 30 days so that each new month begins with a new moon. What is the disadvantage of using this calendar?

activity 20 B

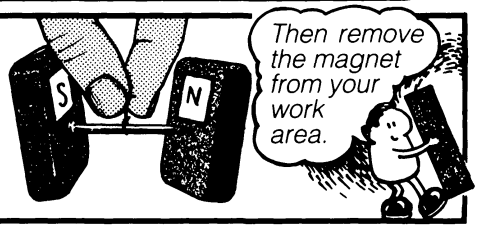
How far do you move the Moon Marker on your lunar calendar to track the passing of 1 month? The passing of 1 year?

AZIMUTH

1. Tie thread to a steel pin. Trim one end near the knot, cut the other end about 1 cm long. Slide the thread so the pin hangs level.

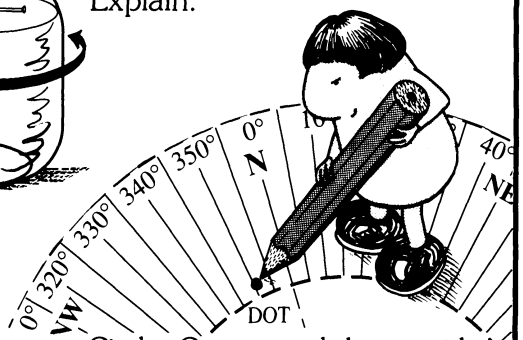


2. Magnetize your pin: touch its *head* to the *south* pole of a magnet; its *point* to the *north* pole.



3. "Float" your pin *on* water in a small jar.

a. Slowly turn the jar. Does the pin turn with the jar? Explain.



b. Get a Compass Circle. Cut around the outside.

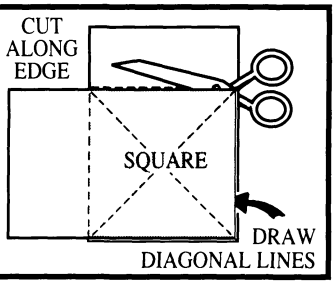
c. Ask your teacher where magnetized pinheads always point in your part of the world. Mark this *bearing* with a bold black dot just outside the center circle.

4. Cut a length of plastic straw as tall as your jar. Stick a lump of clay on one end.

a. Sink your floating pin. Use your "wand" to get it out again.

b. Rescue your pin this way whenever it sinks.

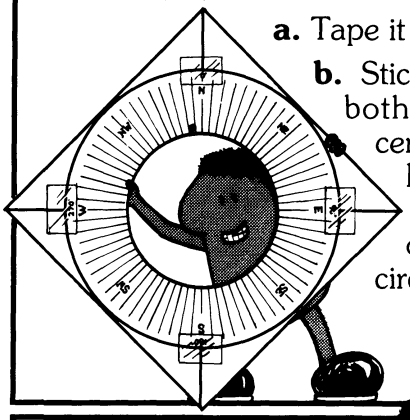
5. Cut an index card into a square, using a second one as a guide. Draw both diagonals on the square.



6. *Center* your compass circle on the square with **N**, **S**, **E**, and **W** over the diagonals.

a. Tape it in this position.

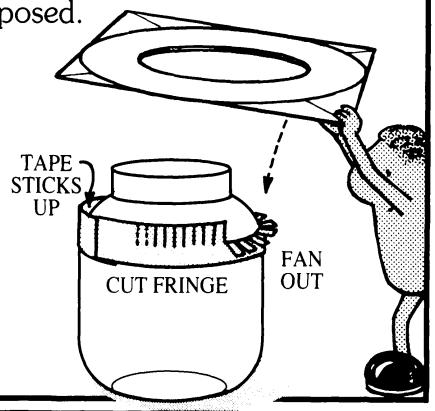
b. Stick a pin through both layers, in the center. Enlarge the hole with a sharp pencil, then cut out the inside circle.



