



THE SKY AT NIGHT

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* These activities will require partial or complete observations of sky objects outside of school hours.

I INTRODUCTION

The Sky At Night is a P1J1 topic recommended for study in year six. The purpose of this unit is not to amass a large collection of facts concerning celestial objects but rather to provide real experiences for the pupils from which concepts of the earth's motions and the relative sizes and distances of the more familiar objects in outer space might be developed.

This booklet was designed as a manual to aid the teacher whose background in astronomy might be limited. The content of the booklet should not be regarded as a course of study but rather as a list of suggestions for activities which the pupils could perform. The teacher should feel free to select some of these activities, to let the pupils devise or select their own activities or to proceed entirely upon independent lines while pursuing this topic.

METHODOLOGY AND EQUIPMENT

Astronomy may be one of the more difficult topics to adapt to the open-ended inquiry approach because there is very little that a pupil can actually reach out and touch. The sizes and distances involved are often staggering to the imagination. However, there are many activities which children can do and many things which the pupils can discover for themselves.

The pupils may plan and decide what activity they are going to carry out and then devise the equipment which they will require right in the school during the time allotted for science. The actual observations, however, may have to be made at home, on the pupil's own time. The data collected could be brought back to the classroom where conclusions could be reached and the information discovered, presented to the class for discussion and evaluation.

It is not necessary that pupils stay up late at night, nor that they spend long hours at any one particular time while making their observations. The sky is sufficiently dark during the late fall and winter months to record much celestial phenomena immediately following the supper hour. Of course, many activities requiring observations can be performed in the daytime.

Powerful telescopes are not essential. Much can be seen with the naked eye. A good pair of binoculars or an inexpensive telescope will be required for some activities. These activities would probably be best carried out at home so that the responsibility placed upon the teacher of having expensive optical instruments brought to school can be reduced.

As the observations made may have to be extended over an interval of perhaps a month, it is conceivable that a group of students might be involved in a number of activities simultaneously.

Many of the activities outlined in this unit will necessitate the building of models and other simple apparatus. To aid the pupils in this type of activity a good supply of research material - books, filmstrips, movies, newspaper articles as well as a few basic tools and household materials such as wire, string, etc. will be required.

Wherever possible the pupils should plan their activities so that they can bring the materials needed from home and improvise their own equipment right in the classroom. Because a wider range of skills will be required than could probably be taught in formal lessons, it might be wise for the teacher to develop a series of work cards or work sheets. These could be used to provide the interested student with the direction he requires should he select an activity where directions are required.

NOTE: Never look directly at the sun with the naked eye. This can result in permanent damage to the retina. Have the pupils use several thicknesses of exposed (black) photographic film when observing the sun.

Some of the activities suggested may contain elements of "busy work" but it was felt that even this type of activity would be more beneficial to the pupil than the customary lecture or text book type of approach so often used when teaching this topic.

Also some of the activities outlined, although they are not entirely scientifically accurate, have been included because they constitute the best methods to develop a concept known to the author. Great care should be exercised when selecting an activity to avoid complicated explanations to which some of these activities might lead.

II THE SUN

1. Does the sun rise and set at the same time and in the same place each day?

Obtain the precise time of sunrise and sunset from the newspaper or the radio every two or three days. Keep a record on a chart. Calculate and then compare the length of day with the length of night.

Use a land mark on the horizon or the astrolabe to record the position of the sunrise or sunset once a week for a month before and a month after Christmas. Be sure to stand in exactly the same spot when making an observation. Record the time and location on a diagram of the skyline. Label N. and S. directions.

Pupil Discoveries

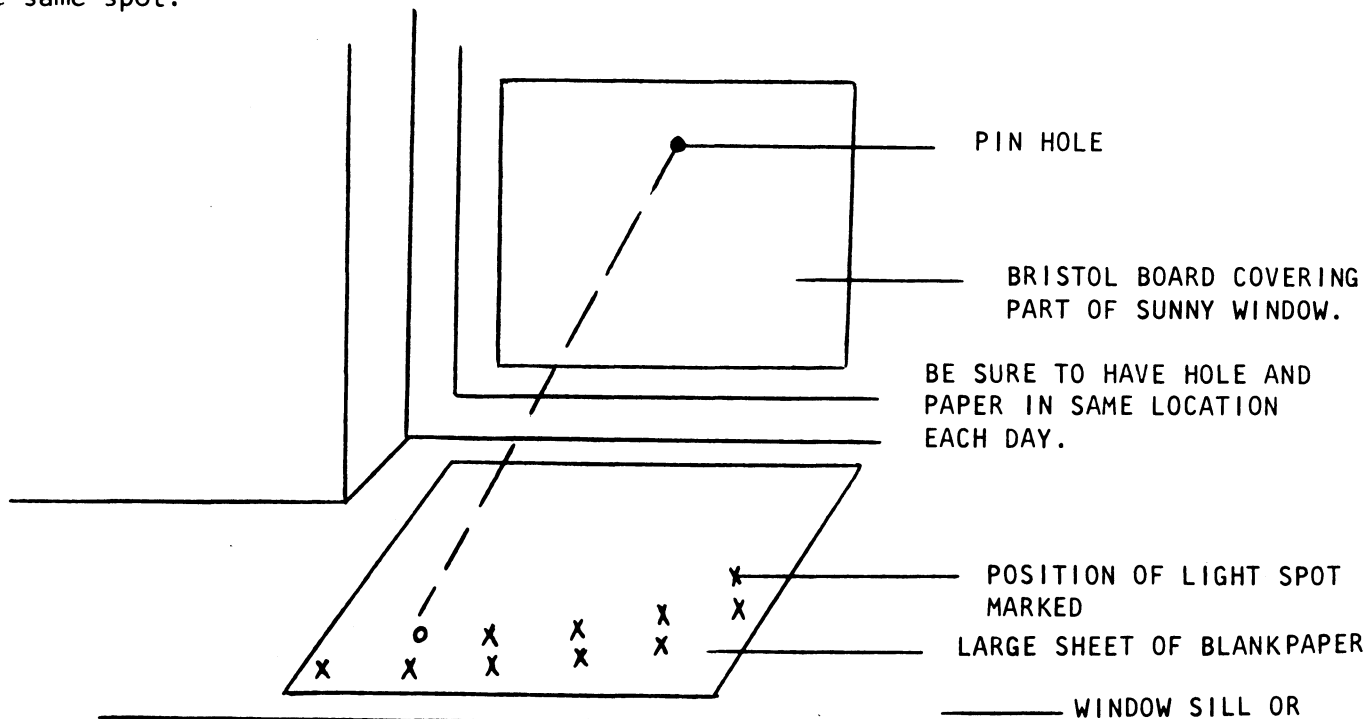
- the position of the sun moves toward the South until December 21st and then moves back toward the South again.
- daylight hours decrease until December 21 and then begin to increase after December 21.

Extended Activities

Pupils could figure out when will be the shortest day, longest day, equal daylight and darkness.

2. How does the position of the sun in the sky appear to change from day to day?

You need a window through which the sun shines for most of the day, a piece of bristol board and a large piece of paper. Cover a portion of the window with one piece of bristol board and place a piece of paper on the sill or on a table adjacent to the window. Make a pin hole through the cardboard covering the window and move the paper so that the spot made by the ray of light pouring through the pin hole will fall on the paper during most of the day. Mark the location of the spot of light at regular intervals each day for a month or longer. If it is necessary to move the paper or the table be sure to mark the exact position so that the table and paper can always be relocated in exactly the same spot.

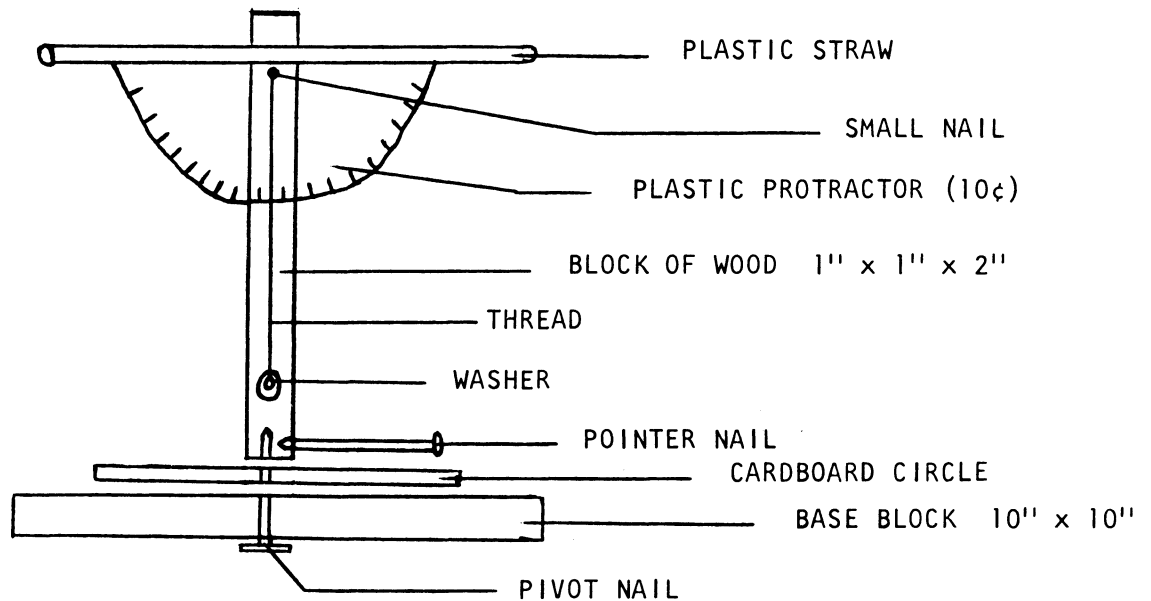


Pupil Discoveries

- the position of the marks change on the paper as the sun's position in the sky changes.
- the angle at which the sun's rays strike the earth changes from day to day. This is a cause of our seasonal temperature changes. From September to December 21 the angle decreases. From December to June the angle increases and the rays strike the earth more directly.

The Theodolite or Astrolabe

Glue a plastic drinking straw to the base line of a plastic protractor. Nail the protractor near the top of a piece of wood about one inch square and 12 inches long as shown in the diagram. This piece of wood could be cut from a hockey stick or broom handle. Attach a plumb bob made from a string and washer to this nail. Use the plastic protractor to trace out a complete circle protractor and then cut this from cardboard. Drive a nail into the side of the block of wood near the bottom so that it points in the same direction as the straw. Drive another nail through the centre of a board about ten inches square, through the centre of the cardboard circle protractor, and into the bottom of the block of wood, to act as a pivot.

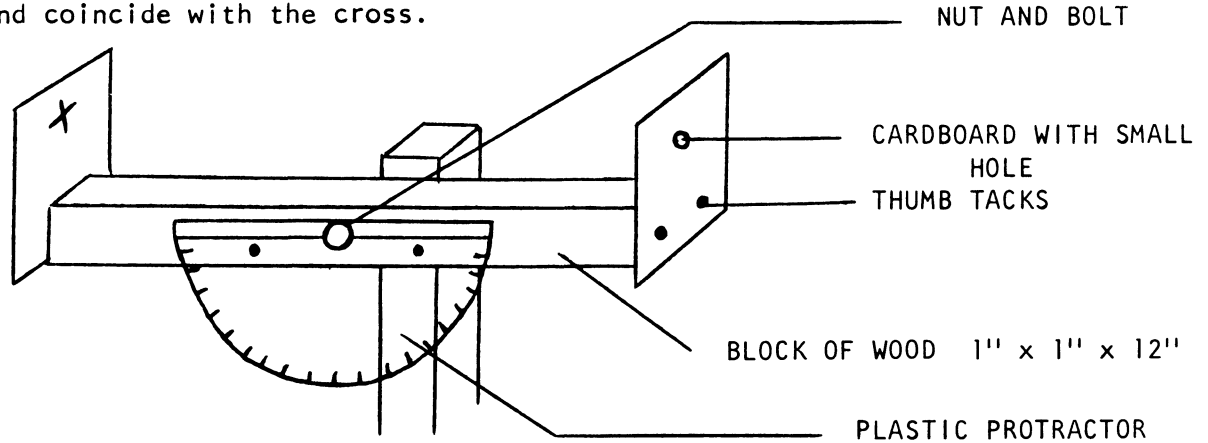


Use a compass in order to get the 360 degree mark on the circle protractor to point to true north (14° West of magnetic North). Sight through the straw so that it points to the sun. Be sure to use a piece of exposed film negative to protect the eyes. Record the angle made by the string on the protractor and the direction in which the nail points. Take readings at regular intervals during the day for several days.

Plot these findings on a graph and join the points observed, for each particular day.

Have several astrolabes constructed so that readings can be averaged and greater accuracy produced.

This alternative theodolite can be used to avoid the necessity of looking directly at the sun. Position the arm so that the sun's light will pass through the hole and coincide with the cross.



During the month of January one group compiled data concerning the angle of the sun above the horizon measured each day at a certain time (12 o'clock noon) by using three home made devices. The following table shows the results of this investigation. Note the variety of readings even though each measuring device was nearly identical.

	<u>Measuring Device #1</u>	<u>Measuring Device #2</u>	<u>Measuring Device #3</u>
January 3	20°	19 1/2°	21°
" 4	cloudy	cloudy	cloudy
" 5	20 1/2°	20°	22°
" 8	21°	21 1/2°	22 1/2°
" 9	cloudy	cloudy	cloudy
" 10	cloudy	cloudy	cloudy
" 11	cloudy	cloudy	cloudy
" 12	22 1/2°	23°	24°
" 15	24 1/2°	25 1/2°	26 1/2°
" 16	25°	25°	27°
" 17	cloudy	cloudy	cloudy
" 18	cloudy	cloudy	cloudy
" 19	cloudy	cloudy	cloudy
" 22	27°	28°	29 1/2°
" 23	27 1/2°	29°	30°
" 24	28 1/2°	29 1/2°	30 1/2°
" 25	cloudy	cloudy	cloudy
" 26	cloudy	cloudy	cloudy
" 29	30 1/2°	31°	32 1/2°
" 30	cloudy	cloudy	cloudy
" 31	32°	33°	34°

The group could organize the above information in graphic form so that they will have a clear record of what was learned from this investigation.

3. How can the sun be used to tell time?

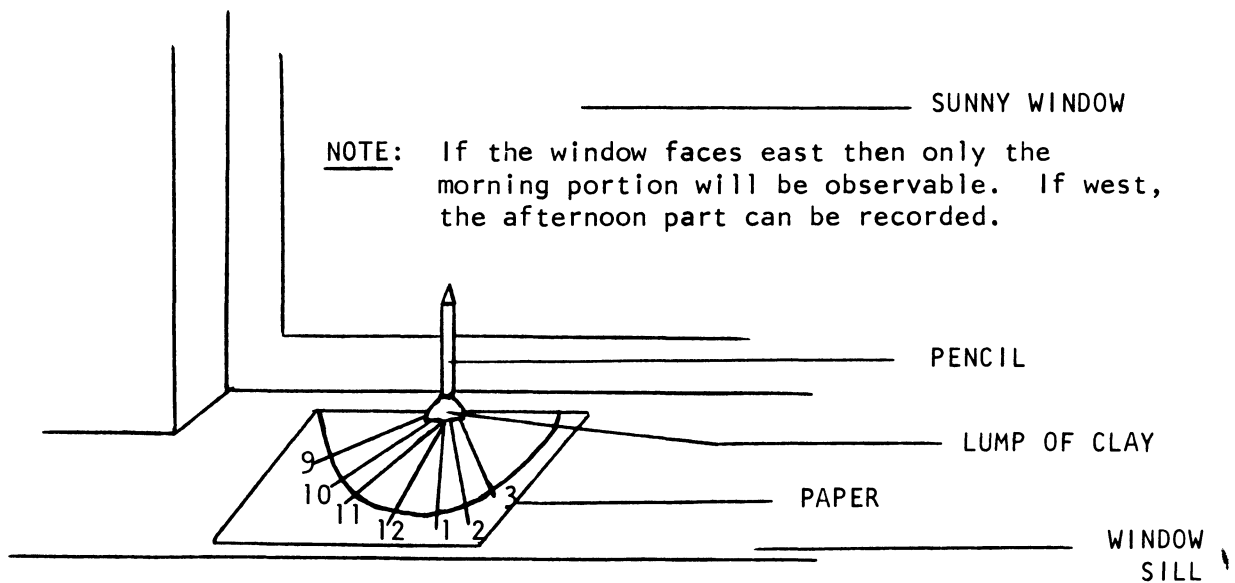
You need a window sill and a window through which the sun shines most of the day, a short pencil, a lump of plasticene, a piece of blank white paper and a watch.

Place the pencil in the clay so that it will stand upright in the centre of the edge of the paper nearest the window. Using the position of the pencil as the centre, draw a semicircle on the paper. If the sun is shining the pencil will cast a shadow on the paper. Mark the position of the shadow every hour by drawing a line along the shadow and extending it until it reaches the semicircle. At the point where the lines intersect the semicircle, record the hour when that shadow occurred.

Check the position of the shadow at similar times for several other sunny days.

Pupil Discoveries

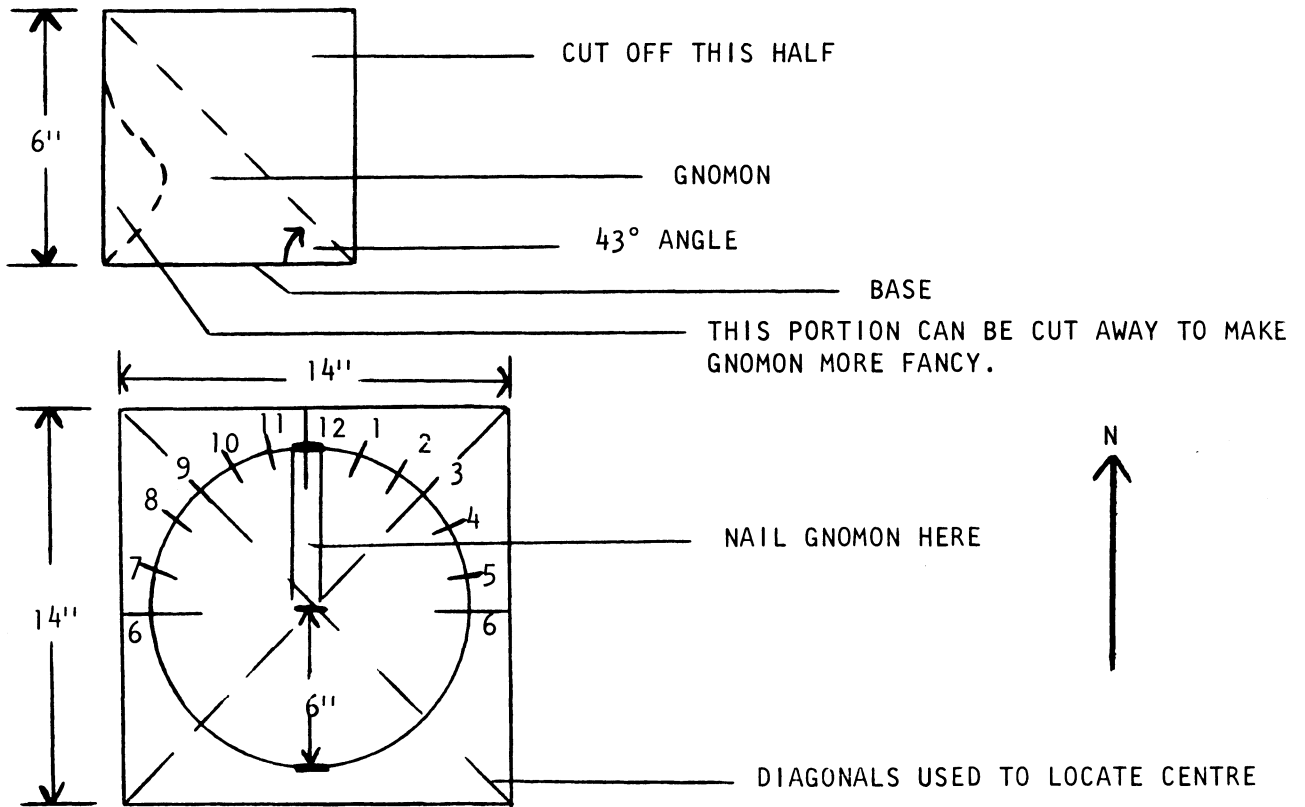
- the position of the shadows at a particular time will correspond from day to day so that the sun can be used to tell time.
- the length of the pencil's shadow could be measured in order to show the daily changes in the sun's position.



The Sundial

To make a sundial to be used out of doors, you will need 2 boards, one six inches square and the other fourteen inches square. To make the gnomon (pron. nomon) (the part which casts the shadow, Greek for one who knows) cut the six inch square from corner to corner. This will give an angle of 45° . For a more accurate sundial this angle should equal the degree of latitude on which Hamilton is situated. This angle is approximately 43° . To make the dial, find the centre of the fourteen inch square block by using the intersection of diagonals drawn from corner to corner. Using this point as centre draw a circle with a six inch radius. Divide the top half of the circle into 12 equal parts and number them as shown in the diagram. Nail the gnomon to the dial so that it is located between the centre of the circle and the 12 o'clock mark. When the

sundial is permanently installed outside, the gnomon must point to true North. This can be done in two ways. Point the gnomon towards Polaris the North Star at night or use a compass in the daytime. If a compass is used the gnomon should not point to Magnetic north but rather 14° to the west of North. This is the angle between magnetic north (where the compass needle points) and true north.



