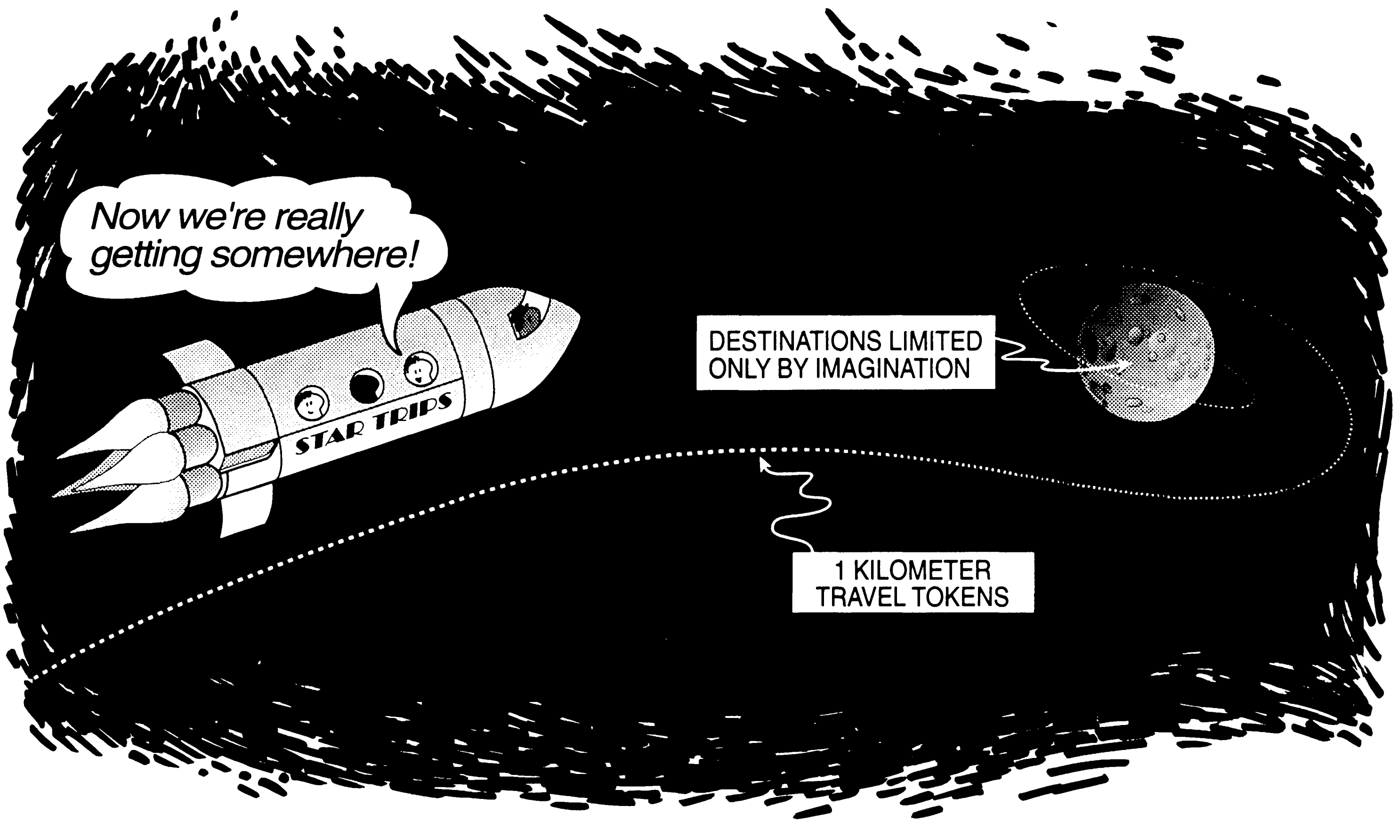
THE PLANETS AND STARS



SCIENCE WITH SIMPLE THINGS SERIES

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CONTENTS

PART I — PREPARATION AND SUPPORT

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PART III — 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 readily 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 for storage and put it away, ready to use again.
(substituted materials):	***optional materials:**
Parentheses enclosing any item suggests 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. Ask students to bring recycled items from home. 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.