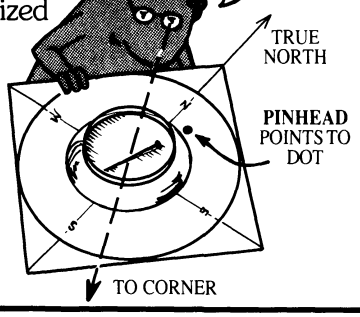
7. Stick a raised "collar" of masking tape around the "shoulder" of the jar so half of its sticky side stays exposed.

a. Cut the raised tape into a fringe. Bend it outward all around the jar.

b. Set your compass circle onto this sticky fringe so it rests level.



8. "Float" your magnetized pin on the water. To find your bearings, always turn your compass circle so the pin*head* points to the dot.



a. Find the *azimuth* (compass bearing) of corners A, B, C and D in your room from where you sit.

b. Clearly print these results on a small piece of paper. Fold it twice and toss it into a class "hat." *Don't* write your name on it.

c. Draw someone else's paper from the hat. Use your compass to find whose desk it belongs to.

Objective

To build a compass. To define the location of your desk by finding the azimuth of each room corner.

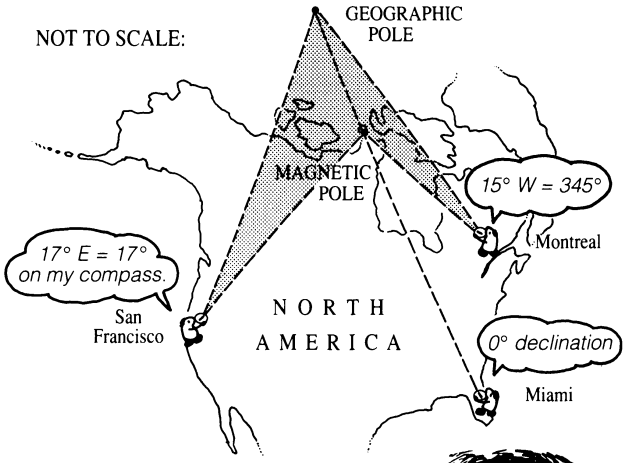
Lesson Notes

Notice that steps 3a and 8a in this worksheet are underlined. Point out to your class that all underlined steps in each worksheet signal that a question should be answered, or that data should be entered, on a separate assignment sheet or in a personal science notebook.

2. Touching the pin as illustrated magnetizes the head of the pin *north* and its point *south*. It will keep this orientation unless it is accidentally remagnetized. Storing the permanent magnet out of reach avoids this potential problem, and also keeps its local magnetic field from influencing the compass pin.

3. The pin rests on top of the water, supported by surface tension. It doesn't truly float. Push it under, and the water displaced does not buoy it up again.

3b. Since the earth's *magnetic poles* do not coincide with its *geographic poles*, compasses show varying degrees of *declination*, as shown by the shaded angles below.



Find your nearest city in the list below to estimate where magnetized pinheads point in your area. (All magnetic declinations have been translated into simple compass bearings.) Write your local bearing next to the head of a pin sketched on your blackboard. If you live outside of North America, ask a reference librarian.

8. As students complete this step, check compasses to make sure all pinheads point in the same northerly direction. Any pin that points opposite was touched to the wrong pole in step 2, and should be remagnetized.

Metal desks may attract magnetized pins and skew compass readings. If this is a problem, tape the jars on top of inverted drinking cups to distance them from this influence.

Water in the jar should be changed daily to prevent surface stagnation that will eventually immobilize the magnetized pin.

Although students are not specifically directed to do so, they should identify this compass (plus all other instruments and models made in this TOPS module) with their names. These will be reused in activities that follow.

Answers

3a. No matter which way you turn the jar, the pin always points in the same direction.

8a. All azimuths should be recorded in degrees (°).