Pupil Discoveries

- the time shown by the gnomon's shadow is solar rather than standard time. (In standard time a wide region such as the Province of Ontario has the same time in order to avoid confusion when travelling from place to place.)
- the time shown by the sundial is not daylight saving time so one hour may have to be added.

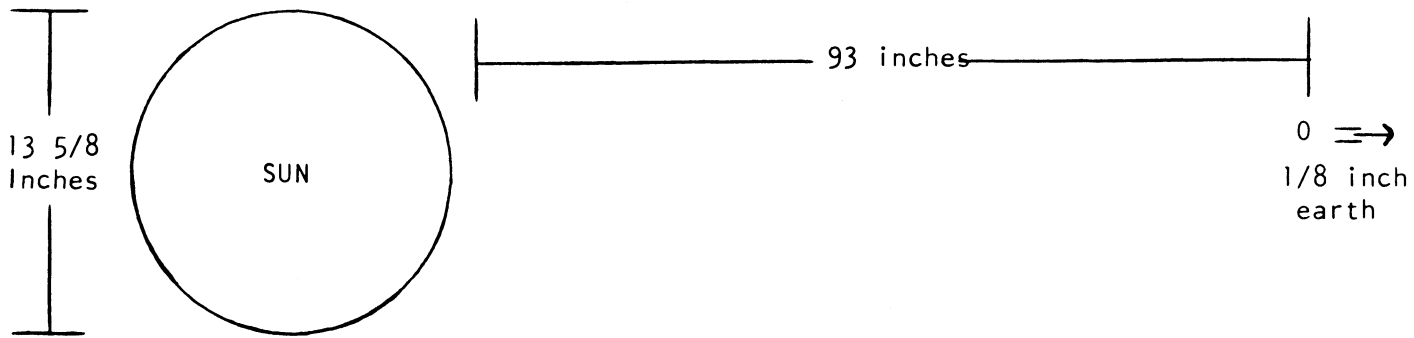
Extended Activities

Sundials can be made in a variety of ways. Do research to construct other types.

4. How big is the sun as compared to the earth?

You need a large piece of bristol board, a compass, a pencil, and a ruler.

Use the compass to draw a circle with a diameter of $13 \frac{5}{8}$ inches to represent the sun. Draw a circle $\frac{1}{8}$ inch in diameter to represent the earth. Place the two circles 93 inches apart. You now have a model of the sun and earth drawn to the scale $1'' = 93,000,000$ miles.

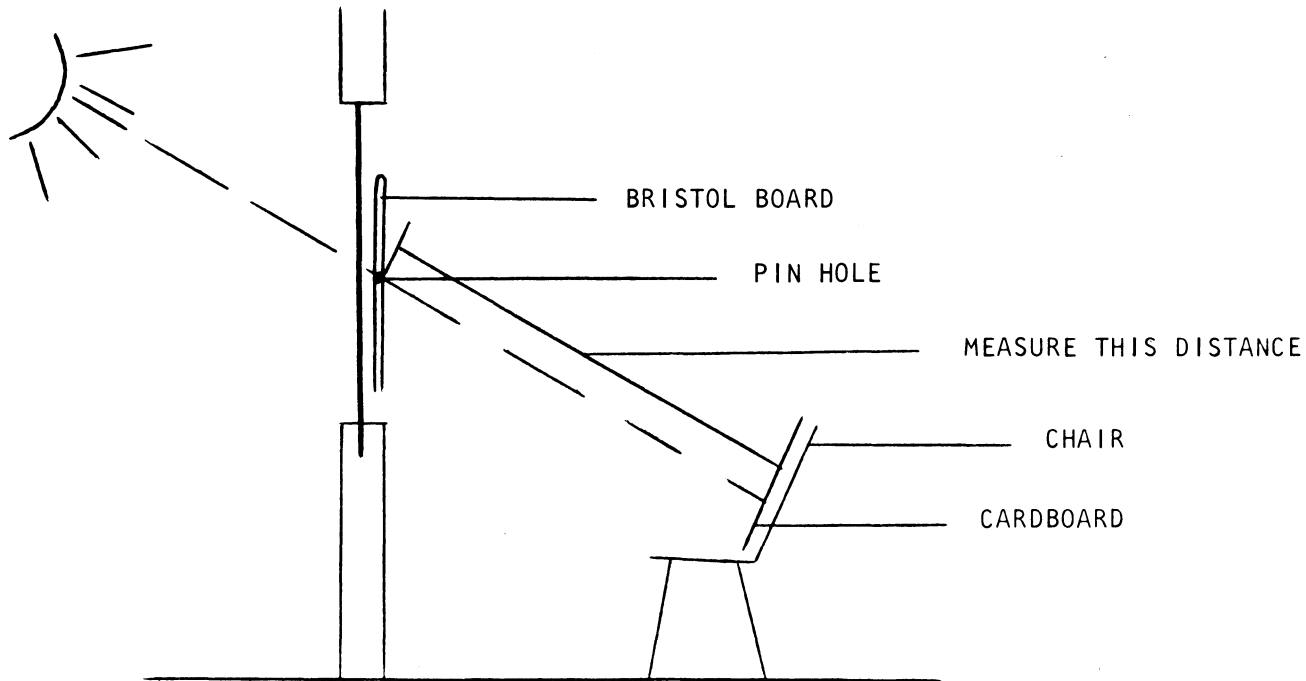


Pupil Discoveries

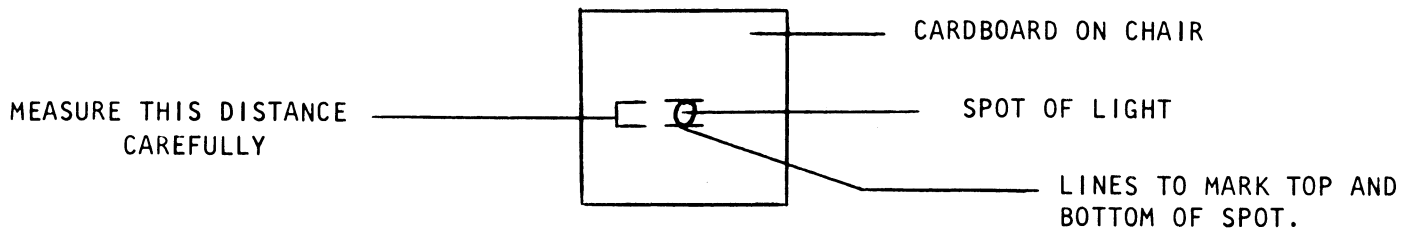
- the larger circle's diameter is 109 times the smaller circle's diameter.
- if the sun were a hollow ball it could hold more than one million earths.

5. How can the diameter of the sun be found?

Cover a window which faces the sun with a piece of bristol board. Use a pin to make a small hole in the bristol board. Place a chair so that the ray of light which passes through the pin hole will make a spot of light on it. Attach a piece of cardboard to the chair so that it is at right angles to the beam of light.



Mark the top and bottom of the spot with a line and carefully measure the distance between the two lines and the distance from the pin hole to the cardboard on the chair.



You also need the distance to the sun (93,000,000 miles). The diameter of the sun can now be calculated because the following proportions are equal.

$$\frac{\text{The diameter of the spot}}{\text{The distance of the spot to the pin hole}} = \frac{\text{The diameter of the sun}}{\text{The distance of the sun}}$$

Have the pupils substitute their measurements in the following formula:

$$\text{Diameter of the sun} = (\text{Distance to sun} \times \text{Diameter of spot}) \div \text{Distance from spot to pin hole.}$$

If the diameter of the spot was $1 \frac{1}{4}$ or 1.25 inches and the distance from the spot to the pin hole was found to be 132 inches then the substitution and computation would be as follows:

$$\begin{aligned} \text{Diameter of sun} &= (93,000,000 \times 1.25) \div 132 \\ &= 880,681 \text{ miles} \end{aligned}$$

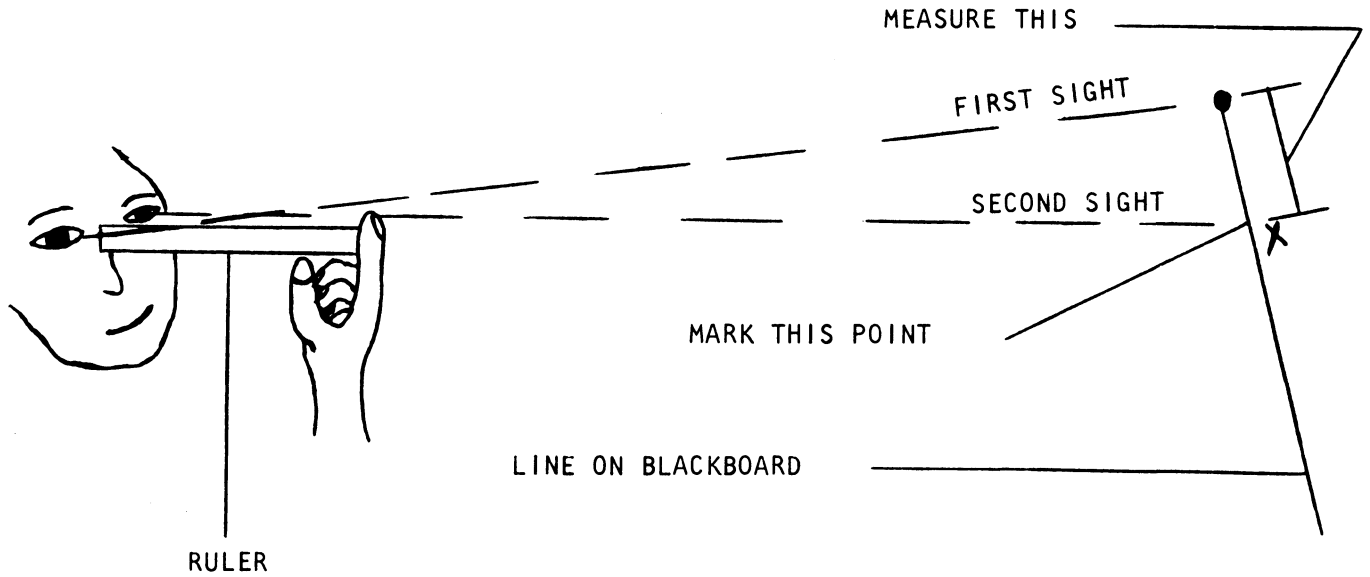
This is a good result as the diameter determined by precise methods is 864,000 miles. The teacher should avoid going into this method too deeply as the geometry of congruent triangles from which this formula is derived may be beyond the scope of most Grade 6 pupils. However, this activity and the others similar to it may serve to show the pupil the correlation of mathematics with astronomy.

NOTE: Pupils should never look directly at the sun with their eyes or with field glasses or with a telescope.

6. How is the distance to the sun or to another star measured?

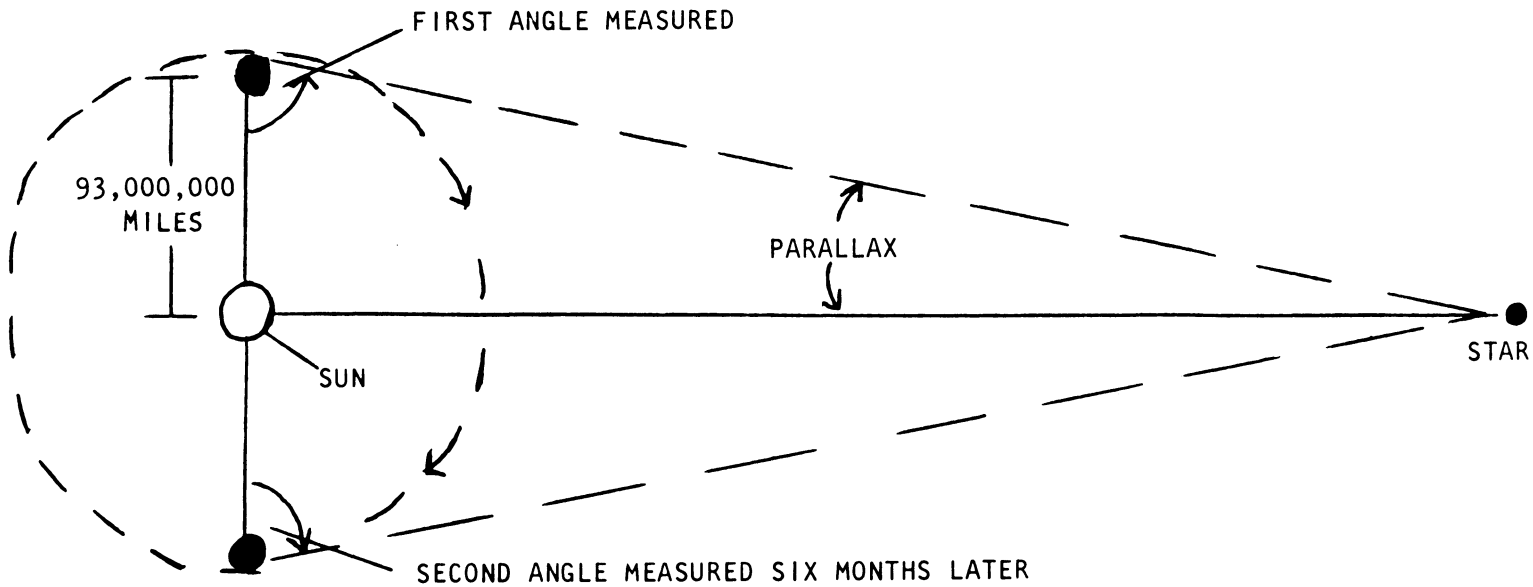
Cover one eye with your hand and look at the vertical lines of a nearby window frame. Line up that part of the frame with some object outside. Now cover your other eye. The lines of the frame will have appeared to have shifted in relation to the background. What has really shifted is the angle of observation. This change of angle is called parallax.

Parallax can be used to find a distance in the classroom. Draw a horizontal line about 5 feet long on the blackboard. Stand about 20 feet away but perpendicular to the blackboard. Hold a ruler between the eyes and the index finger. Close the right eye and sight across the index finger to the line on the blackboard. Without moving your head, close the left eye and sight across the index finger to the line. Ask someone else to mark this point on the chalk line. Measure the distance from the end of the line to the mark. Measure the distance between the eyeballs (usually about $2 \frac{1}{2}$ "). Divide the length of the line measured by the distance between the eyes. The answer should be about 20 feet which is the distance between the observer and the blackboard. Since eye dominance varies from person to person some pupils may be required to use their left eye instead of their right in order to obtain satisfactory results.



To measure the distance to the sun or moon astronomers at two or more widely separated observatories agree to measure the angle of their line of sight to the centre of the sun or moon at the same precise time. They compute the distance that would be a straight line between the observatories. Using these distances as a base line and the angles they have measured, they make a triangle from which they compute the desired distance by using geometry.

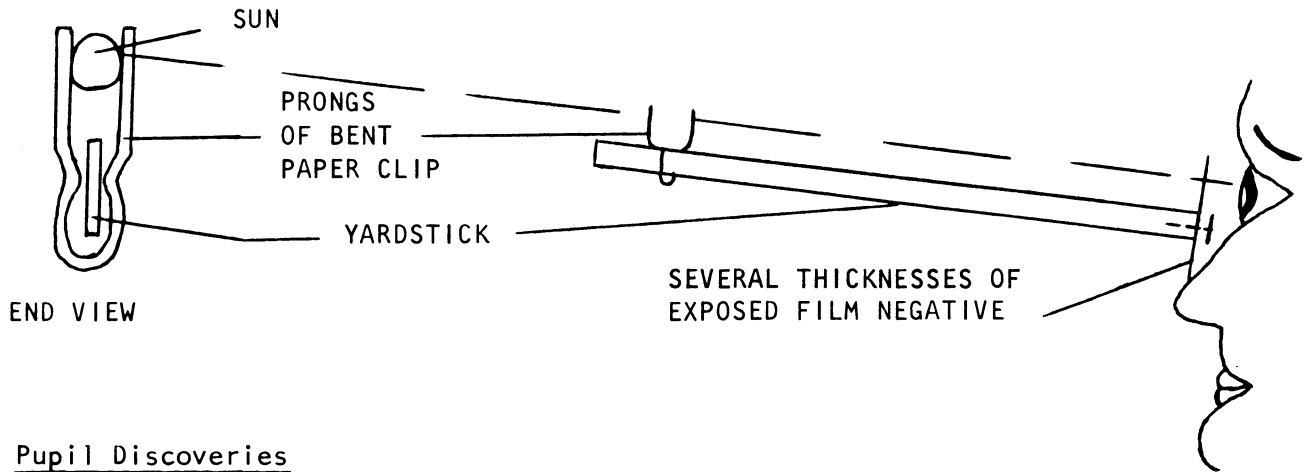
When measuring the distance to stars a similar method is used but observations are taken from one observatory now and then six months later when the earth is on the opposite side of the sun. This gives a base line of 196,000,000 miles.



7. Is the sun really larger when it is rising or setting?

You need a paper clip, a yardstick and a piece of exposed film negative.

Bend the paper clip so that it fits the yardstick snugly. Attach the exposed negative to the other end of the yardstick with a thumbtack. The purpose of the dark film is to protect the eyes when sighting at the sun. Adjust the prongs of the paper clip to just match the sun's diameter at 12 o'clock. Look at the sun just before 4 o'clock or later through the prongs of the paper clip.



Pupil Discoveries

The distance between the prongs of the paper clip is the same at noon and at 4 o'clock. This shows that the diameter of the sun has not changed, in reality, even though it looks bigger when just the eye is used. This is called an optical illusion.

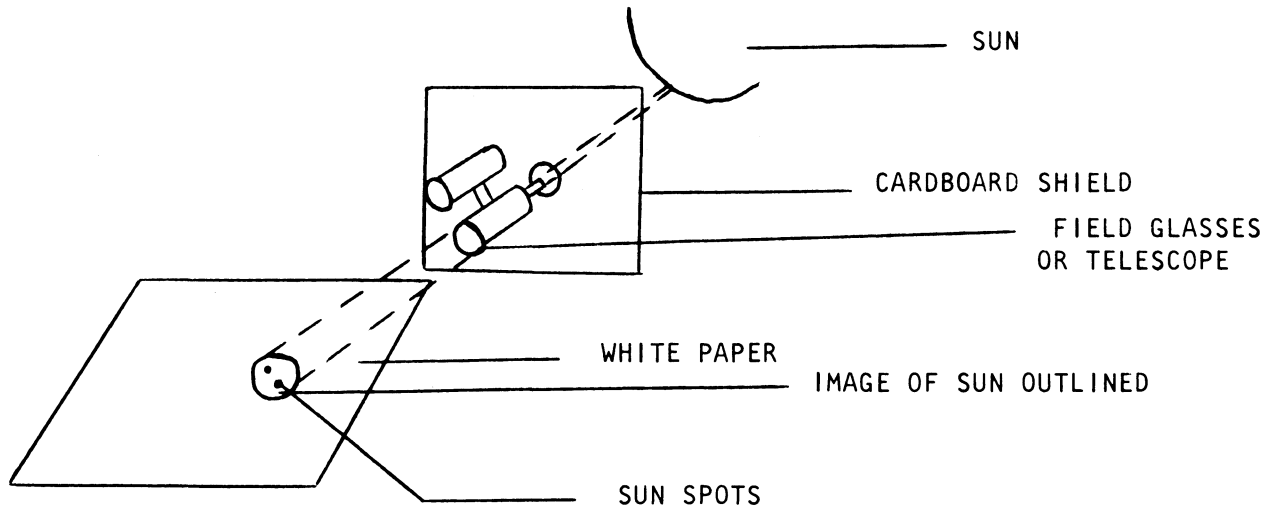
Extended Activities

Do research to find why the sun appears larger when it is near the horizon.

Repeat the same activity for the moon when it is full and rise or sets early in the evening.

8. How can sun spots be studied?

You need a pair of field glasses, a piece of bristol board, a sheet of white paper and a watch. You could use a telescope instead of the binoculars. Hold the field glasses so that the eyepiece is closest to the sun and the sun's rays will pass through one side of the field glasses and be projected onto the sheet of white paper. Adjust the position of the field glasses so that the clearest possible image is obtained. Cut a hole in a sheet of bristol board to fit one eye piece and act as a shield. Draw a circle on the paper the same size as the image and mark the dark areas. Note the time. Repeat the procedure each day at the same time using the same piece of paper and the same sized image of the sun.



Record the date and time of each observation. Compare the position of the spots by plotting them on a graph.

Pupil Discoveries

- dark spots can be seen in the sun's image on the paper. These are sun spots.
- the position of the spots changes from day to day. They can be used to show the sun's rotations.
- spots near the sun's equator rotate faster than those near the poles.
- sun spots come in cycles.