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

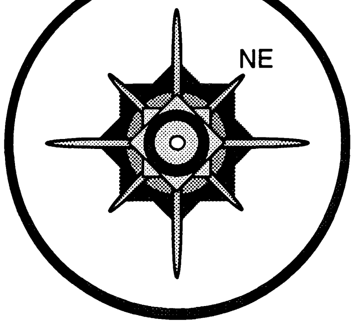
$Q_1/Q_2/Q_3$	
1/15/15	scissors — younger children should use blunt scissors in activity 10
1/8/8	rolls masking tape
1/2/8	meter sticks
1/1/1	wall clock (wristwatches)
1/1/1	pkg. standard 1 inch straight pins
1/1/1	**pkg. extra long pins — about 1.5 inches*
2/30/30	Post Grape Nuts cereal boxes, 32 oz. size or equivalent — see notes 2
1/5/15	pennies
1/5/5	rolls clear tape
2/30/30	straight plastic straws, 1/4 inch in diameter or slightly smaller
1/1/1	box standard-sized paper clips
1/3/8	paper punch tools
1/1/1	spool of thread
1/5/15	metal washers, any size
1/5/15	*lbs. gravel, large rocks or bricks
1/15/15	baby food jars with tight-fitting lids — use 4 oz. size only, with basic cylindrical shape
1/5/15	*graduated cylinder, 50 ml
1/1/1	*roll paper towels
1/3/8	*bottles white glue
.1/1/1	cup oil-based modeling clay
1/1/1	bottle food coloring with dropper dispenser — blue is best color
1/1/1	roll plastic wrap
1/30/30	flashlights filtered with *red cellophane, red plastic from shopping bag, or red tissue paper* — students will use these at home
1/5/15	hand lenses
1/1/1	stack of standard-sized newspaper 3 feet high — see note 11
1/5/15	each, yellow and black crayons or markers
3/63/75	paper plates, standard 9 inch diameter with traditional rippled border
1/5/15	drawing compasses
1/1/1	*shaker of black pepper*
1/1/1	*container of coarse sand with pebbles*
1/5/15	tennis balls, new or used
1/1/1	roll heavy string
1/2/2	*pkg. clothespins
1/1/1	copy of The World Almanac and Book of Facts, or equivalent reference
1/1/1	*a current calendar with moon phases
1/1/1	ball of cotton

Review / Test Questions

Photocopy both pages of test questions. Cut out those questions you wish to use and tape them onto clean paper. Include questions of your own design, as well. Crowd them all 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 leftover questions as a class review in preparation for the final exam.

activity 1-2

Write the direction on each point of this compass rose:



activity 1-3

Dwayne lives on the North American plains. He sees the sun rise in the northeast at 5:40 am and set in the northwest at 7:50 pm.
a. Compute Dwayne's high noon to the nearest minute.
b. Where does Dwayne's shadow point at this time? Where is the sun in the sky?
c. Is there snow on the ground? Explain your answer.

activity 1-4

Required: Pointer Box with Sun Protractor.

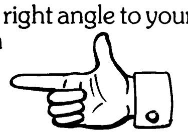
a. Trace the path of the sun at your latitude from sunrise to sunset for a calendar date of September 1. Briefly describe what you did.
b. What is the sun's declination on September 1? Where does it rise and set?

activity 1,5,6

You are lost in the high Oregon desert without a compass.
a. How would you locate N, S, E and W during the day?
b. How would you find your way by night?

activity 2,3,4

Hold your thumb at a right angle to your index finger. Explain how to use this hand to trace your celestial equator.



activity 3

Optional: Sun Protractor.