Materials

☐ Steel pins. Aluminum or brass pins *cannot* be magnetized.
☐ Thread and scissors.
☐ Any strong magnet. A "refrigerator" magnet is suitable. Make sure its poles are correctly labeled. (Hang it from a thread: the north pole will face north; the south pole, south.)
☐ The Compass Circle cutout, one per student. Students can work together in cooperative lab groups, but each one should make his or her own compass. These and other instruments will be used later for observations at home. Find this and all other reproducible cutouts in the back pages of this module, identified by activity number.
☐ A small baby food jar or equivalent, with a diameter that is small enough to accept the Compass Circle. If possible, select jars with well-defined "shoulders." Jars with a gradual slope are more difficult to fit with the tape fringe in step 7.
☐ Water.
☐ Your area's angle of declination marked on the blackboard.
☐ A straw and a small lump of clay.
☐ Two 4 x 6 inch index cards.
☐ Clear tape and masking tape.
☐ A pencil sharpener.
☐ Four room corners labeled A, B, C and D. Boldly write these letters on scrap paper or paper plates. Hang them where each corner meets the ceiling, so they can be seen from all desks. Leave these in place for the next 2 activities.
☐ A class "hat." If you're working with just one or two students, hide a penny for them to find. List the azimuths of each corner on scratch paper in advance.

Albany NY 347°	Cincinnati OH 0°	Honolulu HI 11°	Miami FL 0°	Pierre SD 11°	Santa Fe NM 13°
Amarillo TX 11°	Cleveland OH 356°	Hoquiam WA 22°	Milwaukee WI 1°	Pittsburgh PA 355°	Slt St Marie MI 356°
Anchorage AK 26°	Columbia SC 358°	Hot Springs AR 7°	Minneapolis MN 6°	Port Arthur ON 1°	Savannah GA 359°
Atlanta GA 1°	Columbus OH 358°	Idaho Falls ID 17°	Mobile AL 4°	Portland ME 343°	Scranton PA 350°
Atlantic Cty NJ 350°	Dallas TX 8°	Indianapolis IN 1°	Montgomery AL 3°	Portland OR 21°	Seattle WA 22°
Austin NV 17°	Denver CO 13°	Jackson MI 5°	Montpelier VT 345°	Providence RI 345°	Shreveport LA 7°
Baker OR 20°	Des Moines IA 7°	Jacksonville FL 0°	Montreal QE 345°	Quebec QE 341°	Sioux Falls SD 9°
Baltimore MD 352°	Detroit MI 357°	Juneau AK 29°	Moose Jaw SK 17°	Raleigh NC 356°	Sitka AK 28°
Bangor ME 341°	Dubuque IA 4°	Kansas City MO 8°	Nashville TN 2°	Reno NV 18°	Spokane WA 22°
Birmingham AL 3°	Duluth MN 5°	Key West FL 1°	Needles CA 15°	Richfield UT 16°	Spgfld IL 4°
Bismarck ND 12°	Eastport ME 339°	Kingston ON 348°	Nelson BC 22°	Richmond VA 354°	Spgfld MA 346°
Boise ID 19°	El Centro CA 14°	Klmth Flls OR 19°	New Hvn CT 347°	Roanoke VA 356°	Spgfld MO 7°
Boston MA 345°	El Paso TX 12°	Knoxville TN 359°	New Orleans LA 6°	Sacramento CA 17°	Syracuse NY 349°
Buffalo NY 352°	Eugene OR 20°	Las Vegas NV 15°	New York NY 349°	St John NB 338°	Tampa FL 1°
Calgary AB 22°	Fargo ND 9°	Lewiston ID 20°	Nogales AZ 13°	St Louis MO 5°	Toronto ON 353°
Carlsbad NM 12°	Flagstaff AZ 14°	Lincoln NB 9°	Nome AK 17°	Salmon ID 19°e	Trinidad CO 13°
Charleston SC 358°	Fresno CA 16°	London ON 355°	N Platte NE 11°	Salt Lake City UT 16°	Victoria BC 23°
Charleston WV 357°	Garden City KS 11°	LA CA 15°	OK Cty OK 9°	San Antonio TX 9°	Watertown NY 348°
Charlotte NC 358°	Grand Jnctn CO 15°	Louisville KY 1°	Ottawa ON 347°	San Diego CA 14°	Wichita KS 9°
Cheyenne WY 13°	Grnd Rpds MI 359°	Mnchstr NH 345°	Phila PA 350°	San Francisco CA 17°	Wilmington NC 356°
Chicago IL 1°	Helena MT 19°	Memphis TN 5°	Phoenix AZ 14°	San Juan PR 352°	Winnipeg MB 9°