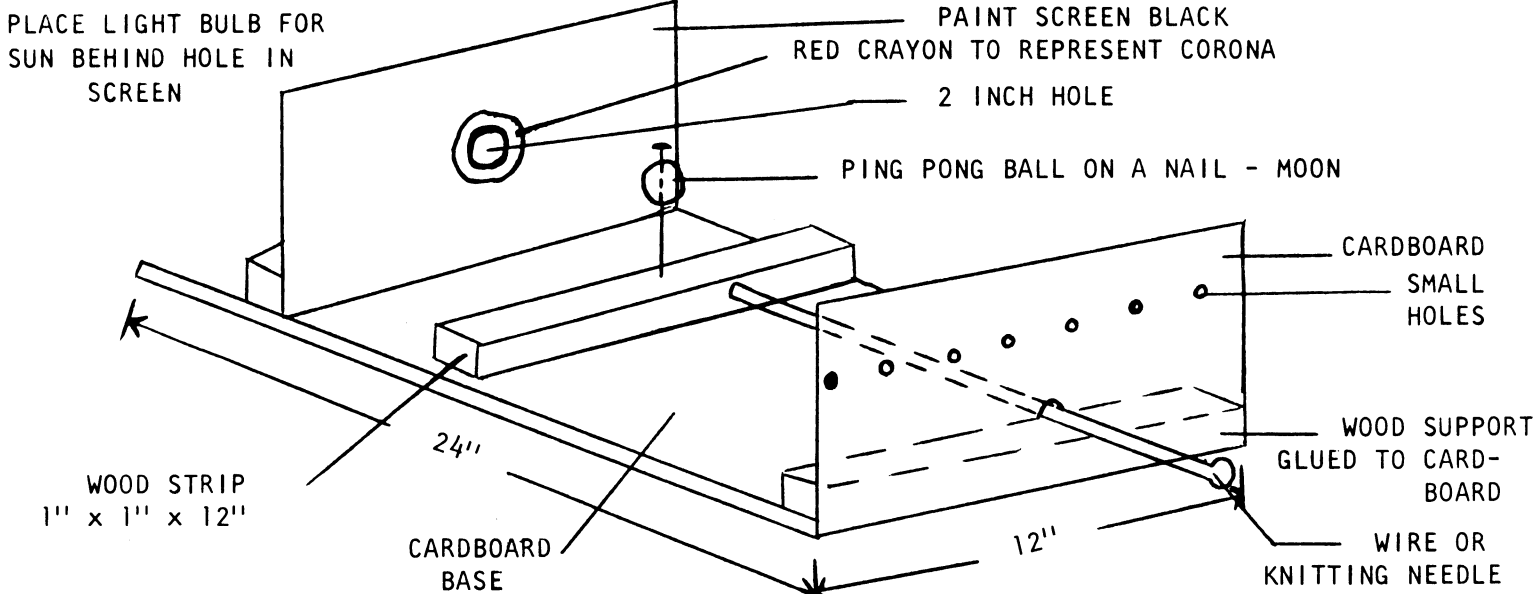
Extended Activities

1. Check daily newspapers for the occurrence of sun spot activities.
2. Find the diameter of the sun by doing activity number five. Then calculate the size of the spots observed by using a scale or a ratio.
3. Do research to (a) find the temperature of sun spots as compared to the sun's other parts
(b) find how sun spots affect the earth's weather, communications, etc.

9. How can an eclipse of the sun be duplicated?

- a) You need an electric light bulb which can be illuminated, a ping pong ball, some strips of wood, some heavy cardboard, a nail and a long knitting needle, or the straight wire section of a coat hanger.

Construct the apparatus as shown.



Use the knitting needle to adjust the distance of the moon from the sun. View the sun through successive peep holes in order to see the eclipse patterns.

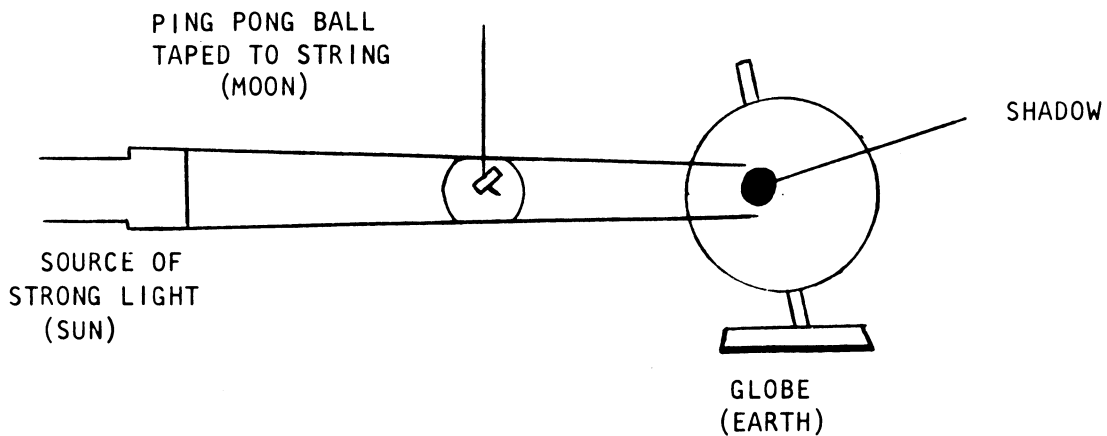
- b) Hold a small coil (the moon) a few inches from one eye and close the other eye while looking at an electric light bulb (the sun) placed at the other side of the room. By adjusting the position of the coil slightly an eclipse of the sun can be seen. Have another student note the shadow cast by the coin on the face of the first observer.

Use these two activities to make a series of diagrams which would show the patterns seen during an eclipse of the sun over a period of time.

10. How is an eclipse of the sun caused?

You need a source of strong light such as a slide projector or flashlight, a globe and a ping pong ball. Attach a length of string to the ping pong ball with scotch tape so that it can be suspended from the hand.

Set up the apparatus as in the diagram below. Darken the room and adjust the distances between the ping pong ball, globe and projector so that a sharp shadow falls on the earth. By making further adjustments the three types of solar eclipses can be shown.

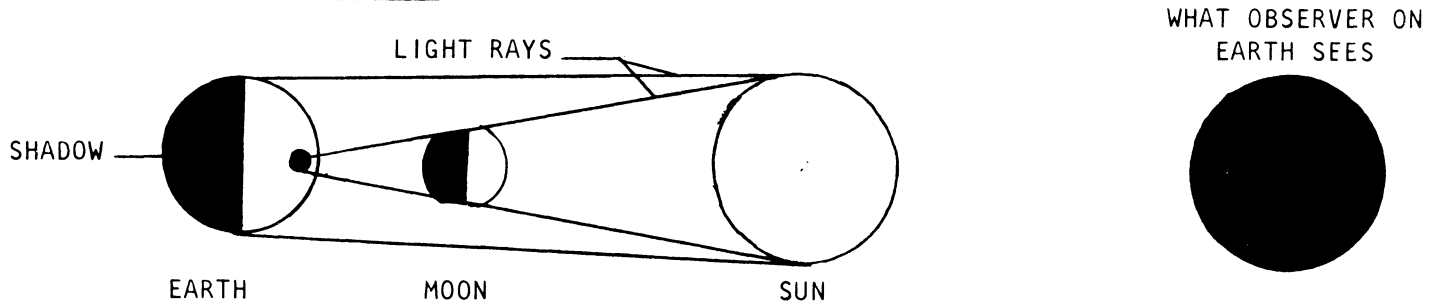


These activities can be performed by using balls of plasticene of various sizes impaled on the ends of sharpened pencils and held in the light of a flashlight in a partially darkened room.

Pupil Discoveries

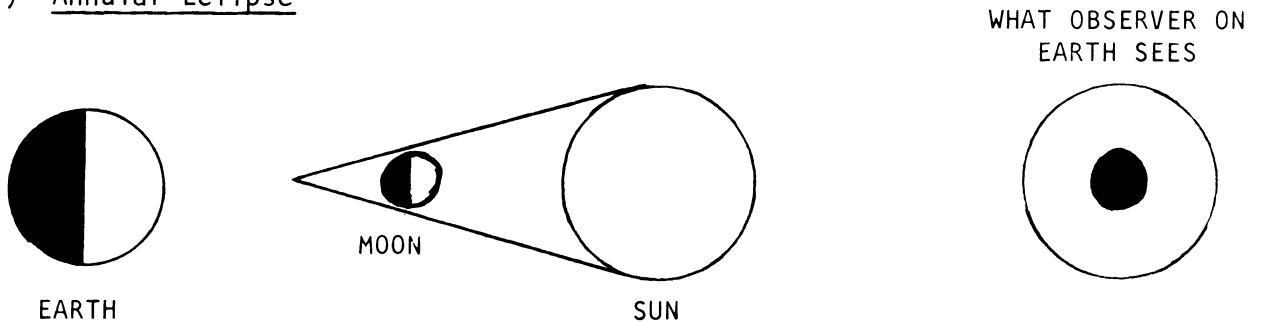
A solar eclipse occurs when the sun, moon and earth are in a straight line and the moon is between the sun and the earth. There are three types of solar eclipses: total, annular and partial.

(i) Total Eclipse



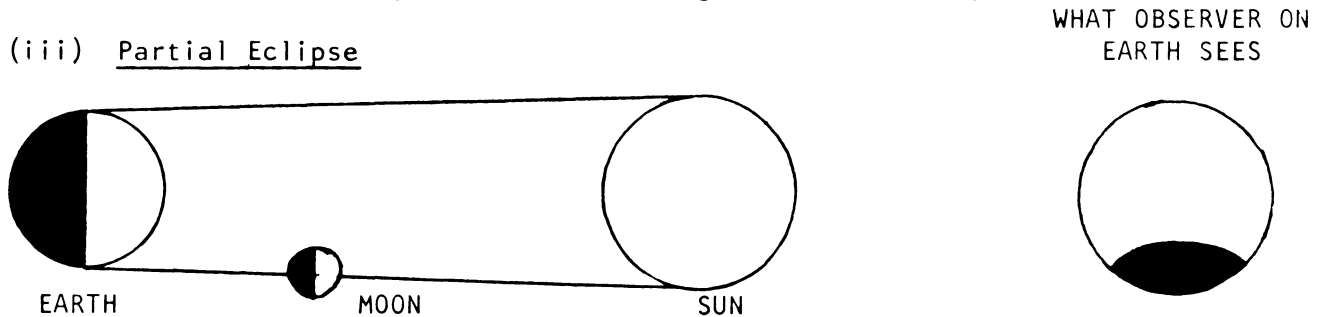
When the moon is closest to the earth in its orbit, even though it is much smaller than the sun, it can black out its image. (See activity No. 9 (b)). If the complete image of the sun appears to be blacked out this is a total eclipse.

(ii) Annular Eclipse



When the moon is farther from the earth in its orbit it is too small to block out all of the sun's image. The moon appears as a black dot with a ring of light around it during an annular eclipse.

(iii) Partial Eclipse



When the moon only partly blocks the image of the sun we have a partial eclipse.

III THE MOON

II. Teacher Background

The moon is a natural satellite of the earth and travels around it in a nearly circular path at an average distance of about 239,000 miles. This is roughly 100 times the distance across the Atlantic Ocean. However, the moon lies in the ocean of space that stretches outward from the earth. Compared with distances in space to other planets or the sun, the moon is just an offshore island of the earth. However, this island, like all the other objects in space including the earth, is constantly moving. It glides through space around the earth at about 1/2 mile per second and takes about 4 weeks to make one complete trip. Its path is not a perfect circle, so it is sometimes farther, sometimes nearer, than its average distance from the earth. The farthest distance is about 253,000 miles. The nearest is about 221,000 miles.

The moon rotates very slowly in comparison with the earth's daily rotation. It makes just one rotation during the approximately 4 weeks it takes to travel once around the earth. For this reason the same side of the moon is always turned toward the earth. From this side of the moon an observer would see the earth always in about the same place in the sky, never rising or setting. An observer on the other side of the moon would never see the earth at all, just as no one on earth can see that side of the moon. Actually, various irregularities in the moon's motions and in our own point of view from the earth permits us to see at different times a total of 59 per cent of the moon's surface. In 1959 a rocket was sent around the other side of the moon, and it transmitted to earth our first view of the rest of the moon's surface.

Our moon is fifth largest in size among the 31 known satellites of the planets in our solar system. Its diameter of 2160 miles is about one fourth the earth's diameter. No other moon is nearly so large in comparison with its parent planet. The other large moons all belong to the giant planets Jupiter, Saturn and Neptune.

The moon's mass, only 1/81 that of the earth, is too small to retain an atmosphere. Without atmosphere to transmit sound waves the moon is a world of total silence. There is no wind, no rain. The long periods of daylight and darkness without a tempering atmosphere breed excessive temperatures. At "moon" of the two-week period of daylight the temperature is near the boiling point of water. At "midnight" two weeks later the temperature is below -200°F.

The surface of the moon is probably dark brownish rock and lava. Wide, relatively dark plains on the moon are known as maria, or seas, but they contain no water. At the edge of some of these maria high mountain peaks rise to heights of 26,000 ft. The most striking feature of the surface is its thousands of craters. The largest of these is 150 miles across and the walls of its rim are 12,000 ft. high. From some craters bright streaks, called rays, spread out across mountain and plain alike for hundreds of miles. Less obvious are the long straight clefts in the moon's surface, called rills. Some rills are 60 miles long and several miles wide.

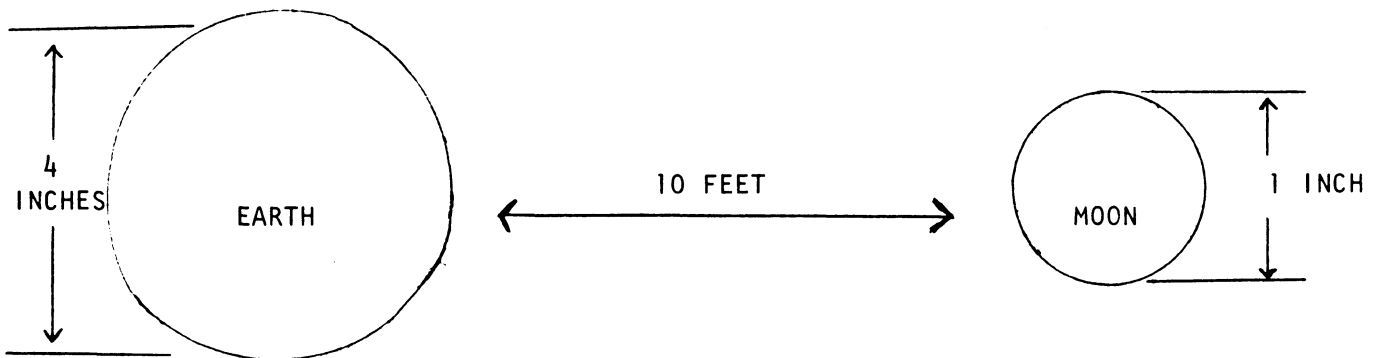
The changing patterns of sunlight and shadow on the moon, as viewed from the earth, are called its phases. When the moon is directly between the earth and the sun, we can see only its shadow side. This we call the new moon or the dark of the moon. Then, as the moon slowly circles around the earth, it reveals a crescent-shaped edge of its sunlit face. After about a week we can see a full half of this sunlight face, which we call the half moon.

The moon is now one fourth of the way around the earth, so this first week of its journey is called the first quarter. During the following week, or second quarter, the moon moves on around the earth till it is exactly opposite the sun. Now the entire sunlit face is turned toward the earth, and the moon is full. During the next week, or third quarter, the sunlit face is turned more and more out of view till we again see the moon half in shadow, half sunlit. In the last quarter the sunlit crescent shrinks until the moon is again between the earth and sun, we see only its shadow side, and the moon is new. Now the cycle begins again. The moon is called a crescent moon during the first and last quarters when it is less than half full. It is called a gibbous moon during the second and third quarters when it is more than half full. We say it is waxing during the first two quarters when it grows from new to full. It is waning during the last two quarters when it shrinks from full to new.

The earth has a dark shadow that stretches some 859,000 miles outward into space in the shape of a tapering cone. When the moon is on the shadow side of the earth, it usually passes above or below the shadow because the moon's orbit is tilted in relation to the plane of the earth's shadow. However, occasionally the moon does enter the shadow and we call this event an eclipse of the moon. At the moon's distance the shadow has tapered to about 5700 miles across, which is still over twice the diameter of the moon. If the moon passes through the widest part of the shadow, it will be in eclipse for 3 hours and 40 minutes. For 1 hour and 40 minutes the moon will be entirely within the shadow or in total eclipse. Even during total eclipse the moon does not become totally dark, for sunlight bends around the earth through the atmosphere and casts a faint, reddish glow on the eclipsed face of the moon.

12. How big is the moon as compared to the earth?

Cut two disks from cardboard, one four inches in diameter and one one inch in diameter. Place the two disks on the blackboard, bulletin board or wall so that they are ten feet apart. The scale used is one inch = 2000 miles. This could be used to calculate the actual diameter of the earth and moon and the distance between them.



Pupil Discoveries

- The earth's diameter is 8000 miles approx.
- the moon's diameter is 2000 miles approx.
- the distance from the earth to the moon is 239,000 miles approx.
- the moon is one quarter of the earth's size but appears smaller because of the great distance between them

13. How can the moon's diameter be measured?

You will need a window through which the moon can be seen easily, a full moon, two strips of adhesive tape, a table, a pile of books, a string and a ruler.

This activity can be done at any time in which the full moon can be seen through the window but the best time is an hour or two after the moon rises. Of course, these observations could probably be made during the day. If the moon is visible at 10 P.M. it may also be visible at 10 A.M. Place two 6" lengths of tape on the window so that they are exactly one and 1/4 inch apart. Look at the moon through the slit between the tapes.

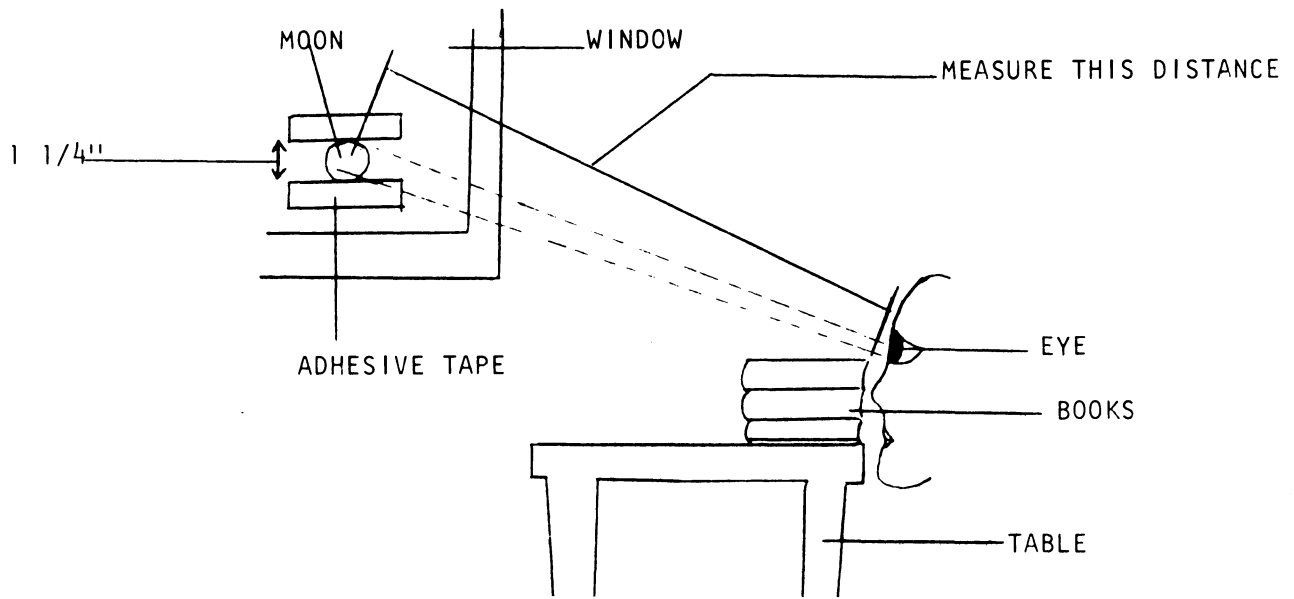
Move back from the window until the edges of the moon just touch the edges of the tape. Use the table and pile of books to mark the exact spot where your eye was. Carefully measure the distance from the tapes to your eye using the string and ruler. Use arithmetic and the idea of proportion to calculate the moon's diameter. You need to know the average distance to the moon which is approx. 239,000 miles.

$$\frac{\text{Distance of tapes from eye}}{\text{Distance between tapes}} = \frac{\text{Distance to moon}}{\text{Diameter of moon}}$$

If the distance measured from the eye to the tape was 137.5 inches then the arithmetic would look like this:

$$1.25 \times 239,000 = 298,750$$
$$298750 \div 137.5 = 2,170 \text{ miles}$$

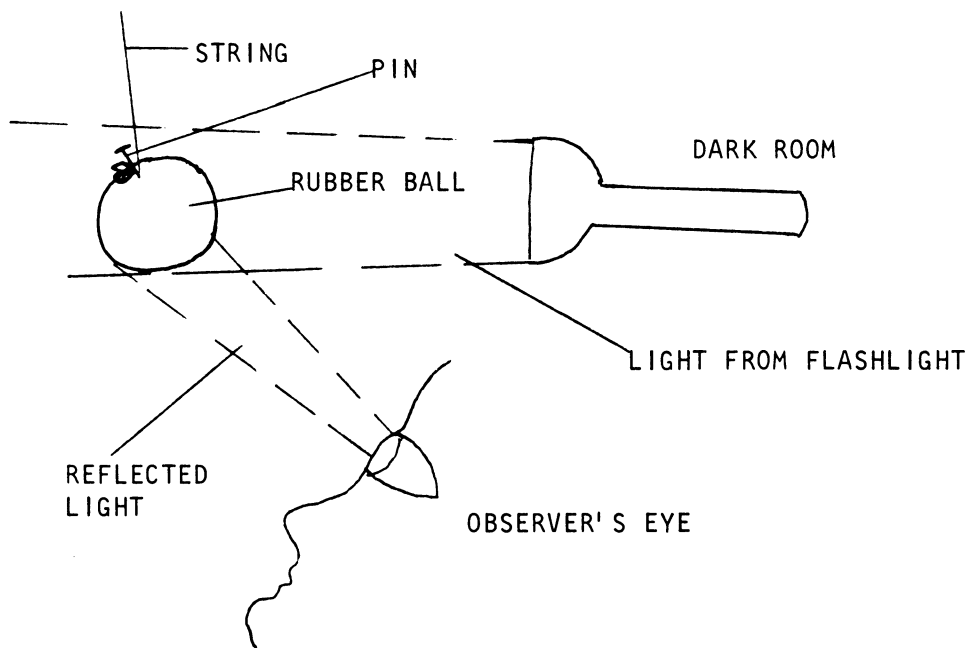
This is only slightly larger than the moon's diameter when measured by astronomers.