Name the 4 special days that begin the 4 seasons. What are the declinations of the sun at these times of year?

activity 3-6

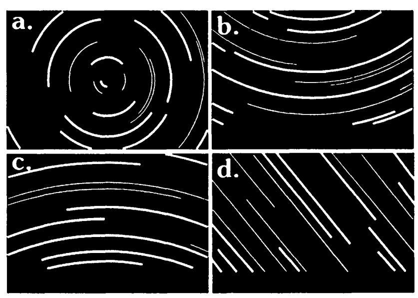
Sara is looking at the rings of Saturn in her new telescope. Leaving everything in place, she goes to find her brother Raul so he can look, too. After a while they both return. Raul looks into the telescope without disturbing its alignment, but sees no Saturn! What happened?

activity 4-5

The sun and stars appear to arc across your sky from east to west once a day. What is really happening?

activity 5-6 A

A camera, set up in Ohio, is aimed at different parts of the starry sky. Its shutter is left open so the circling stars leave trails on the exposed film. At what part of the sky did the camera point to take each of these pictures?



activity 5-6 B

Required: Star Jar.

Name the month of the year when...
a. the sun is "in" Orion.
b. Orion culminates at sunset.
c. Orion culminates at midnight.
d. Orion culminates at sunrise.

activity 7,9

Make your little finger *appear* larger than your thumb. How did you did this?

activity 7,12

Required: Dipper Box with Star Ruler.

Locate these pairs of star on your Dipper box: Megrez-Phecda, Phecda-Dubhe.
a. Measure the apparent separation between each star pair.
b. Measure the actual separation between each star pair.
c. Are star distances as they appear in the night sky? Explain.

activity 7,9,14

Does your Sky Sphere model the *actual* position of the stars in space, or their *apparent* positions in the sky? What about your Dipper Box?

activity 8 A

Required: Polar Graph.

What are the coordinates of Alkaid at the end of the Dipper's handle? State the name of each coordinate as well as its value.

activity 8 B

Required: Polar Graph.

a. Plot the position of the star Alderamin (in the constellation Cepheus) on your Polar Graph. It has a sidereal time of 21.3 hours and a declination of 63° N.
b. What constellation could you use as a "signpost" to find Alderamin? Explain.

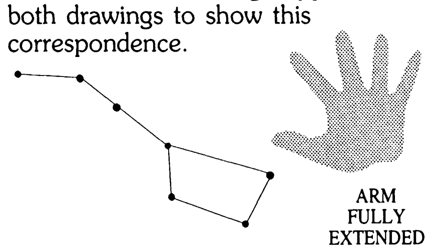
activity 8,9

Optional: Polar Graph

You can model the motion of the Big Dipper and Cassiopeia in our night sky with an umbrella. Explain how to do this.

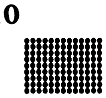
activity 9

The fingers of your outstretched hand match the angle of separation between certain stars in the Big Dipper. Label both drawings to show this correspondence.



activity 10

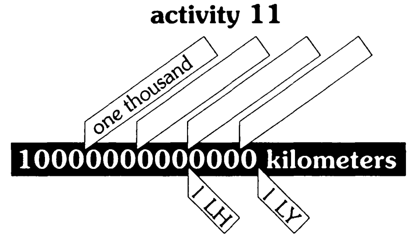
How many dots are in this grid?



activity 10-11

A million dots are printed in a perfect square. How many rows and columns are there?

activity 11



a. Fill in the 3 empty boxes on this Kilometer Bar.
b. The distances that light travels in 1 hour and in 1 year are marked at the bottom. According to this bar, how many times farther does light travel in 1 year than in 1 hour?

Review / Test Questions (continued)

activity 10-12 A

a. A full sheet of newspaper printed with Lots-o-Dots contains exactly 1 million dots. Write out this number with the correct number of zeros.

b. Light travels about 10 trillion kilometers in 1 year. Write out this number with the correct number of zeros.

c. If each dot is a token good for 1 kilometer, how many sheets of dots do you need to travel 1 Light Year?

activity 10-12 B

Light takes 500 seconds to travel from the sun to the earth.

a. A solar flare happens on the sun. How many *minutes* pass before we can detect this event on earth?

b. Light travels 300,000 k/second. How far away is the sun in kilometers?

c. How would you represent this distance with Lots-o-Dots?

activity 12

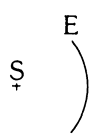
In our part of the Milky Way, stars are scattered through space with an average separation of about 7 LY.

a. Traveling at the speed of light, how long would it take, on average, to travel from star to star?

b. How many earth years would it take to visit every star in an average cube of space that measures 70 LY on a side?

activity 13

Required: Solar Squares.



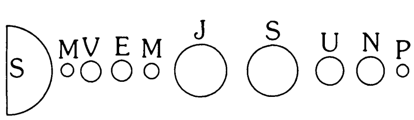
Earth's orbit is drawn around a cross-mark representing the sun's position.

Sketch in the orbits of Venus, Mars and Jupiter at the correct scale. Label them V, M and J.

activity 13,18

Required: Solar Squares.

What is useful about this model of our solar system? What is misleading?



activity 14-16

Optional: Sky Sphere or Star Jar

Describe how each constellation appears to move at your home latitude.

a. Cassiopeia.

b. Orion.

c. The Southern Cross.

activity 15-16 A

Optional: Sky Sphere

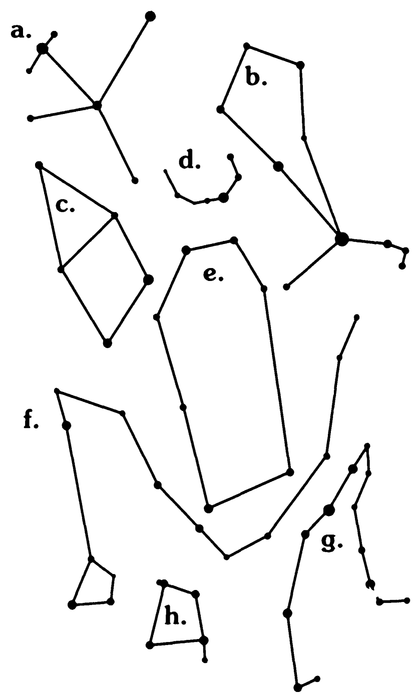
a. Draw any 4 of these 8 constellations: Sagittarius, Capricornus, Taurus, Gemini, Auriga, Canis Major, Ursa Minor, Cygnus.

b. Which of these constellations are part of the zodiac?

activity 15-16 B

Required: Sky Sphere

Identify these constellations by name. (They are all turned so N is up.)



activity 16

Describe the path of your meridian from the NCP to your horizon.

activity 17

Required: Solar Squares and a penny.

If the earth is as big as a penny...

a. Draw Mars to scale.

b. Draw Jupiter to scale.

c. How big is sun at this scale?

activity 13,17-18 A

Can you draw the solar system to scale on a sheet of notebook paper showing *both* the size of the planets and their distances from the sun? Explain.

activity 13,17-18 B

A star ship enters our solar system from deep space. How does the view change?

activity 15,16,18

Leo is lost in the sun about one month out of the year. Explain why.

activity 19 A

Optional: Sky Sphere.

Mars is in eastern quadrature. Where (if at all) do we see this planet...

a. After sunset?

b. At midnight?

c. Before sunrise?

activity 19 B

Optional: Sky Sphere.

Jupiter is in opposition. Where (if at all) do we see this planet...

a. After sunset?

b. At midnight?

c. Before sunrise?

activity 19 C

Optional: Sky Sphere.