Repeat Activity 7 using the yardstick and paper clip to test the moon's apparent change in size as it rises above the horizon.

14. From where does the light from the moon and planets come?

You will need a closet which is almost totally dark, a solid rubber ball and a flashlight. (A thick blanket could be used and the pupils could do some undercover work!) Stick a pin into the ball and attach a thread to the ball so that it can be held suspended from the hand. Wait in the darkened room until the eyes become accustomed to the dark -- The outline of the ball will be seen dimly. Now shine a flashlight on the ball.



Pupil Discoveries

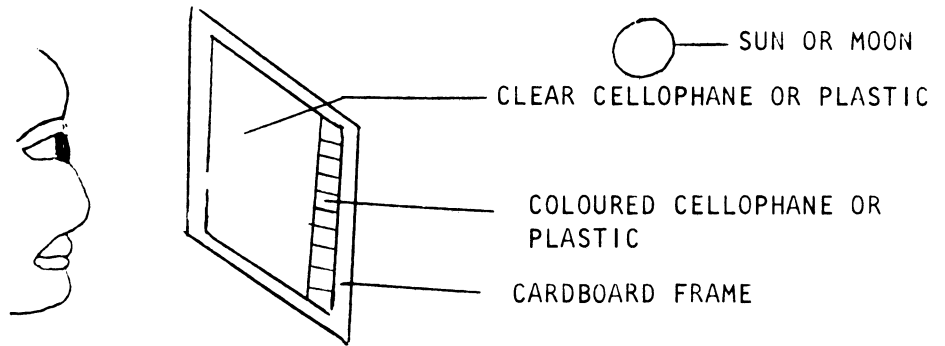
- The ball can be seen clearly only when light shines on it.
- Some of the light is reflected to the eye
- Like the ball planets and moons do not give off light of their own
- The flashlight represents our sun or another star.

15. Are moonlight and sunlight the same?

You will need pieces of cellophane which represent the colours of the rainbow red, orange, yellow, green, blue, violet and purple and colour charts which show the gradual change in colour from white to each of the above colours. These can be obtained from paint stores.

Look through each of these colours of cellophane at sunlight coming through a window. DO NOT LOOK AT THE SUN. Find the colour which most nearly matches the colour of the cellophane when the light passes through it.

On a clear night with a bright moon look at it through the coloured cellophane pieces. Try to match the colour for each piece of cellophane with one from the colour chart.



Compare the shade of colour selected for each colour of cellophane used for the sun and the moon.

Pupil Discoveries

- for each cellophane colour tested the shade of colour from the colour chart will be darker due to the lesser intensity of the moon's light.
- The degree of change from light colour to darker colour will be much greater in the case of the red cellophane. When the light from the sun is reflected by the moon it is changed slightly
- The greatest change occurs in the red section of white light (see booklet on Light and the section on refraction). A highly technical explanation of this change should be avoided.

16. How can a moon calendar be made?

This is a long term study which should be carried on for a month or more.

Select a month when the moon will be visible from the school window or playground in the daytime or when the moon will be visible in the early evening. Rule off a large piece of bristol board so that it will correspond to the calendar for that month and number the appropriate squares to represent the dates. Observe the moon at an identical time each day or night. Sketch the appearance of the moon according to its phase, in the appropriate square of the calendar. Use a complete circle and shade in the darked portion.

Use the astrolabe shown in Activity 1 to measure the angle of elevation of the moon above the horizon as well as its position according to the compass.

Record this information along with the diagram in each square. At the end of the month examine the calendar and draw some conclusions.

This activity could be repeated once each season and the results obtained could then be composed.

If the activity is continued until the moon's phase is identical with the first observation, the length of a solar month could be calculated by counting the days between these two recordings.

RECORDINGS

CALENDAR

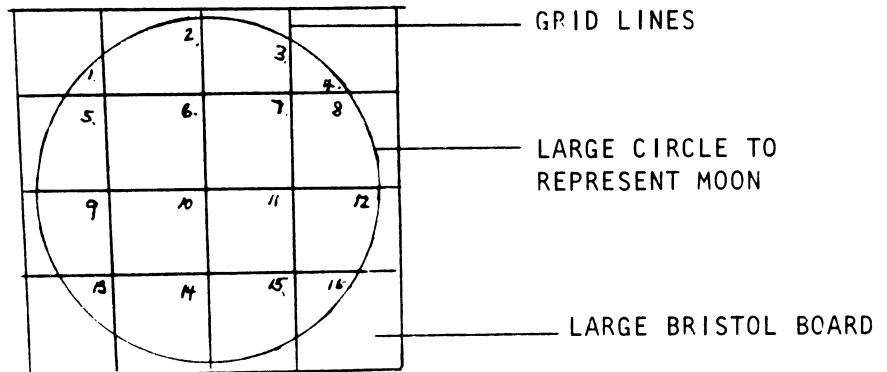
DATE	MONTH _____		TIME _____				
	S	M	T	W	T	F S	
MOON DIAGRAMS			1	2	3	4	5 ETC.
ELEVATION	6	7	8	9	10	11	12
DIRECTION	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
	27	28	29	30	31		

17. How can a map of the moon's surface be made?

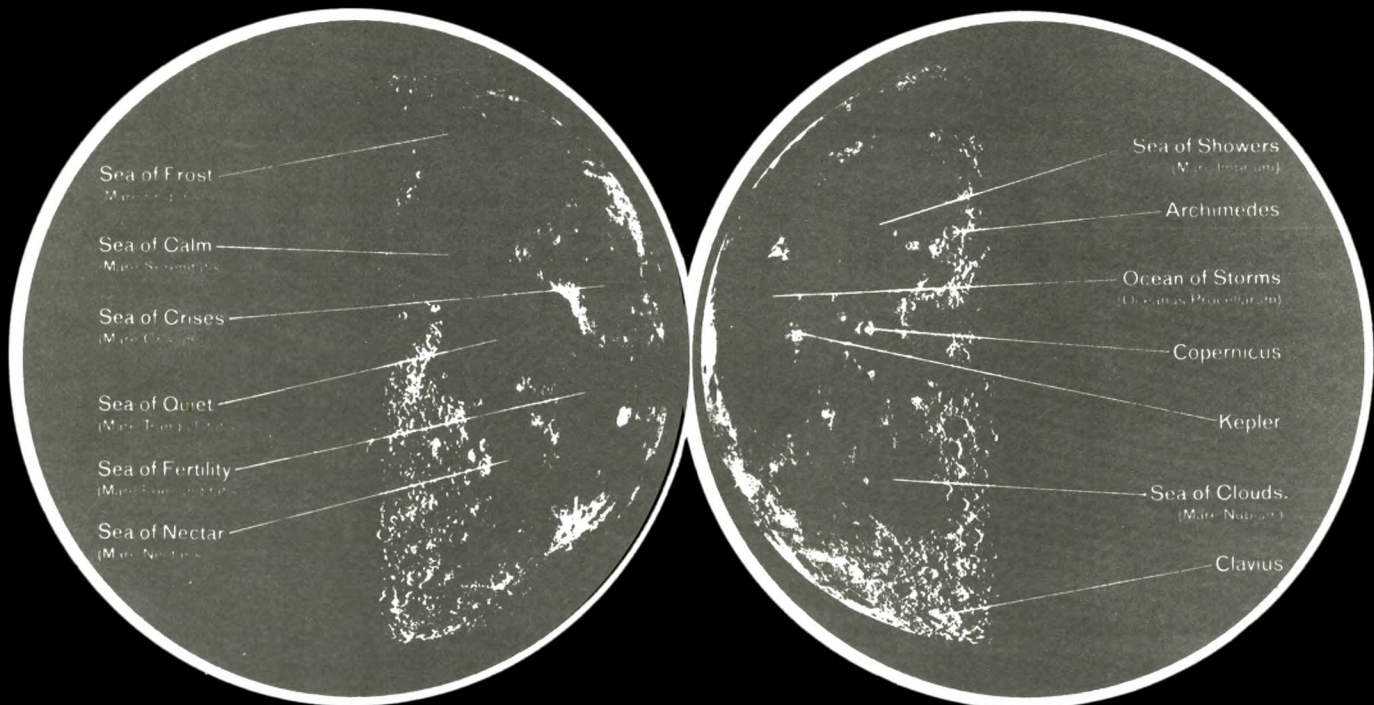
This activity can be done best when the moon is full and perhaps visible in the daytime.

Use a yardstick to make a grid of 6" squares on a large piece of bristol board. Use a string, thumb tack and pencil to draw the largest circle possible on the bristol board.

Number the squares or parts of squares which occur inside the circle. Assign various squares to each member of the group. Use binoculars or a small telescope to observe and sketch on the bristol board the makings of the moon which would be found in a particular square, one at a time. Use an encyclopedia or reference book on astronomy to label the main features as mountain ranges, craters, plains (seas) etc. The actual names of some of these could be labelled but this is relatively unimportant.



MAPPING THE MOON



Hundreds of craters, some with rays, are visible in these photographs of the Moon at first quarter (left) and at third

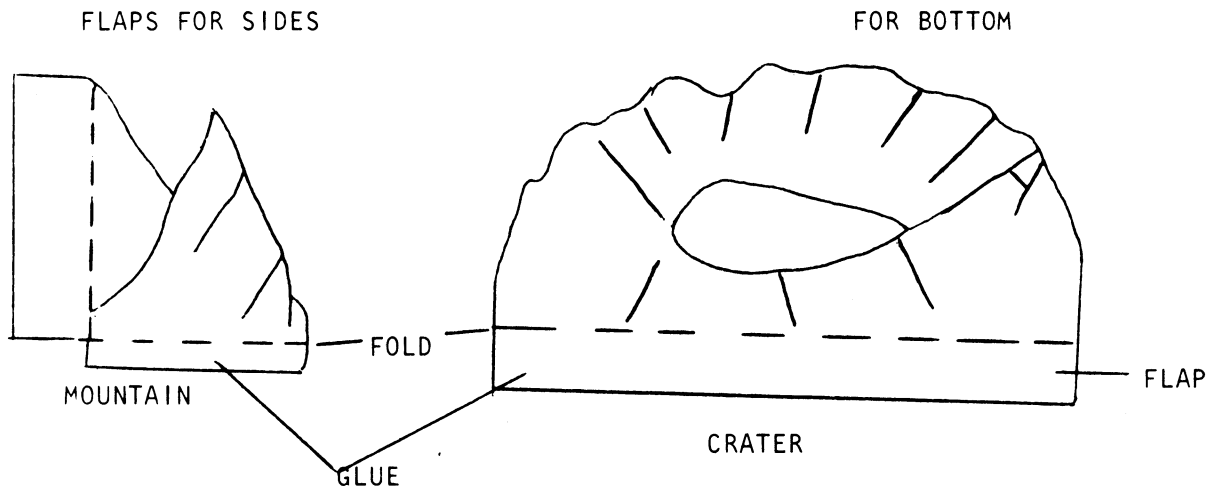
quarter. The great, dark "seas" are not water, but may be plains of lava, which do not reflect much sunlight.

18. How can the surface of the moon or of a planet be duplicated?

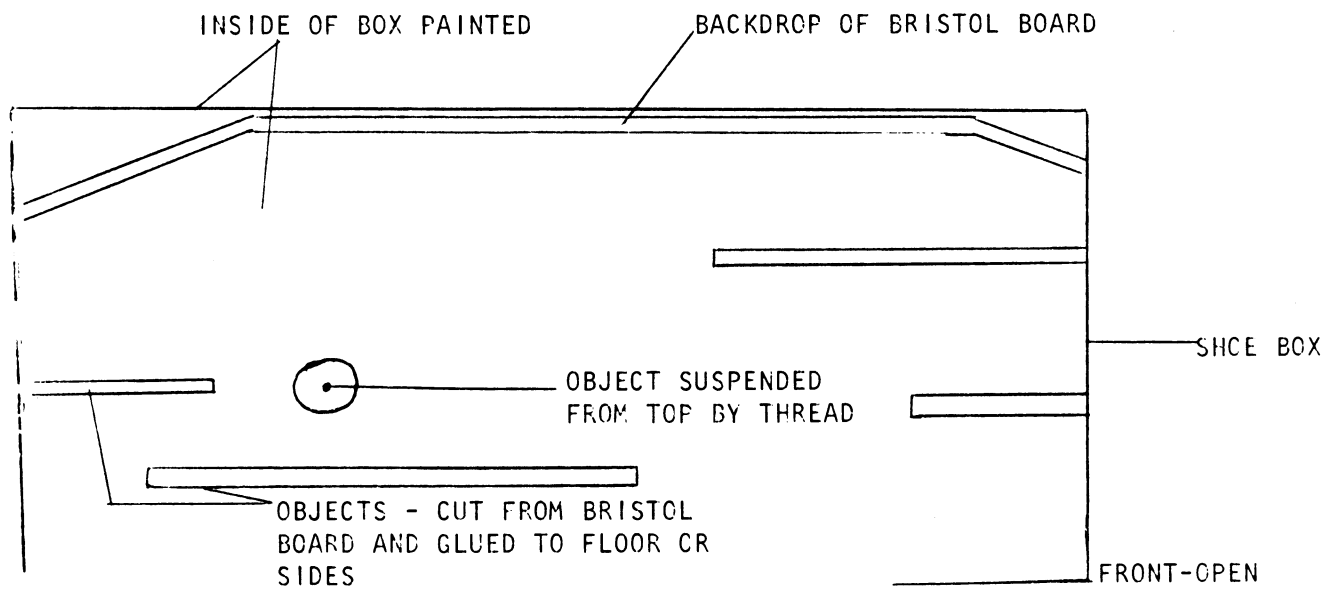
You need a shoebox, some bristol board, glue, black thread, tempera paints, cellophane and some scotch tape.

Do research from several books to obtain details of the object's surface. Paint the inside of the box in the appropriate colours. Draw objects on the bristol board -- rock, craters, etc. Paint them and cut them out so that they have flaps by which they can be attached to the bottom or sides of the box to give a three dimensional effect. Parts of large objects nearer the front help to create perspective. Use the black thread to suspend objects which would appear in the sky from the roof of the box. Cover the opening of the box with cellophane either clear or coloured. The finished product is often referred to as a diorama.

EXAMPLES OF CUT-OUT OBJECTS



TOP VIEW - SHOWING POSSIBLE ARRANGEMENT OF PARTS



Alternative Method

Construct surface and objects from paper maché, salt and flour or asbestos then paint them when they are dry.

Recipes for Modelling Materials

Asbestos:

6 parts asbestos
1 part powdered paste
Enough water to make it workable. Add slowly as you stir so you will not add too much and get it sticky.

(a) Salt & Flour (for maps)

1 part salt
1 part flour

or

(b) 1 part salt
2 parts flour

Add enough water to make the mixture stick together. Keep your hands well floured when working with this.

Paper Pulp

For modelling

Tear up newspaper into small bits. Soak in water (overnight at least). Stir until a pulp. Drain off any extra water. Add some powdered paste. Stir thoroughly.

or

Soak paper strips (torn) in paste and build up your forms from this.

Paste

(For cardboard pasting)

For about 1 1/2 cups of paste

1/4 cup sugar
1/4 cup flour
1 1/4 cups cold water

Mix thoroughly, boil until thick stirring constantly over a medium heat.

To make this keep for a long time you may add:

- (a) a few drops of oil of cloves and
- (b) a tiny pinch of powdered alum before
you cook it.

Asbestos may be bought at the hardware store by the pound. (also plaster of paris)

Powdered paste may be bought from the wallpaper store.

Oil of cloves and alum come from the drug store.

Thick laundry starch (the kind you cook) makes good paste for paper mache work. (glide will do for this too).

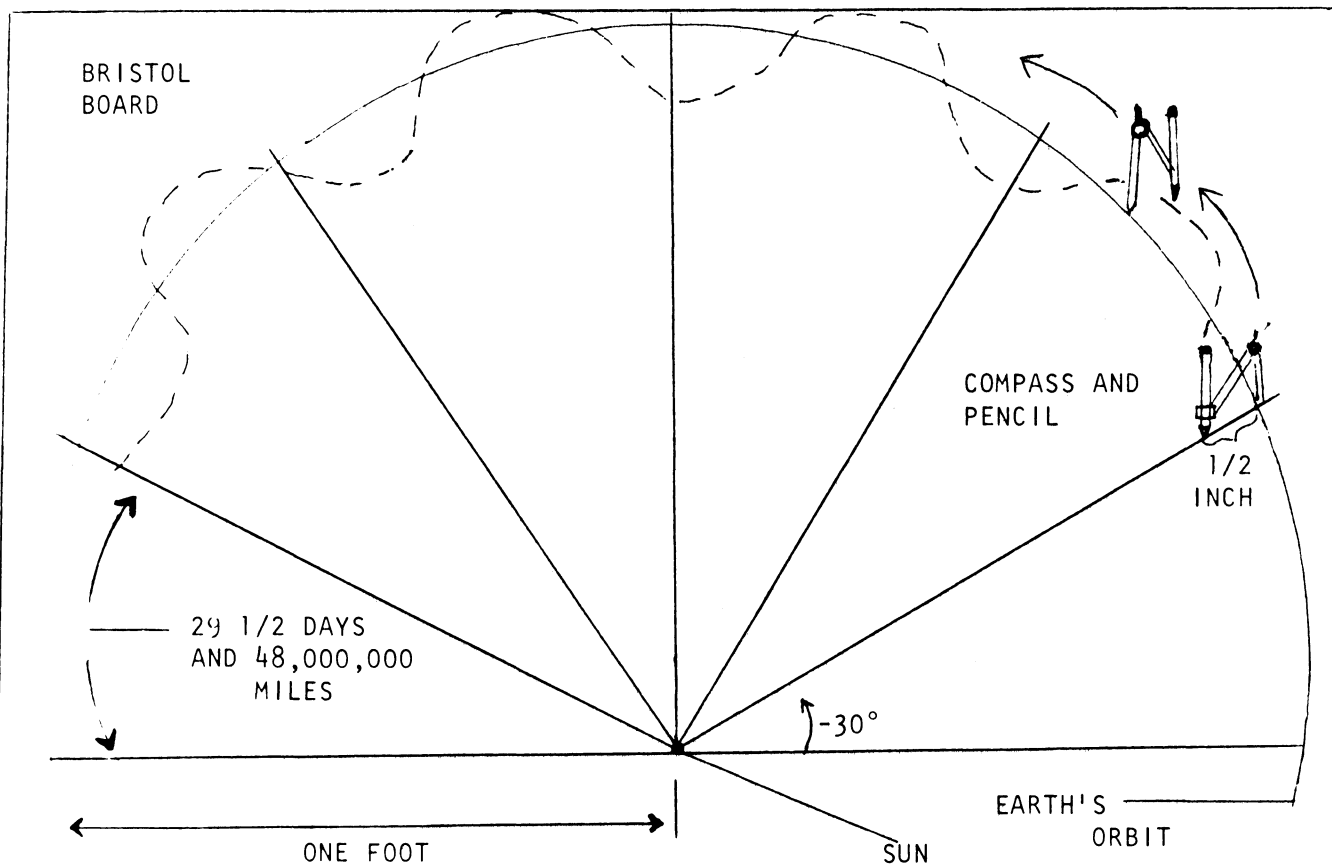
19. How can the moon's orbit around the sun be drawn?