Venus and Mercury are both at maximum Western elongation.

a. During what part of the night (between sunset and sunrise) do you see these planets?

b. Which planet do you see first? Why?

activity 20 A

Scorpius shines against the soft light of our Milky Way Galaxy. The square of Pegasus, by contrast, shines in inky darkness. Account for this difference.

activity 20 B

You broadcast your home address toward Andromeda, 2.2 million LY away, so that someday aliens from that galaxy might knock at your door and stay for dinner.

a. Detail your full address that you will broadcast, so these aliens will be able to locate you. Assume they can understand English.

b. How much time might pass before you could hope for their arrival? (Radio waves travel at the speed of light.)

activity 20 C

Optional: Kilometer Bar

Order by size from smallest to largest:

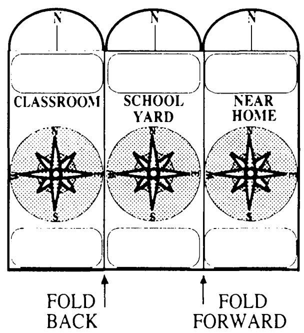
Sun's diameter
Earth's diameter
Earth's orbit
Jupiter's orbit
Pluto's orbit
across the Universe
distance to Alpha Centauri
distance to Mizar
distance to Alkaid
distance to Andromeda
Pluto's diameter
diameter of Milky Way
Jupiter

LANDMARKS

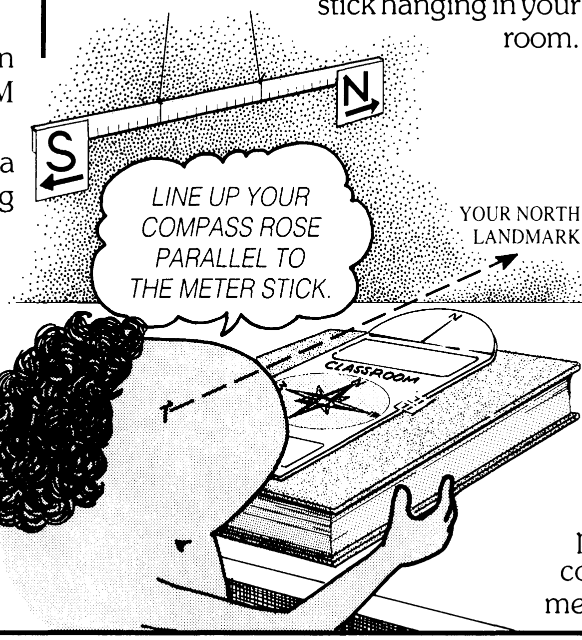
1. Cut around the outside of the Landmark Maps, keeping them all in *one* piece.

a. Fold the maps like an accordion so CLASSROOM faces up.

b. Lightly stick them to a book on your desk, using masking tape.



2. Turn the book so N on the *compass rose* points north, just like the meter stick hanging in your room.



a. In the top curved section, draw a *distant* landmark that you now see to your north. (The "N" line should pass through the part of your drawing that is *exactly* north.)

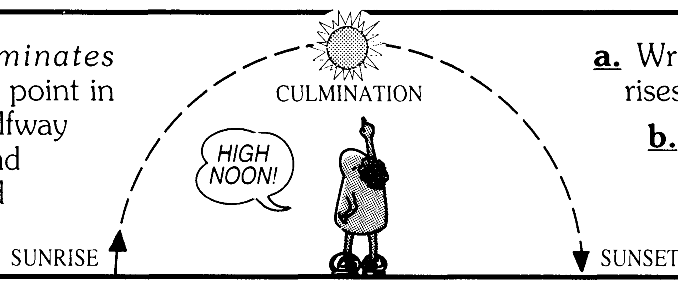
b. Describe this landmark in words under your drawing.

c. Describe your position, in the box to the south of the compass rose.

d. Name something that is now due south of you; northwest of you; at a bearing of 60°.

e. Point your map toward its north landmark from other places in your room. Does your compass rose still agree with the meter stick? Explain.