Draw a circle with a radius of 1 ft. on a piece of bristol board. This circle represents the earth's orbit and the centre of the circle is the sun. Divide the circle into 12 equal parts using a protractor. Draw lines from the centre to the circle every 30° ($360^\circ \div 12$ months). The distance of the part of the circle between each line represents a lunar month or $29 \frac{1}{2}$ days.

Use a pencil and compass set for $\frac{1}{2}$ an inch to represent the distance from the moon to the earth. The point of the compass is the earth and the pencil represents the moon.

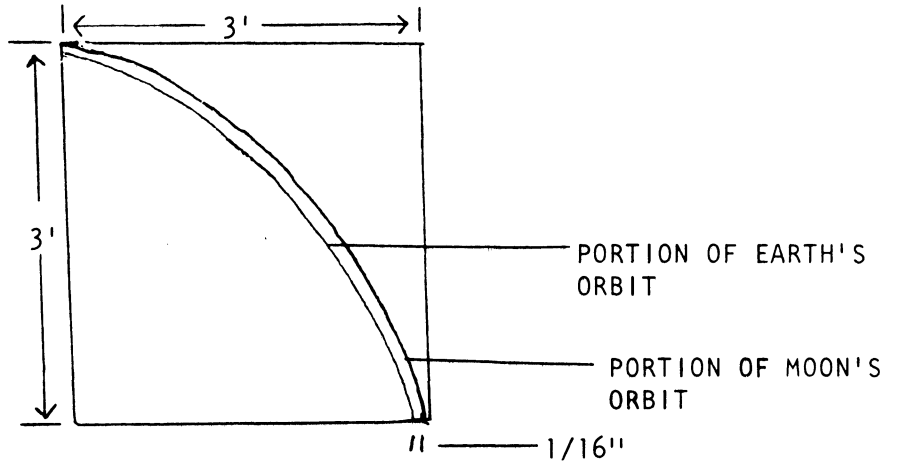
Start at any one of the lines. Place the point of the compass on the circle at the point where the line intersects it, and so that the pencil is on the part of the line which is inside the circle. Now move the point of compass along the circle slowly, rotating the compass slowly at the same time. Practice the speed at which each movement of the compass is made so that when you arrive at the next line the pencil is touching the line inside the circle and the pencil has made one complete turn.

When the right amount of skill has been achieved complete the moon's orbit for the other parts of the circle.



Pupil Discoveries

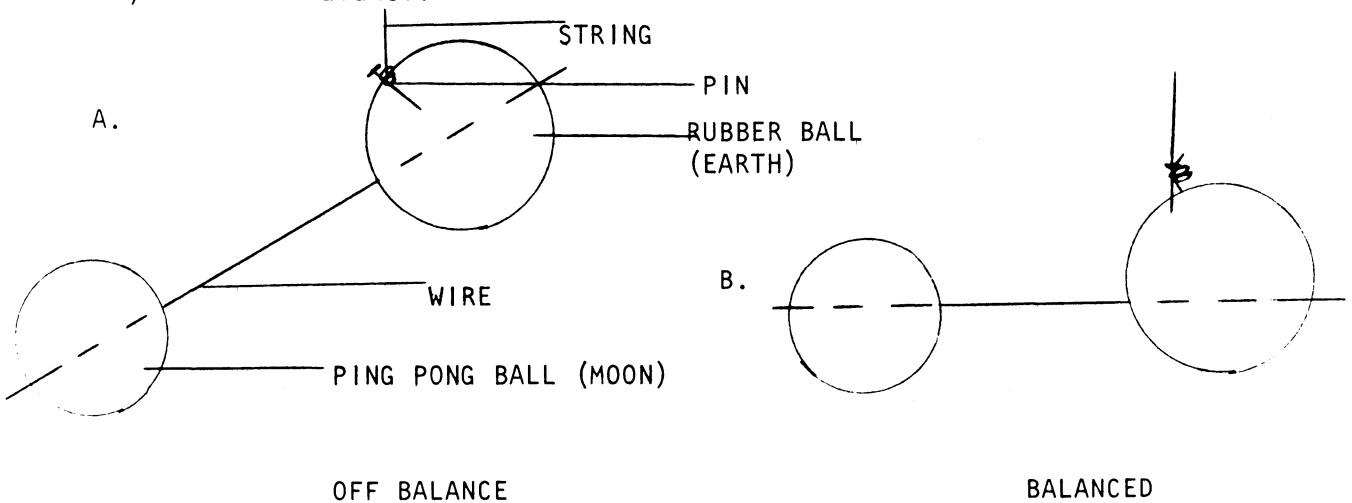
- the moon's orbit is not a series of loops nor is it a circle, but rather a wavy type of path
- when this is drawn to scale the actual difference in the size of the two orbits is only about $1/16''$



20. How does the earth balance the pull of the moon?

You need a ping pong ball, a solid rubber ball, a length of stiff wire (cut from coathanger), some pins and a string.

Insert the wire through the ping pong ball and the rubber ball as shown in the diagram. Suspend the rubber ball by the string which is tied to a pin inserted into the rubber ball. Adjust the position of the pin until the system will balance.



Pupil Discoveries

The point of balance is not the centre of the earth. A point to one side of the earth is the centre about which the earth and moon revolve around each other.

- the point at which the system will balance is called its centre of gravity.

It should be remembered that other bodies such as the sun also exert a force on the moon so that the model created here is not entirely correct.

21. How does the moon rotate on its axis?

Tape an X onto a large volley ball with white adhesive tape. Have one pupil sit in the centre of the room and represent the earth. Have a second child carry the ball (the moon) around the room keeping the X facing to the centre. Note how many times the ball rotates during one trip around the room.

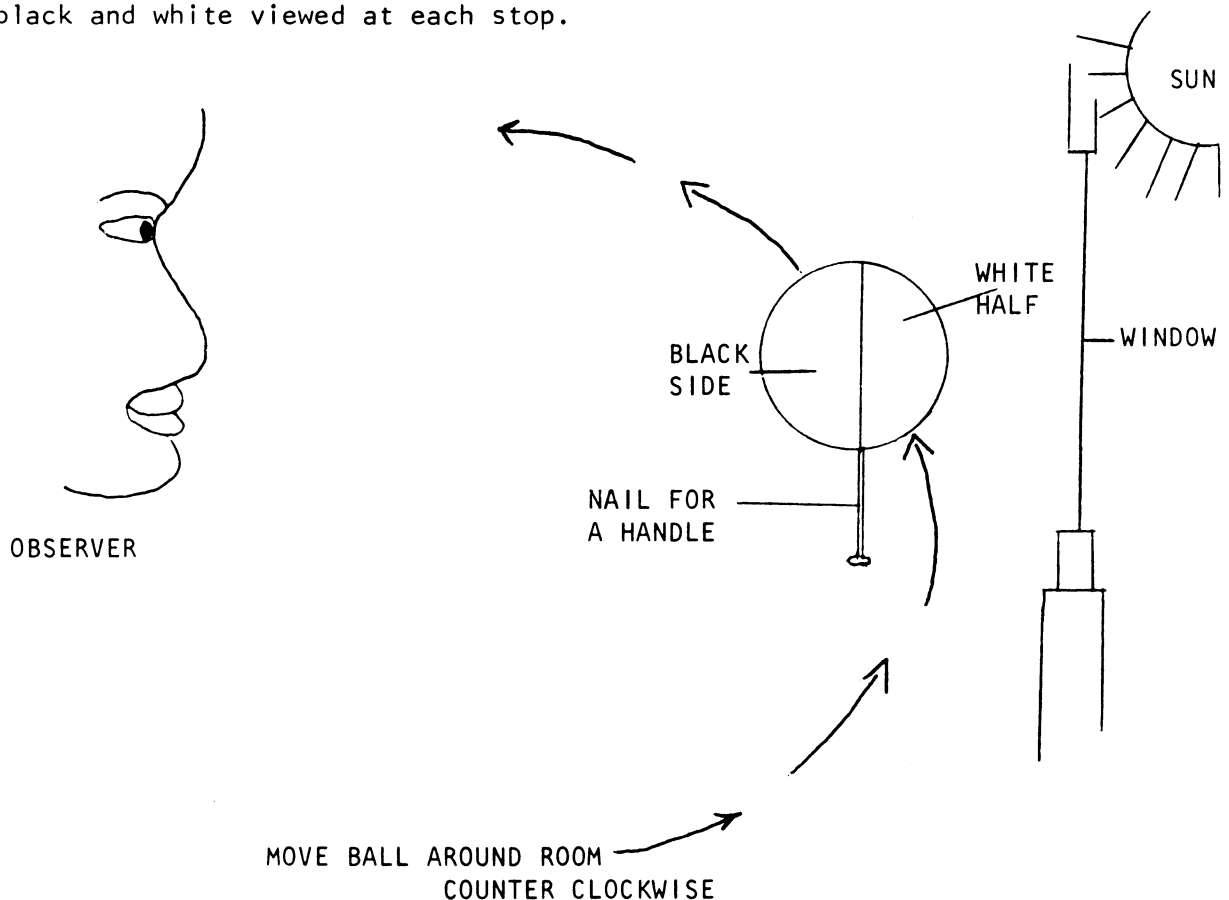
Pupil Discoveries

- the ball will rotate once in one revolution around the earth
- the same side of the moon always faces the earth

22. How can the moon's phases be duplicated?

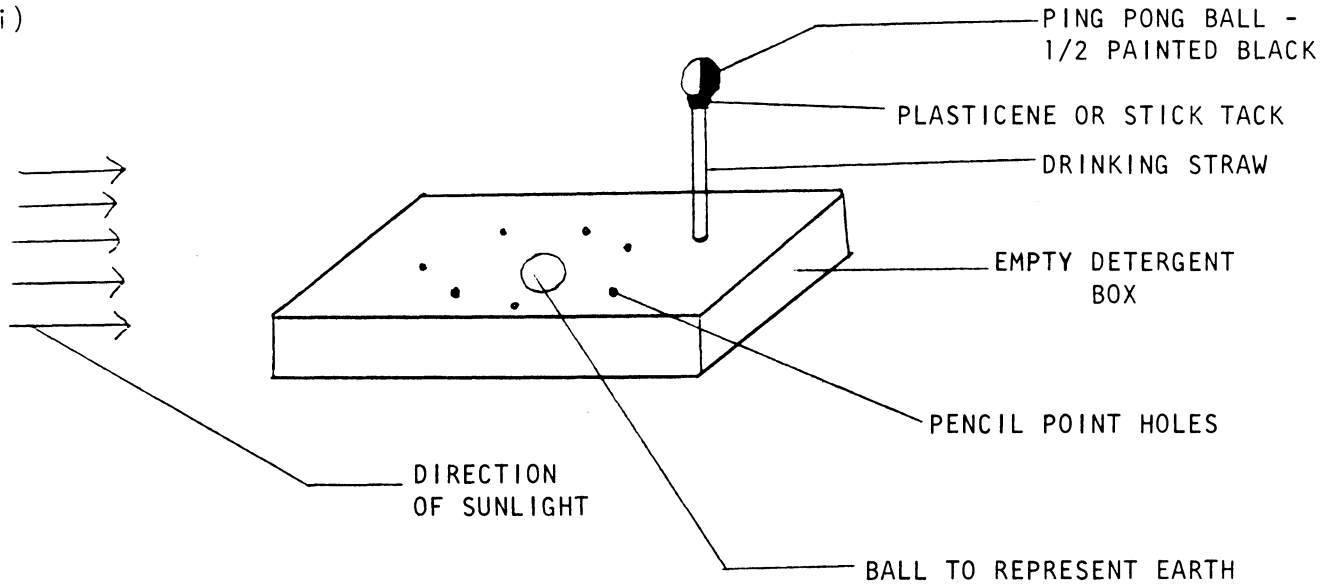
You need a rubber ball which can be painted half black and half white, and a nail or a knitting needle, which can be inserted into the ball. This ball represents the moon.

Have the observer stand in the centre of the room. He is on the earth. Have a pupil hold the moon by the handle, starting at the window side of the room with the white side of the ball toward the window. The window represents the sun and so the black side of the ball is in shadow. Now have the pupil walk slowly around the outside of the room pausing when he reaches the corners and the centre of each wall. The pupils will have to turn slightly each time in order to observe the ball. Have the pupil holding the ball be sure to always keep the white side of the ball facing the window side of the room. Sketch the proportions of black and white viewed at each stop.



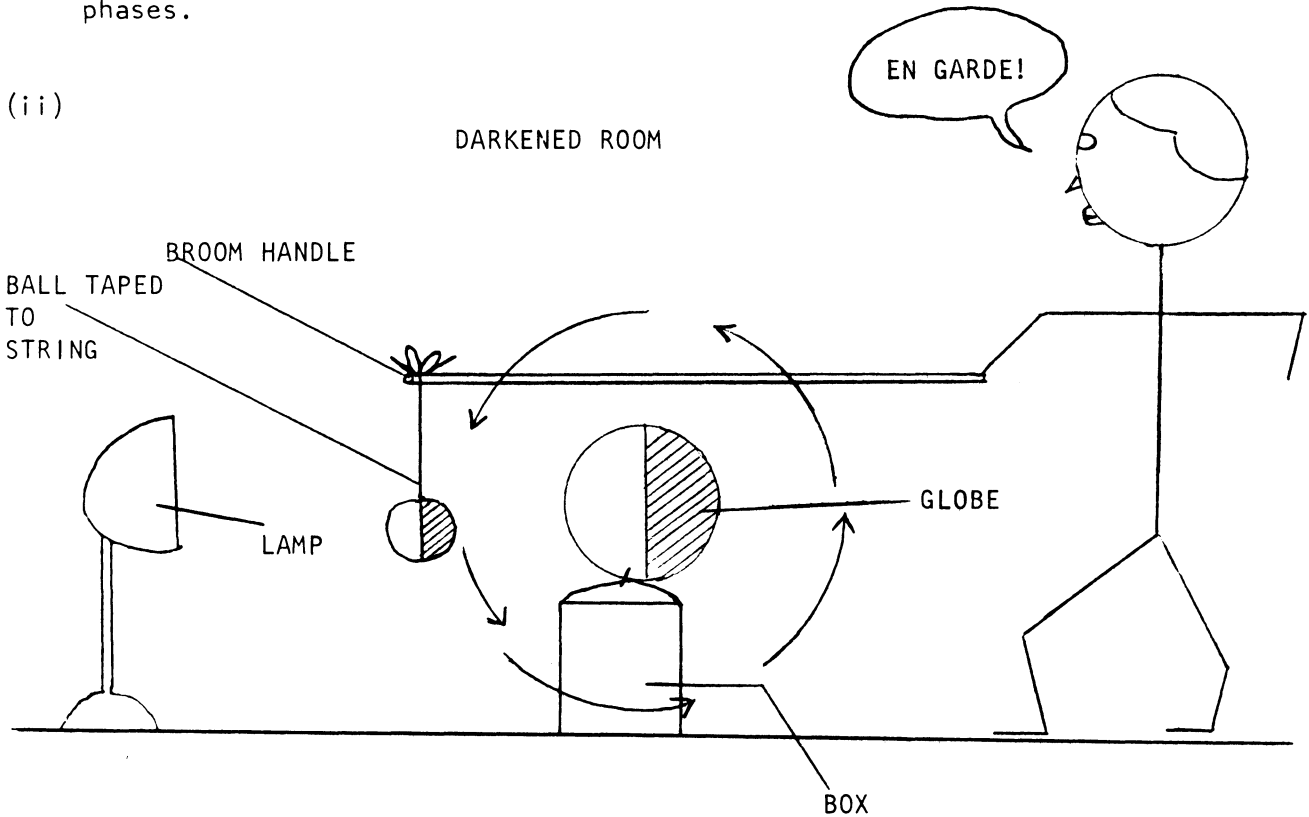
Alternative Methods

(i)



Move ball and straw from hole to hole keeping light side of ball facing the direction from which the light comes. Change your position so that you can look from the earth to the ball each time in order to see the phases.

(ii)

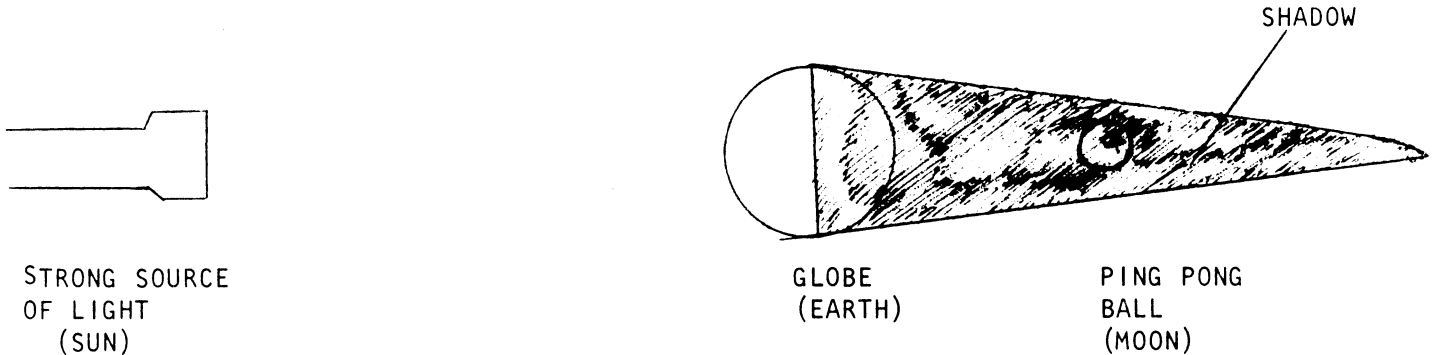


The pupils could sketch their observations on a chart similar to the one for a calendar. As the chart represents a calendar, the starting position should be carefully chosen and the phase sketched at four-day intervals. The intermediate phases could be sketched in later.

23. How is an eclipse of the moon caused?

You need a source of strong light such as a slide projector or flashlight, a globe and a ping pong ball. Attach a length of string to the ping pong ball with scotch tape so that the ball can be suspended from the hand.

Set up the apparatus as shown in the diagram below and darken the room.



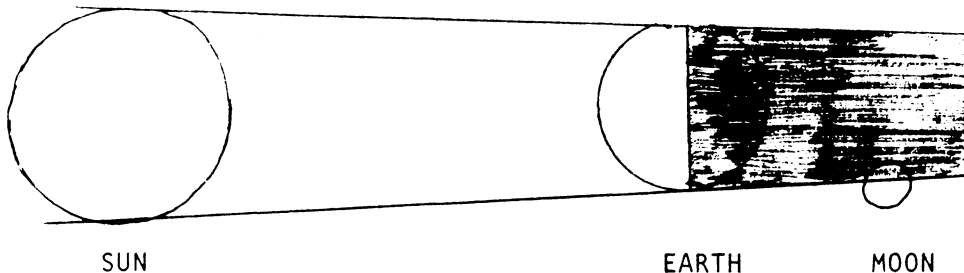
POSITION FOR A TOTAL LUNAR ECLIPSE

Pupil Discoveries

A lunar eclipse occurs when the sun, moon and earth are in a straight line and the earth is between the sun and moon.

- the earth's shadow cuts off the light from the sun which is normally reflected by the moon
- a lunar eclipse occurs only when the moon is in its full phase
- a lunar eclipse does not occur each time the moon is full because the moon's orbit is tilted at an average angle of 5° to the earth's orbit. There can never be more than seven or fewer than two per year. We do not see every eclipse because due to the earth's rotation we do not always see the moon.