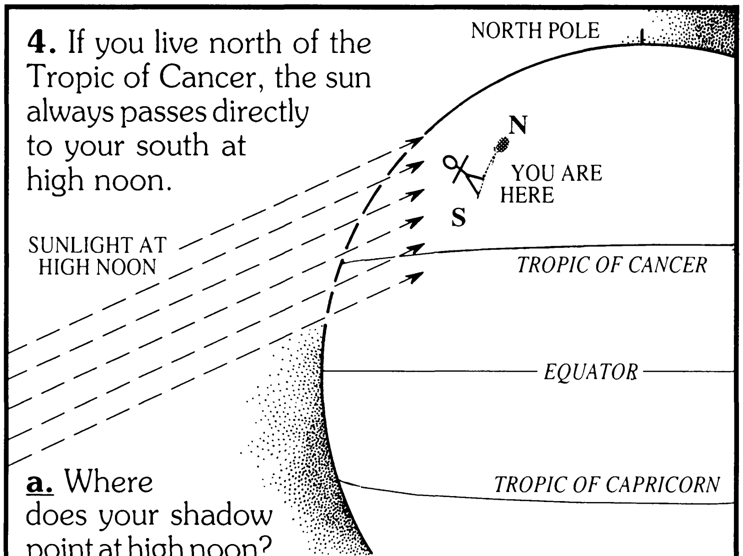
3. The sun *culminates* (reaches its highest point in the sky) exactly halfway between sunrise and sunset. This is called *high noon.*



a. Write down when the sun now rises and sets where you live.

b. Calculate when high noon happens where you live. Give your answer to the nearest minute.

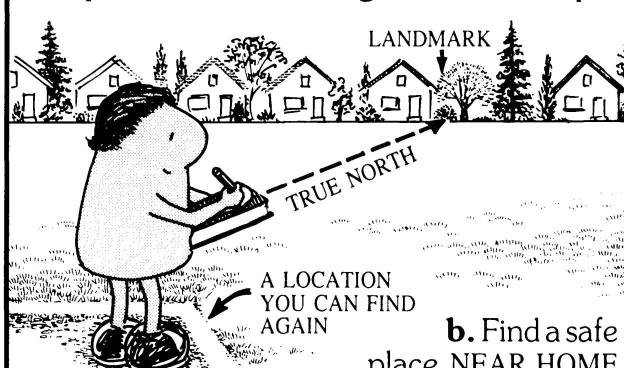
4. If you live north of the Tropic of Cancer, the sun always passes directly to your south at high noon.



a. Where does your shadow point at high noon?

b. How can you use the sun and a clock to find true north outside?

5. Use the sun, if possible, to accurately complete the 2 remaining Landmark Maps.



a. Choose a well-marked open place in the SCHOOL YARD that you can find again.

b. Find a safe place NEAR HOME with clear views to the N and S. It should be protected from bright street and house lights as much as possible.

Objective

To fix reference points that line up with true north in your classroom, on the school grounds and at home.

Supporting Concepts

The supporting concepts presented here, and throughout this module, may already be familiar to your students. Depending on the needs and abilities of your particular age group, you might decide to try all the ideas presented under these headings, cover a select few, or skip them entirely. The *less* you do and say by way of introduction, the *more* independent and self-directed your students will become.

✪ Call attention to the meter stick hanging in your classroom lettered N for north and S for south. These point toward earth's north and south poles. Ask everyone to point north, just like the meter stick. How can we describe the orientation of all our pointing fingers? (If everyone is pointing correctly, they are all parallel.)

✪ Ask volunteers to describe, in specific terms, something in the room that is due north of them. Does everyone describe the same object? (No. Different locations in the room have different North landmarks.)

Lesson Notes

2, 2a. Students tend to select prominent objects (a wall clock, for example) somewhere *near* true north, then draw these in the center of the available space. Encourage them to *first* align their maps parallel with the N-S meter stick, then accurately draw what they see as they sight along the N-line (not likely the exact center of the clock).