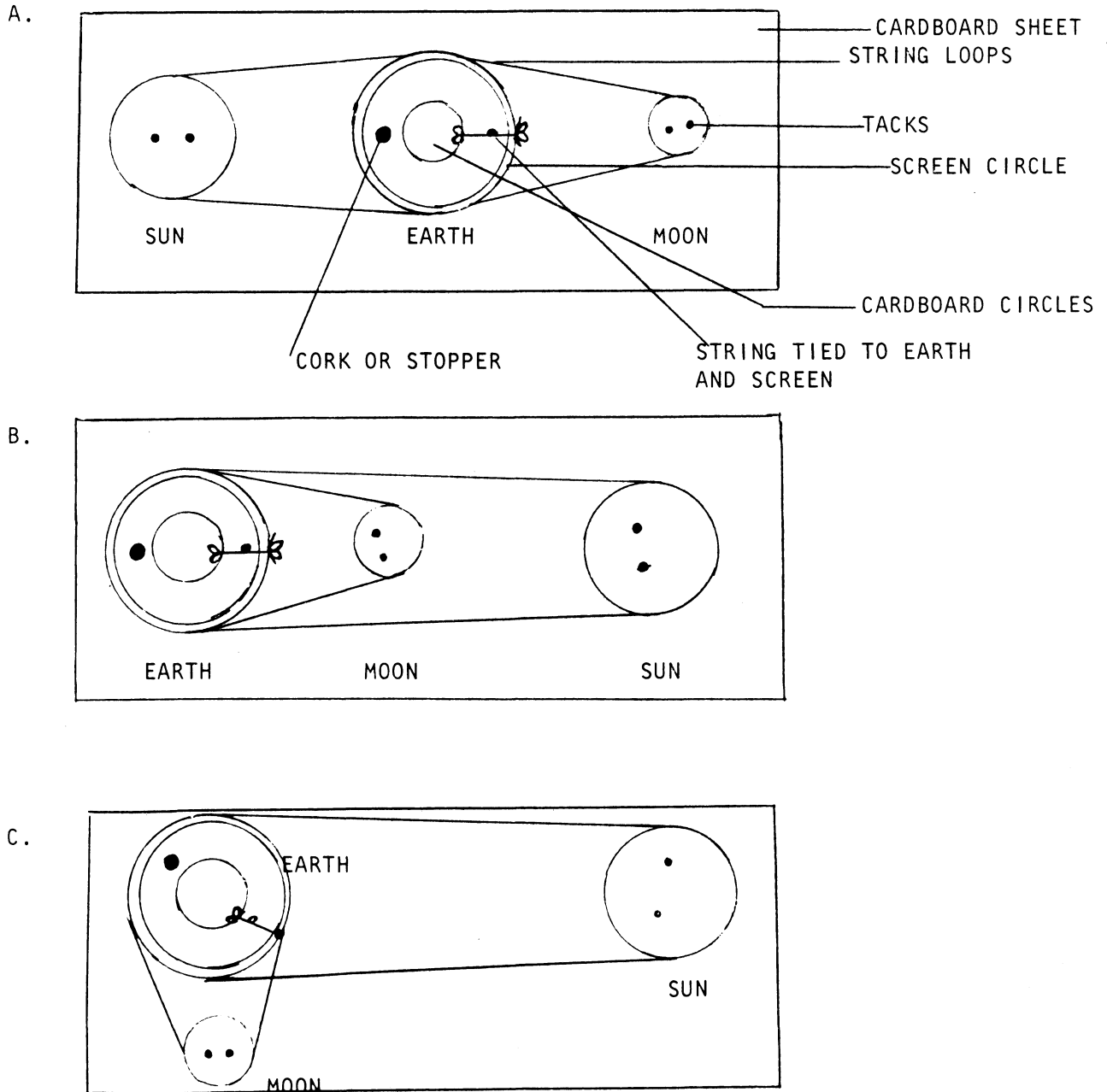
A partial lunar eclipse occurs when the moon is only partly in the earth's shadow. A crescent shaped section of the moon is darkened.



24. How do the sun and moon cause tides?

You need a strip of wire screening approximately one inch wide and 24 inches long, some string and two pieces of heavy corrugated cardboard from a large box. Cut three disks from one piece of cardboard: -- the moon having a 3" diameter, the earth having a 4" diameter and the sun having a 5" diameter.

Use tacks to attach the sun and moon circles to the second piece of cardboard according to the diagrams which follow. Fasten the screen ends together to make a circle. Make loops of string which will go around: the moon and the screen, and the sun and the screen. Attach the earth to the screen with string leaving a little slack in the string. Pull the strings and observe what changes occur in the shape of the screen.

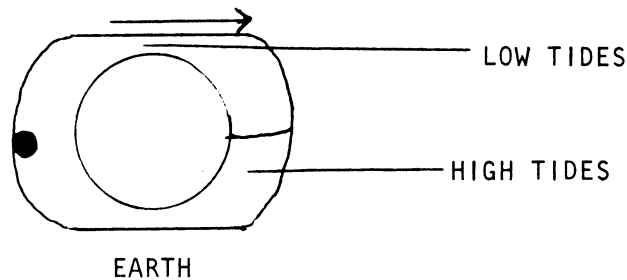


Pupil Discoveries

The screen represents the waters in the earth's oceans and the string represents the pull of gravity of the sun and moon on these waters.

-- Pulling on the strings causes the wire screen to bulge on the sides from which the pull comes

-- as the wire screen is pulled further the earth begins to move toward the moon. The earth is pulled toward the moon leaving a pile of water behind.



-- there are two kinds of tides. Spring tides occur when the moon and sun are in the same line as in A. These tides occur during the new and full moon phases.

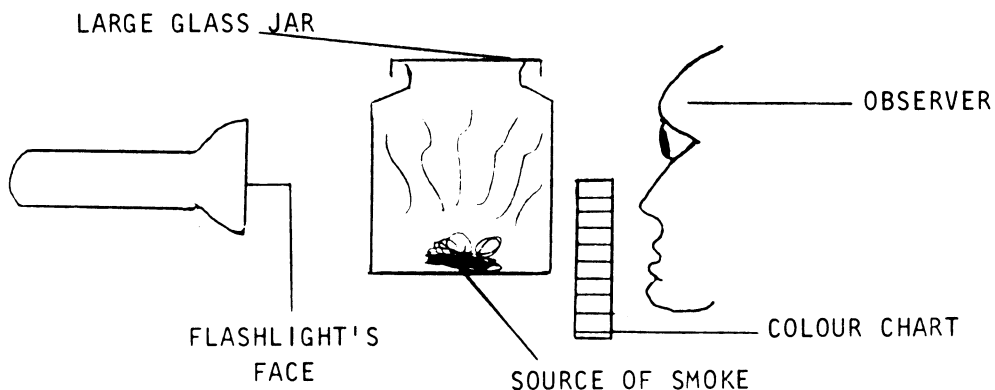
Neap tides occur when the sun and moon are located as in B. These tides occur during the half moon phases (1st and 3rd quarter)

-- Spring tides cause larger bulges than neap tides

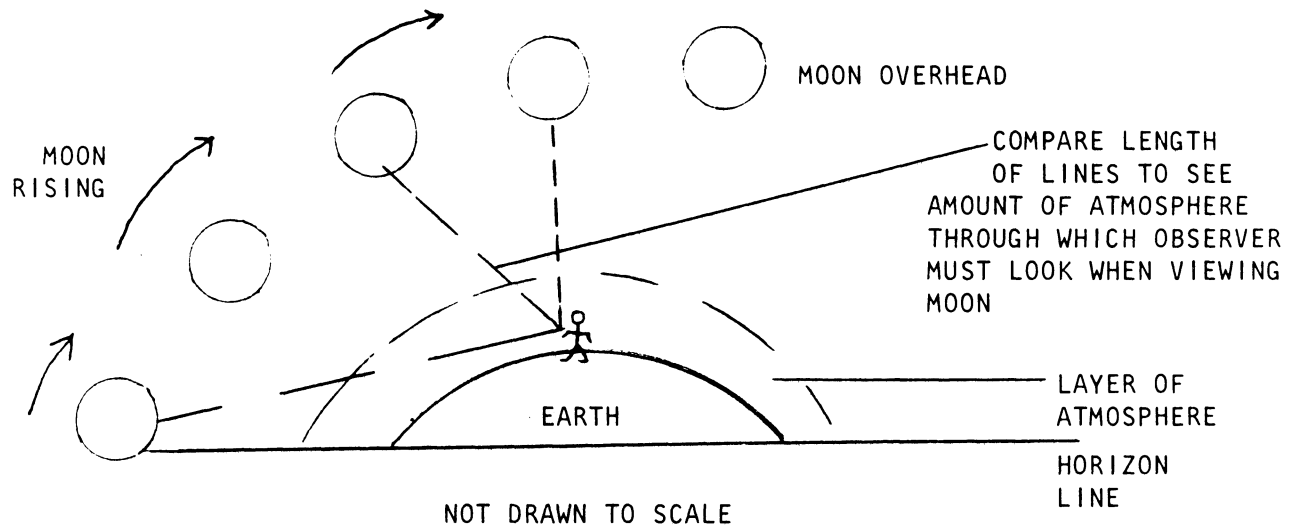
25. Why does the moon's colour appear to change?

You need a large glass jar, a flashlight, a source of dust or smoke, and some colour charts from a paint store which show a gradual change from white to each of these colours: grey, yellow, orange, blue, red.

1. Look at the face of a lighted flashlight and use the colour chart to find the shade which matches it most closely.
2. Shine the light through the glass and use the colour chart to find the colour of the face of the flashlight again.
3. Place some chalk dust in the jar by shaking a rag, which has been used to clean a blackboard, inside the jar. Repeat the test with the flashlight and colour charts.
4. Place smoke in the jar either from smouldering string or a burning cigarette. Repeat the test with flashlight and colour chart.



5. Examine this diagram.



Pupil Discoveries

1. As more impurities are added to the air the colour becomes darker
2. The more air that one must look through the darker the colour becomes
3. The moon's colour only appears to change. Use the colour charts to measure the moon's colour at half hour intervals from the time it can be run above the horizon every fifteen minutes for a period of two hours.

This is a technique used by some astronomers to chart the colours of planets and stars when these are viewed through their powerful telescopes.

IV THE PLANETS

26. How can a scale model of the planets in our solar system be constructed?

Find a string or wire long enough to reach from the front to the back or from corner to corner of the classroom. Cut out disks from cardboard according to the following chart and attach them to the string or wire with tape or paper clips.

<u>BODY</u>	<u>DIAMETER</u>	<u>DISTANCE FROM SUN</u>
Sun	27"	-----
Mercury	1/8"	1 3/4"
Venus	1/4"	3 1/4"
Earth	1/4"	4 3/4"
Mars	1/8	7"
Jupiter	2 3/4"	2'
Saturn	2 3/8"	3' - 8"
Uranus	1"	7' - 5"
Neptune	7/8"	11' - 8"
Pluto	1/8"	15' - 3"

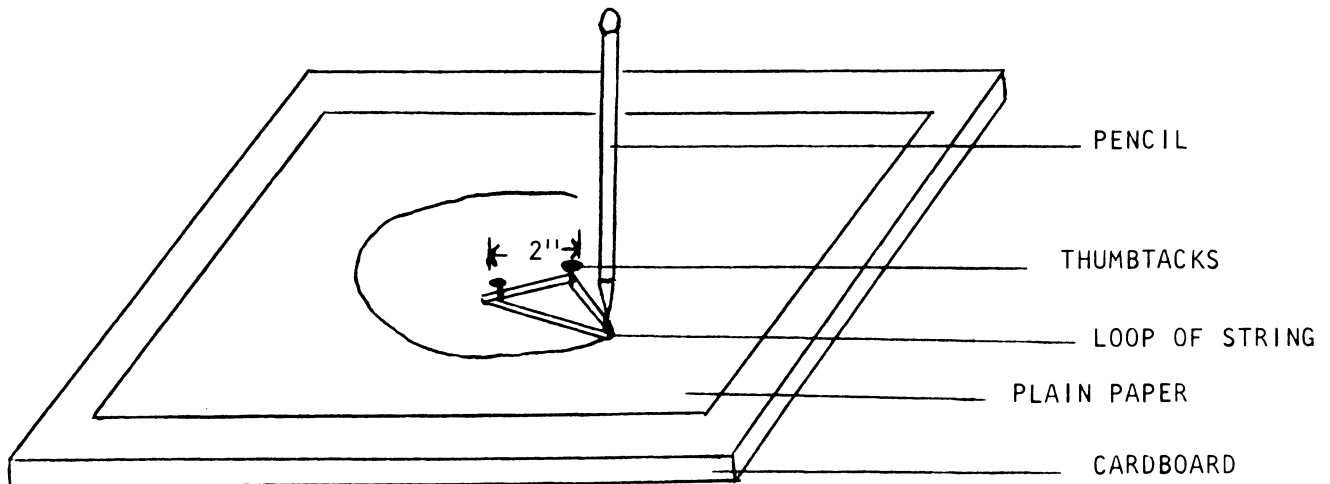
A label could be attached to each giving the body's name and actual size. A piece of cardboard with many small dots representing the asteroids could be attached to the string half way between Mars and Jupiter.

27. What shape are the orbits of Planets?

You need a large piece of thick cardboard, plain paper, two thumb tacks, some string and a pencil.

Place the paper on the cardboard and insert the two tacks near the centre so that they are about 2" apart. Tie the string to make a loop about 8 inches in circumference. Place the loop around the tacks. Stretch the loop as tight as possible by using a pencil point inside the loop. Keep the loop tight and the pencil held vertically. Move the pencil around the loop as if to make a circle.

Repeat the procedure using different sized loops and varying the distance between the tacks.



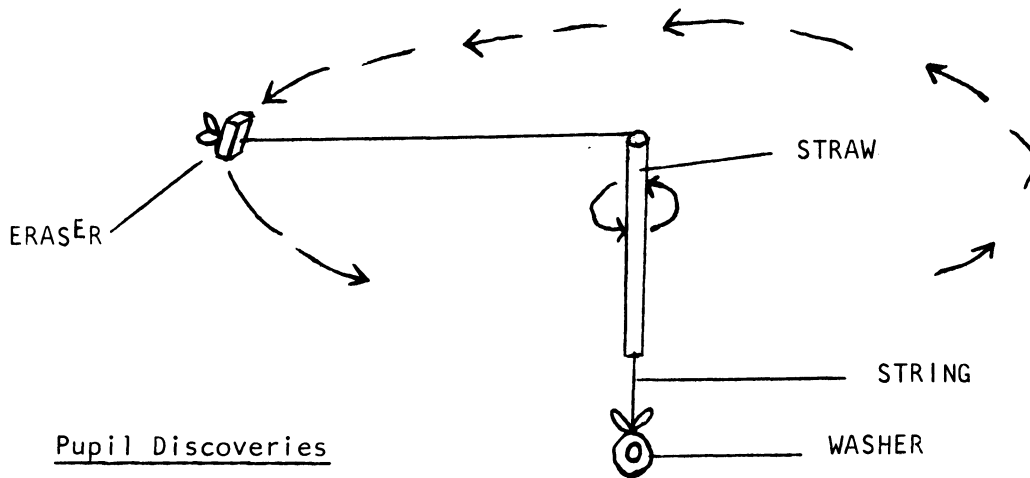
Pupil Discoveries

The shape of the figure produced is called an ellipse. An ellipse which almost resembles a circle is the shape of the orbit of the planets. An ellipse which is long and narrow is the shape of a comet's orbit.

28. Why do (a) the planets revolve around the sun?
(b) the moons revolve around the planets?

You need a drinking straw, an eraser, a large nut or washer and a piece of string.

Pass the string through the straw. Tie the eraser to one end of the string and the washer to the other. Oscillate the straw so that the rubber will whirl around in a circular path and the washer will hang downward. Increase the speed at which the eraser is moving by oscillating the straw faster. Observe what happens to the position of the washer.



Pupil Discoveries

The straw represents the sun and the eraser a planet. The washer and string represent the pull of gravity of both the sun and the planet combined. By increasing the speed of the rotating eraser the washer moves upward showing that the pull has been increased, and the object is now travelling in a different path. As long as the speed and pull remain constant the object continues to rotate in the same path or orbit. The same thing is true for the moon and the earth.

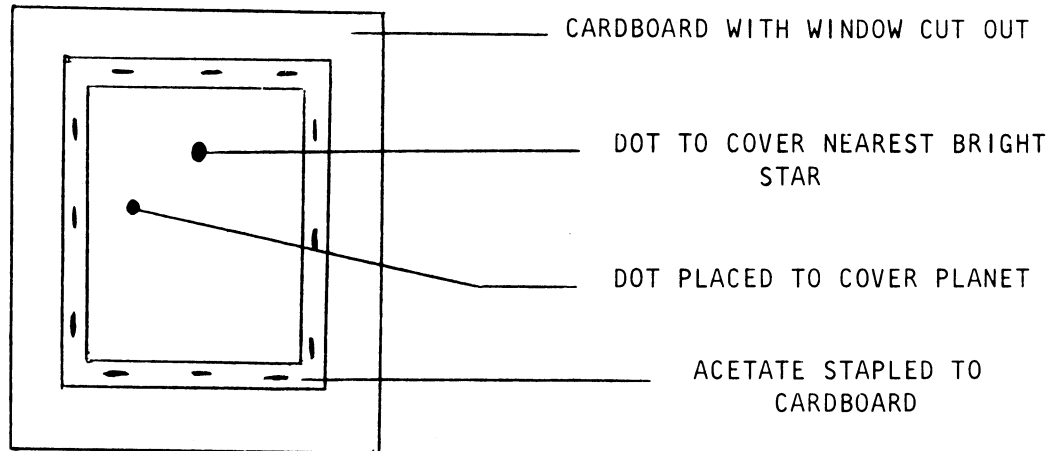
29. How does a planet's position in the sky change?

You need a sheet of clear acetate from which overhead projector transparencies are made, a piece of cardboard, a magic marker and graph paper.

Use the cardboard to make a window over which the acetate sheet can be stapled in order to make it firmer. Find where one of the following planets is located: Venus, Mercury, Mars or Jupiter (These are large enough or close enough to be seen without binoculars). Look in the newspaper or write to Centennial Observatory, 93 Currie Street, Hamilton, Ontario.

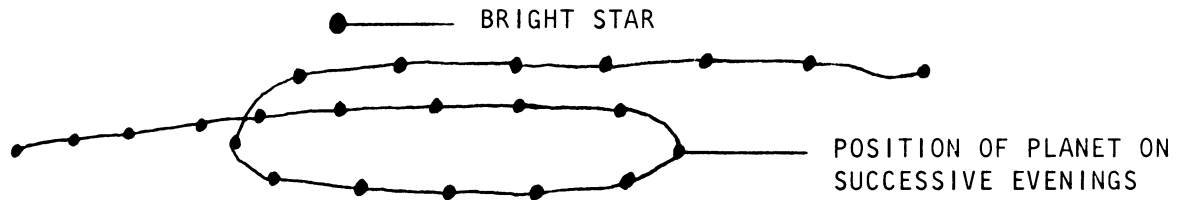
Mark North, East, South and West on the acetate sheet so that the sheet can be held in the same position each night. Place a magic marker dot on the sheet. Use this same dot every night. Hold the sheet so that this dot will cover the bright star nearest to the planet you are going to observe being careful not to

move the sheet. Use the same star each night. Make a second dot on the acetate which will cover the planet. Repeat the procedure at approximately the same time each night for two or three weeks. Each night transfer the dot made which covers the planet into a piece of graph paper according to its distance and direction from the bright star.



Pupil Discoveries

- when the successive dots which represent the position of the planet are plotted a pattern similar to the following will be obtained.



- the planet appears to go forward then back up and then go forward again
- this apparent looping is due to the difference in speed of rotation between the earth and the planet. Its affect is very similar to what is seen from a fast-moving train which passes a slower-moving car. The car may appear to be moving backwards at one point
- this is called retrograde motion of orbit

30. How can the morning or evening star be studied?

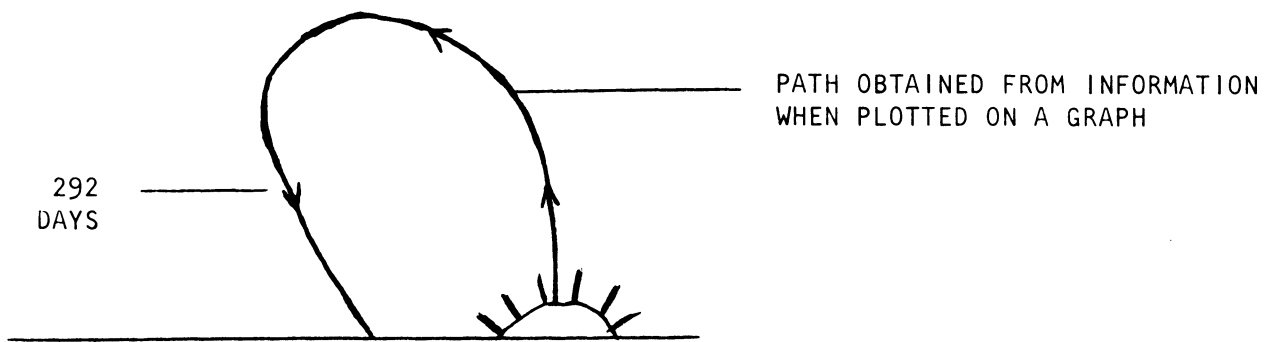
You will need the astrolabe constructed in Activity One and some graph paper.

The morning or evening stars are not stars but they are planets. Both Mercury and Venus can be either a morning or an evening star. Look in your newspaper or write to Centennial Observatory, 93 Currie Street, Hamilton, Ontario in order to obtain information as to the best time and the right place to look for these planets. When you have obtained this information use the astrolabe to keep a record of the elevation and direction of the planet you are observing.

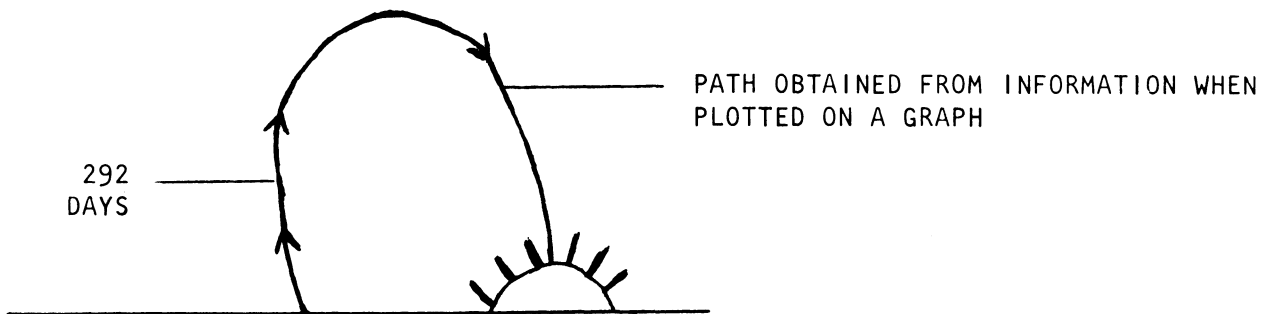
Pupil Discoveries

- the morning or evening star is not necessarily the first star to appear or disappear.
- the morning or evening star is seen in the East or the West only at certain times of the year.
- the morning or evening star appears as a very bright star early in the evening or early in the morning.
- the morning or evening star is either the planet Mercury or Venus.
- the position of Venus changes over a period of 292 days. It is only visible above the horizon for 282 of those days.