2c. Students should complete this activity at their "home" locations within the classroom. This might be at their desks if they work individually, or at an assigned lab table if teams of students share materials.

2d. Notice that this particular step and others in this lesson are underlined. These signal that a response is required on a separate assignment sheet or in a personal science notebook. (Steps 2a, 2b, and 2c are not underlined because students respond to instructions in these steps on their cutouts.)

3. This "peoplet" is standing in the Northern Hemisphere looking south toward the culminating sun, with east on the left, west on the right. South of the Tropic of Cancer (in Hawaii, for example) this illustration is not accurate near summer solstice, as the sun approaches an observer's zenith. In the tropics this picture is inaccurate most of the year. In Australia it is just plain wrong. Our point is this. If you live south of 23.5° N latitude (farther south than the tip of Florida), some adaptation of these lesson materials will be necessary. If you live farther south than this, even more adaptation is required. This is an unfortunate limitation of basic geometry. Wherever you do live, however, you will find this module is still a marvelous astronomy resource.

5. If you can begin this activity about 1/2 hour before high noon, then the sun will culminate just as your students reach this step. If your schedule lacks this flexibility, predetermine a suitable placed on your school grounds and locate its N landmark in advance for students to copy. Use your own sun shadow to do this, or a magnetic compass corrected to true north.

5a. You may wish to discuss suitable SCHOOL YARD viewing sites before going outside:

• The site should be easy to recognize and remember.
• It should have plenty of open sky to the north and south.
• The site's north horizon should be as distant as possible. (If you are able to select a N landmark that is many miles away on your far horizon, then this single landmark will serve as a N reference from anywhere in your whole school yard.)

5b. This is an important homework assignment that lays the groundwork for successful night sky viewing NEAR HOME later on. All of the criteria in 5a apply, as well as issues of darkness and safety.

Though not specifically directed to do so, your students should identify these Landmark Maps (and all cutouts in this module) with their names. They should save these maps (and all future cutouts) to use in later activities.

Answers

2d. Students should describe classroom objects at each compass point. All answers are unique to each site.

2e. No. When you point the map at its north landmark from other places in the room, N and S on the compass rose no longer align (point parallel) to N and S on the meter stick. (The only exception to this is if you move to a new location directly north or south of your original location. Then your north landmark remains unchanged.)

3a. Students should copy the sunrise and sunset times that you wrote on the blackboard.

3b. An easy way to solve this problem is to add and subtract time in equal increments from sunrise and sunset times until you zero in on high noon. Here is a daylight savings time example:

sunrise = 7:20	sunset = 6:34	
+ 6 hr = 1:20	- 6 hr = 12:34	
- 20 min = 1:00	+ 20 min = 12:54	
- 3 min = <u>12:57</u>	+3 min = <u>12:57</u>	(high noon)

(Our clocks keep average solar time. The sun will run ahead or lag behind any high noon you calculate as the year progresses.)

4a. At high noon your shadow always points directly north.

4b. Keep an appointment with the culminating sun. When it is high noon by your calculations in 3b, go outside and observe your sun shadow. It points true north.

✓ <u>Landmark</u> <u>Maps</u>: Are all 3 spaces on all 3 maps complete? Is each student's classroom site at a suitable location for conducting future experiments?

Materials

☐ The Landmark Maps cutout. Find photocopy masters for this and all cutouts at the back of this book.
☐ Scissors and masking tape.
☐ A heavy textbook.
☐ A level work area. This might be a desk or lab table.
☐ A meter stick labeled "N" and "S." (See the illustration in step 2.) Suspend this from your ceiling with string in the correct orientation. To find north, observe the direction of shadows outside your window at high noon, or use a compass.
☐ List the rising and setting times of the sun on your blackboard. These depend on your latitude and time of year. They are often listed in the weather section of local newspapers. You can also calculate these times from a current almanac, or use direct observation.
☐ A clock or wrist watch.