Venus as an Evening Star



Venus as a Morning Star



Mercury's behaviour resembles that of Venus but its cycle lasts for 58 days so it makes four appearances to Mercury's one.

31. How can the moons of jupiter be studied?

You will need a pair of binoculars and some paper. You will also need to know where to look in order to find Jupiter and this information can be obtained from the local newspaper or by writing to Centennial Observatory or to P.O. Box 272, Hamilton, Ontario. Be sure to include a stamped self-addressed envelope.

Divide the sheet of paper into fourteen sections similar to the ones shown in the diagram. Place a circle in the centre of each section to represent Jupiter. Look through the binoculars and place dots to represent the position of the four largest moons. Indicate which one appears the brightest. Repeat this observation at the same time on each night for a period of two weeks.

PARTLY COMPLETED RECORD SHEET

DATE	POSITION OF MOONS	
Mar. 3	• • ○ * •	MOON
4	• ○ • * •	BRIGHTEST MOON (GANYMEDE)
5	* • • • ○	
6	* ○ • •	WHERE DID THE FOURTH MOON GO?
7	○	
8	○	
9	○	
10	○	JUPITER
11	○	

Try to predict where the moons will be next. Can you figure out which moon travels the fastest?

Extended Activity

The orbits of Jupiter's moons are not a series of concentric ellipses like the planets of our solar system. Instead they extend outward from Jupiter in various directions. Jupiter itself is changing rapidly. These changes in weight affect the orbits of its moons. Astronomers are very interested in the changes of the moons' orbits as this is one way in which they can learn about Jupiter. Whenever a moon passes in front or behind Jupiter, it disappears from view. By knowing the exact time at which a moon disappears and comparing it with the time they know it should disappear, they can become aware of these changes.

If a pupil would like to help with this project he could contact the local radio station in order to obtain the correct time and synchronize his watch with it. He need be only as accurate as six seconds in observing the time when one of Jupiter's moons disappears. He should send his information to Centennial Observatory, 93 Currie Street, Hamilton, Ontario.

32. How strong is the pull of gravity on other planets?

Scientists have chosen the amount of the pull of gravity to be one pound of force(pd.) = the force of gravity on Mars or quantity of matter (1 lb.) when measured at sea level here on earth. Since the pull of gravity of an object depends upon the size and the material of which it is made up and that planets are of different sizes and materials, the pull of gravity at their surfaces is different.

The pull of gravity on your body is one times the number of pounds you weigh. To find what you would weigh on other planets, do the following multiplication.

<u>Planet</u>	<u>Your Weight</u>	X	<u>Surface Gravity</u>	=	<u>Your Weight on Planet</u>
Mercury	?		0.38	=	_____
Venus	?		0.88	=	_____
Earth	?		1.00	=	_____
Mars	?		0.39	=	_____
Jupiter	?		2.65	=	_____
Saturn	?		1.17	=	_____
Uranus	?		0.92	=	_____
Neptune	?		1.23	=	_____
Pluto	?		0.16	=	_____
Moon	?		0.16	=	_____
Sun	?		28.00	=	_____

Compare the size of the planet with its pull of gravity and try to discover if it is made of light or heavy material.

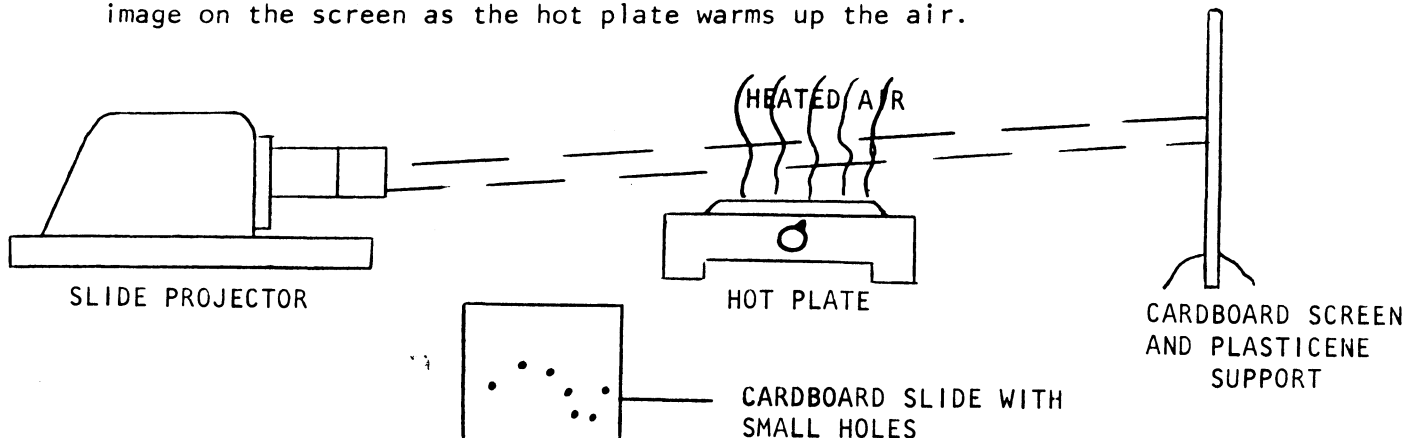
How would a smaller or a greater pull of gravity affect the way you could move if you lived on that planet?

V STARS

33. Why do stars seem to twinkle?

You need a slide projector, a hot plate and a screen or piece of white cardboard.

Cut a piece of bristol board the same size as a slide and punch some small holes through it. Focus the projector so that small round dots appear clearly on the screen. Place the hot plate between the projector and the screen. Observe the image on the screen as the hot plate warms up the air.



Pupil Discoveries

- The image on the screen has a clear outline and does not move before the hot plate is turned on.
- The heat from the hot plate warms the air and causes it to move. This causes the image to move or twinkle.
- The light from the stars passess through a layer of air around the earth which has been warmed by the heat energy from the sun taken in and released by the earth.

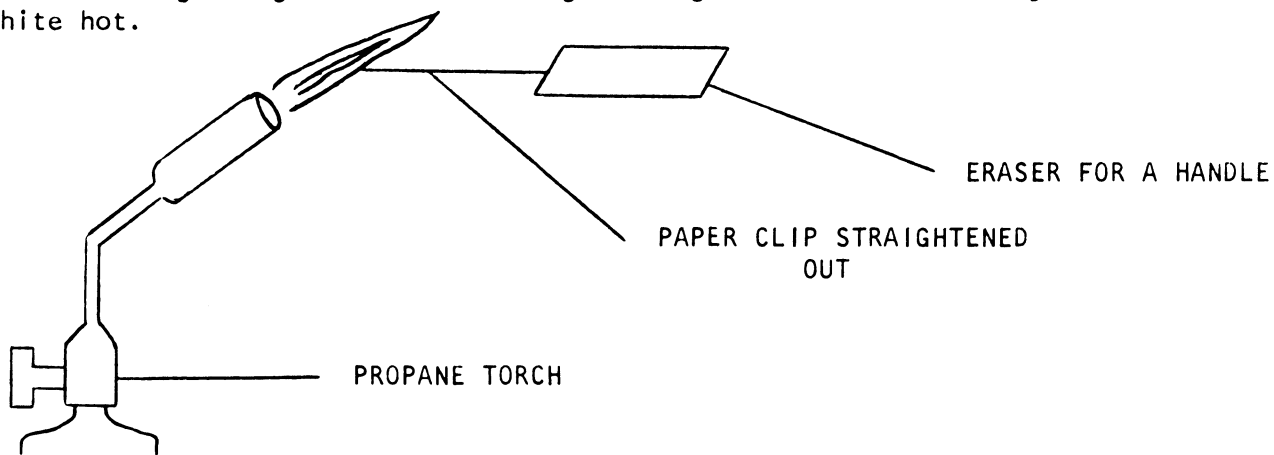
34. Why do stars have different colours?

You need a propane torch, a piece of iron wire(paper clip), and a rubber eraser. Picture wire and pliers could also be used.

Straighten the paper clip and insert one end into the eraser. Heat the other end in the flame of the torch. Observe its colour after each successive small interval of heating time.

Pupil Discoveries

The wire will change from red to orange to yellow as it is heated for longer and longer temperatures and so becomes hotter and hotter. Look at the glowing wire in a clear glass light bulb to see an object which is white hot.



Some star colours and their approximate temperatures are as follows:

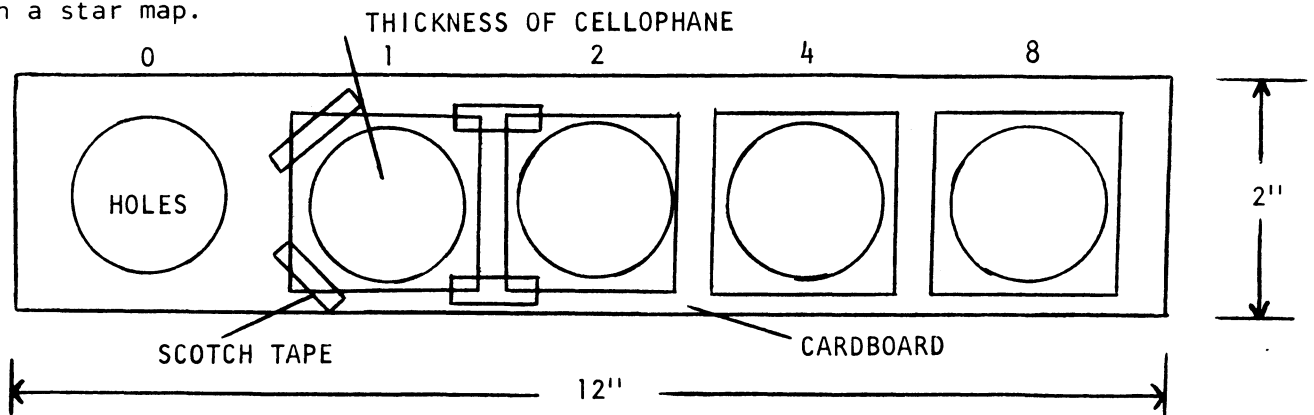
<u>Star</u>	<u>Colour</u>	<u>Temperature</u>
Rigel	blue - white	36,000°F Plus
Procyon	yellow - white	13,500°F
Sun	yellow	11,000°F
Arcturus	orange	7,500°F
Antares	red	5,500°F

35. How can the comparative brightness of stars be measured?

You need a strip of cardboard 12" long and 2" wide. Divide the strip into 5 equal parts and use a coin or jar lid the size of a half dollar to trace out a circle in the centre of each section. Cut out the holes carefully. Obtain some clean, clear, unwrinkled cellophane paper (ie. Saran Wrap).

Leave the first hole uncovered and tape one thickness of cellophane to the cardboard so that the second hole is covered by the cellophane. Use two thicknesses for the third hole, four for the fourth and eight for the fifth.

When observing a star look at it first through the first hole (uncovered) and then try the others in order until the hole which shuts off all the light is found. Number the star's brightness according to the hole which shuts off all the light. Test the stars in the major constellations and record their brightness on a star map.



NOTE: This method does not give a true mathematical comparison of brightness but is reasonably close. It is similar to the technique used by astronomers.

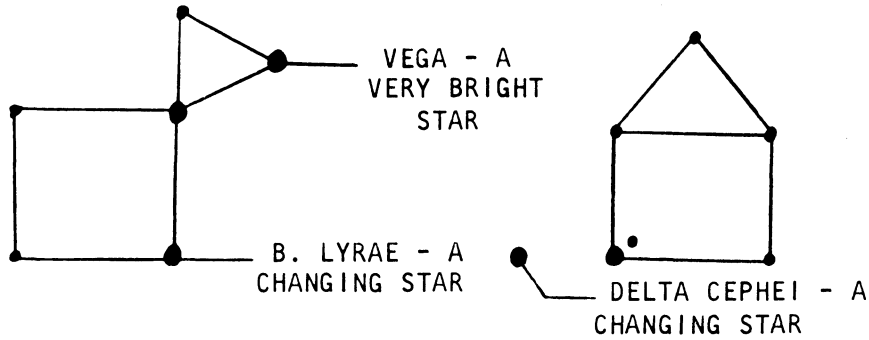
36. Do some stars change their brightness?

You will need the brightness tester constructed from cardboard and cellophane layers from Activity 35, some graph paper and a star map or star finder.

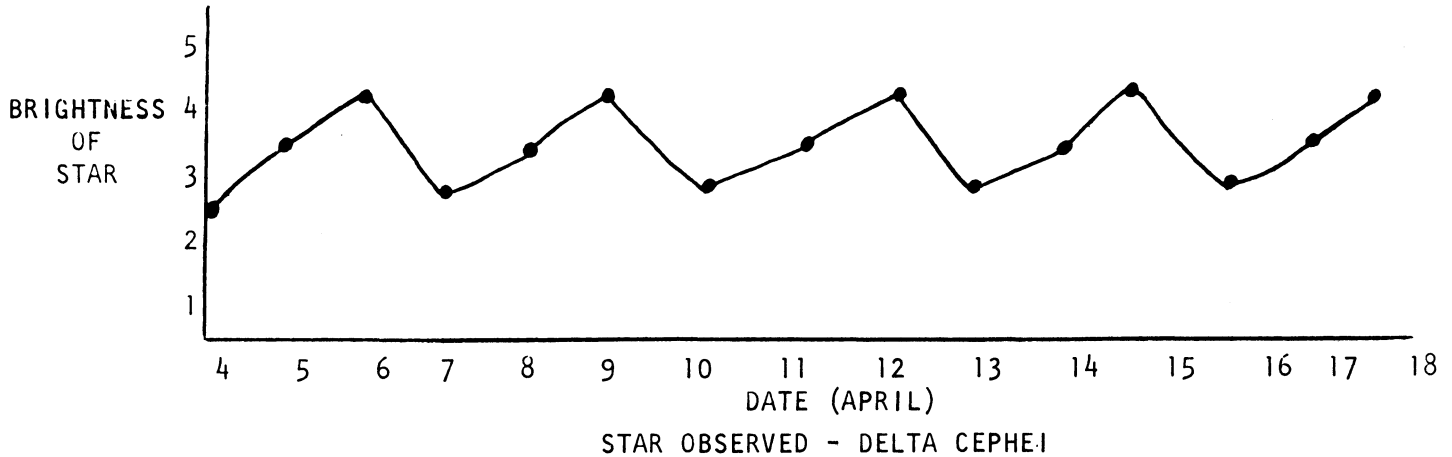
Use the star finder to locate the following constellations and the particular star indicated in each.

CONSTELLATION LYRA

CONSTELLATION CEPHEUS

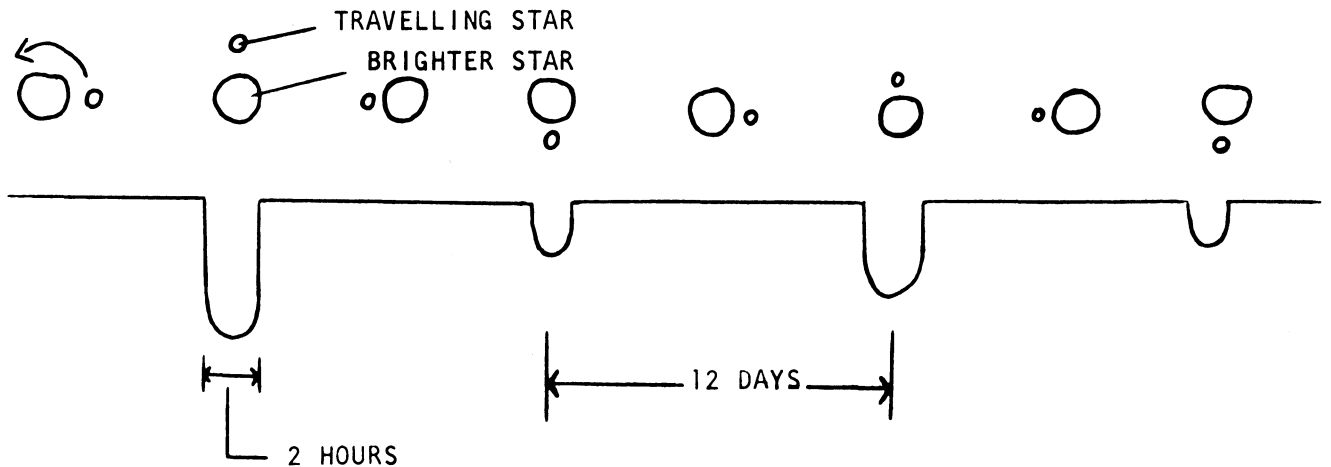


Use the brightness tester to find the brightness of B. Lyrae and Delta Cephei each evening for a period of two weeks or more. Plot the information on a graph similar to the following:

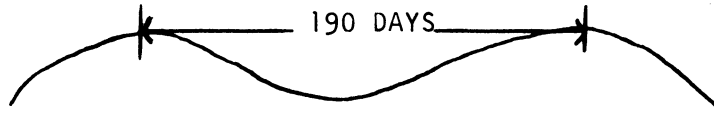


Pupil Discoveries

- A star which changes its brightness is called a variable star.
- There are four main kinds of variable stars 1. An eclipsing binary such as B. Lyrae is really two stars, the less bright of which revolves around the brighter one. When the travelling star is in front or behind the brighter star an eclipse occurs so that some of the light we see is reduced. The time between the two eclipses is 12 days on the average. The graph for B. Lyrae would look like this:



2. A Cepheid is a single star which, due to changes taking place within it, gets brighter then dimmer with a pulse-like rhythm. The period of time between the maximum and minimum brightness of Delta Cephei is approximately five days.
3. A Long period variable star has an average period of 100 days between maximum changes in brightness so this type is impractical for study at this grade level.



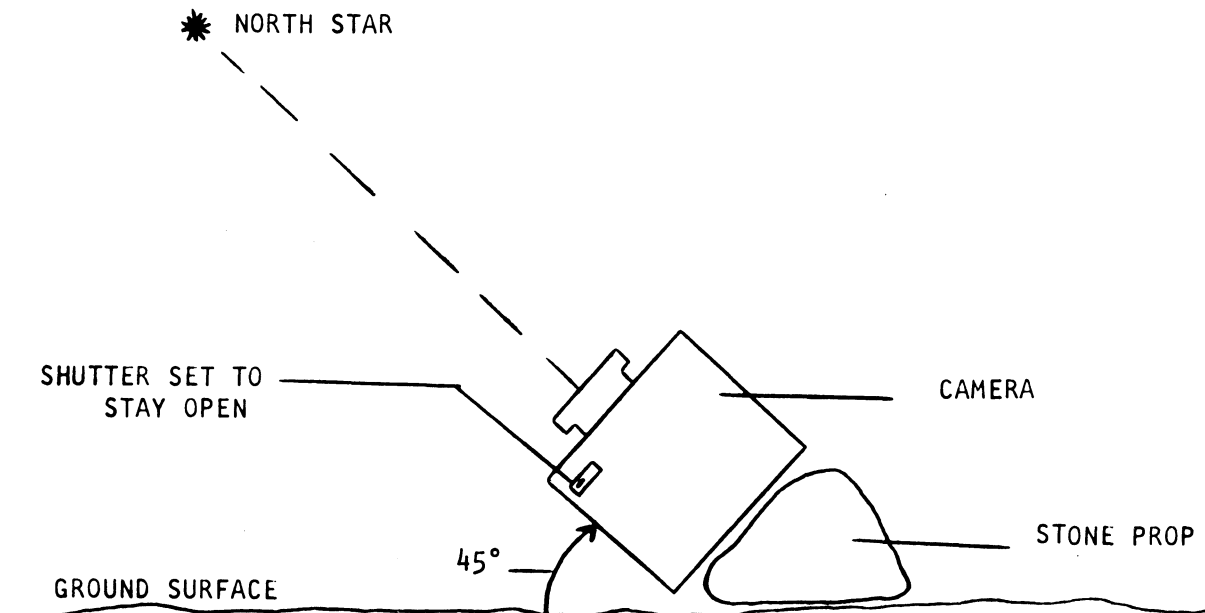
4. An irregular variable star's changes in brightness are never constant and difficult to predict so they too are less suitable for

If you would like other variable stars to observe, write to Centennial Observatory, 93 Currie Street, Hamilton, Ontario and include a stamped, self-addressed envelope.

37. How can the apparent movement of the stars be shown?

(A) During One Night

You need a camera that can take a time exposure and a large stone. Select a night that is clear and moonless. Select a location where the horizon is not overly obstructed and where street lights or car lights will not shine on the camera. If the camera is of a type which can be focused, set it for the longest distance possible (infinity). If the lens opening can be adjusted, keep this aperture quite small. Set up the camera by propping it with the stone so that it points towards the North Star and is at about a forty-five degree angle with level ground. Set the shutter speed to take a time exposure and leave the shutter open from one to six hours.



Try the same thing with the lens opening very large. Try pointing the camera at the Milky Way.

Pupil Discoveries

- a series of parts of concentric circles will be seen when the film is developed.
- the longer the shutter is left open the farther the stars will have appeared to move.

NOTE: This movement is due to the rotation of the earth on its axis and not the movement of the stars themselves.

(B) From Season to Season

Choose a constellation that is easily recognized but which is not always visible. ie. Orion can be seen in the spring and fall.

Use the astrolabe to measure the location of this constellation one night each week for a month at precisely the same time. Sketch the position of this constellation each time. Place the sketches collected side by side and observe the change in position.

This apparent shift in position is due to the tilt of the earth's axis combined with its orbit around the sun.

38. How can a Constellarium be constructed?

Before pupils proceed out of doors to view the sky at night, they should be familiar with the more common constellations.

By consulting such reference books as: STARS -- ZIM AND BAKER -- GOLDEN NATURE SERIES, Simon and Schuster, New York, -

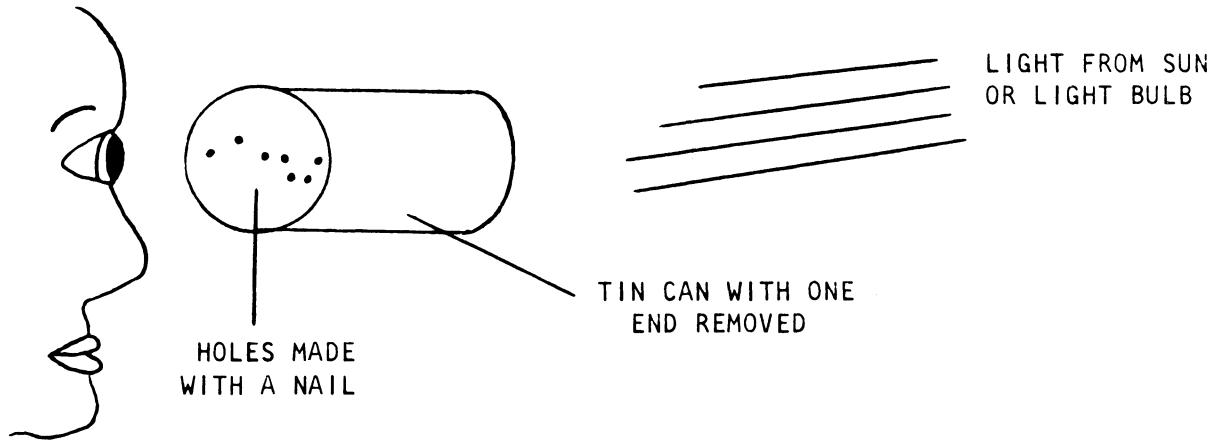
pictures of the constellations could be found which show the pattern made by some stars and the figure they are supposed to represent. An interesting way to record this information and to have the opportunity to practice identification at the same time, is to construct one of the following types of constellaria.

A constellarium consists of a source of light such as a flashlight, sunlight or a light bulb, a card with holes punched through it to represent the stars in the constellation, and a holding device.

If the figure which the star pattern represents is sketched on the back of the card, and the name of the constellation labelled even greater use can be made of the constellarium.

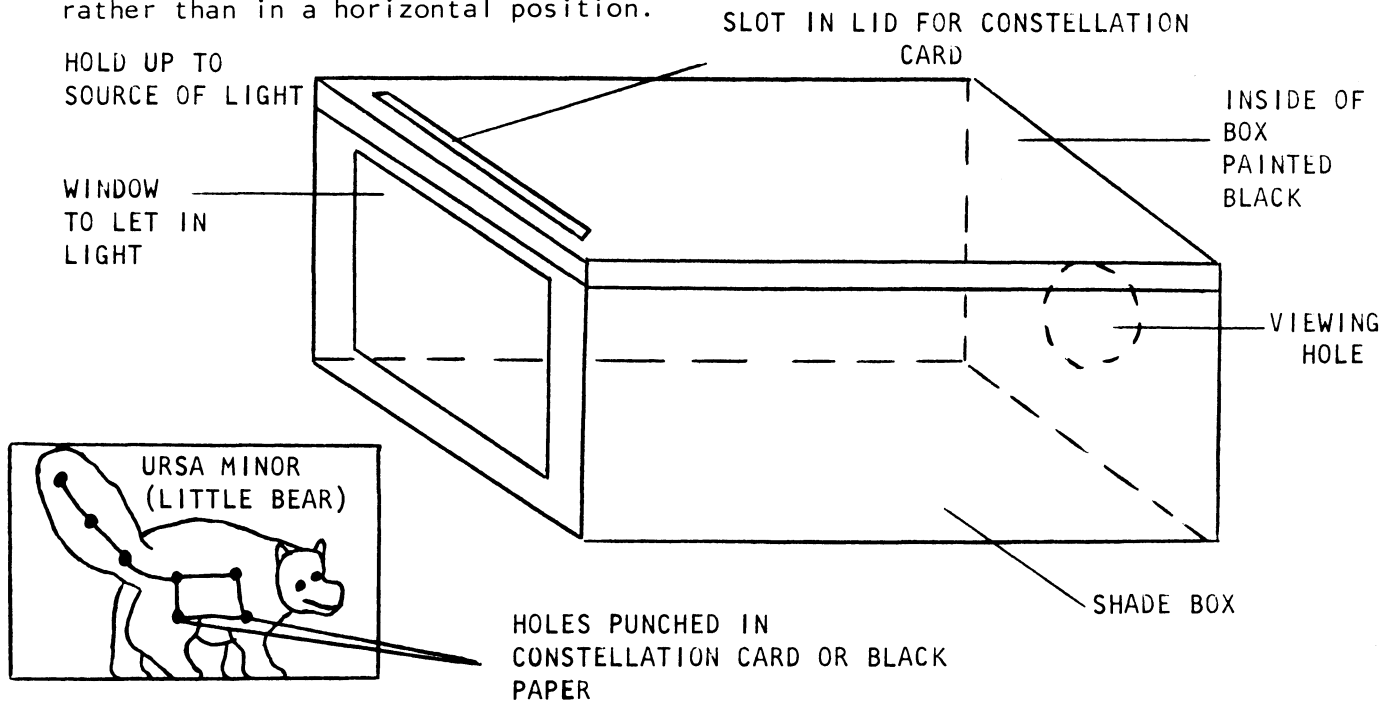
Tin Can Constellarium

- a) Punch holes in the end of several tin cans or small cardboard boxes with a nail. Use one can or box for each star pattern. Hold the can or box up to the light.

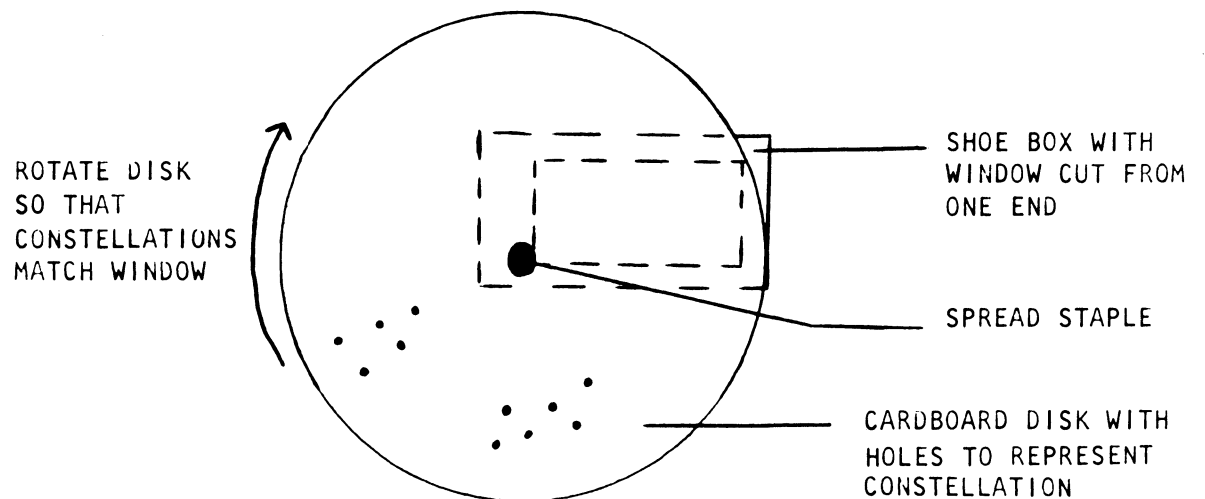


Shoe box Constellariums

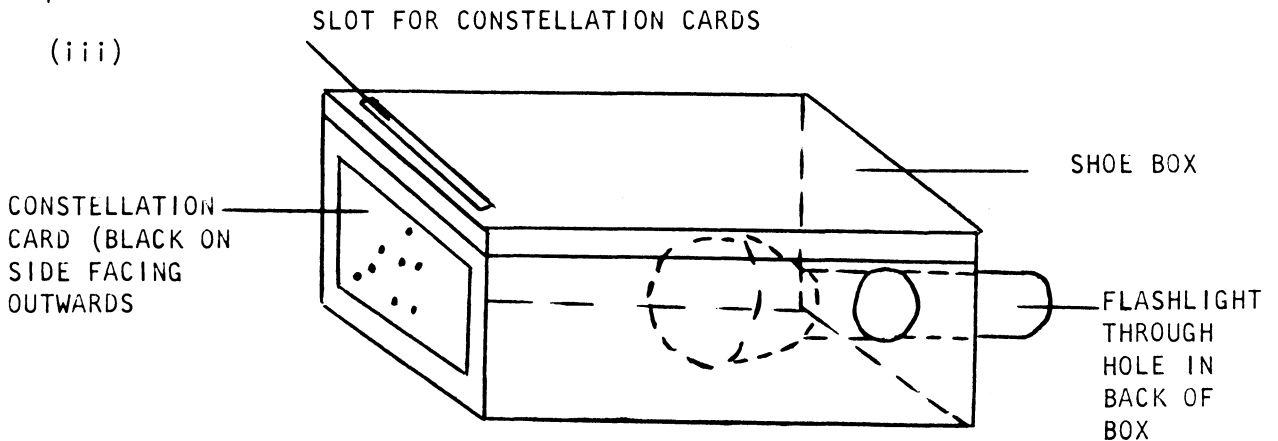
- b) (i) The pupils should be encouraged to tilt the box so that the constellations are at different angles as these stars will usually be observed this way rather than in a horizontal position.



(ii)



This type is especially useful if the staple is used as Polaris and the North Circumpolar Constellations are placed on the disk in their proper positions.



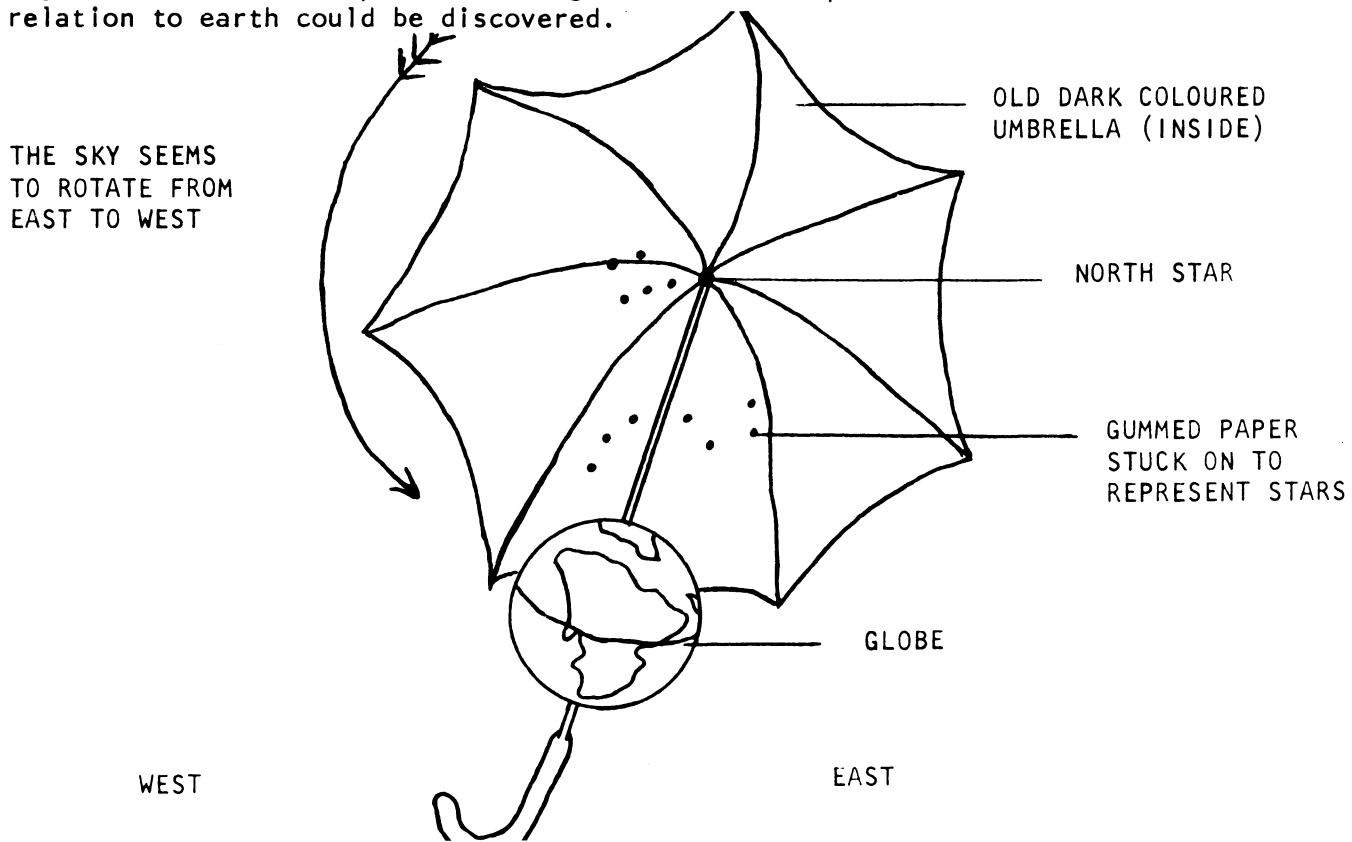
39. How can a simple planetarium be constructed?

Procure a large ancient umbrella, preferably dark in colour, from one of the pupils or possibly from a used clothing store. Let the tip of the umbrella where the ribs converge be the north star which is, of course, the first star in the handle of the Little Dipper. Glue the small circles from the paper punch or use gummed reinforcement rings or discs cut from gummed paper to represent the other stars.

Complete the North Circumpolar constellations first then add others depending on the space remaining on the underside of the umbrella.

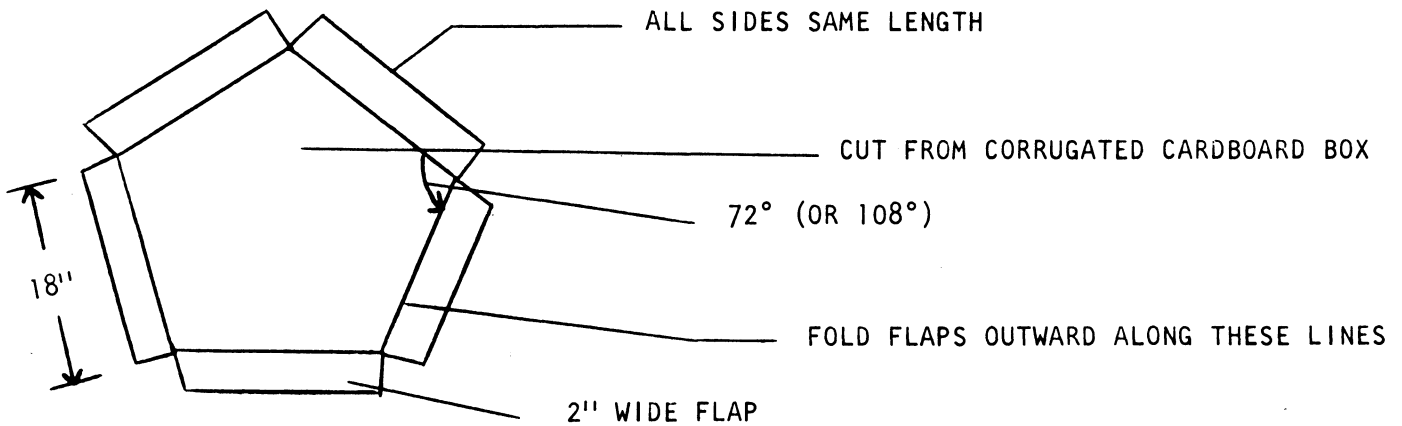
By rotating the handle of the umbrella the rotation of the constellations can be studied.

Remove the handle from the umbrella so that an old globe, which has been removed from its stand, can be mounted on the umbrella, by putting the rod of the umbrella through the holes at the poles of the globe. Now the position of the constellations in relation to earth could be discovered.

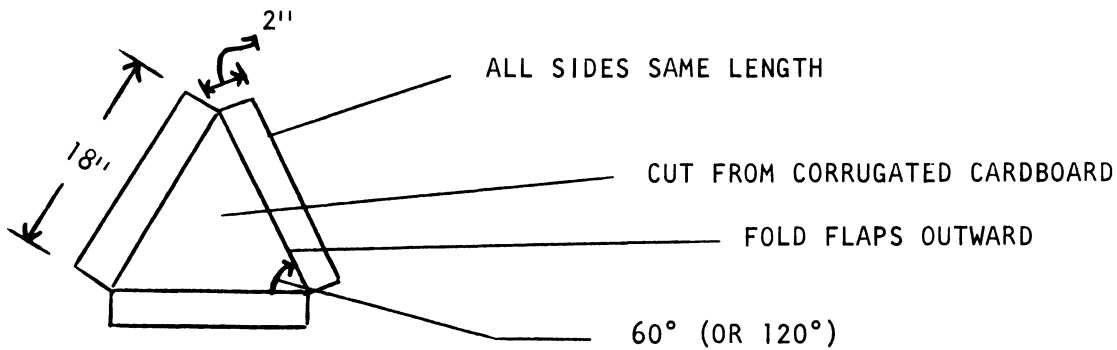


You will need several large cardboard boxes, a length of clothesline rope, a large working light bulb, a gooseneck or other swivel type of lamp, some black paint, some large brass spread staples and a pin. Cut sections from the sides of the cardboard cartons and attach with the spread staples as shown in the diagram below.

Making the Dome

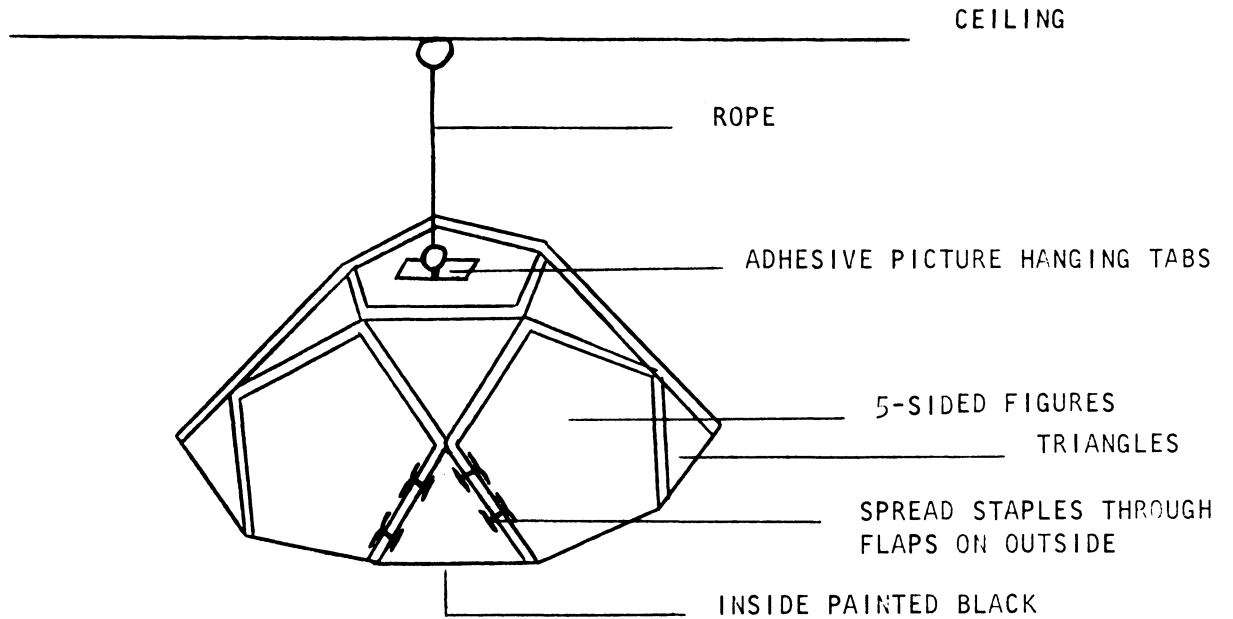


MAKE SIX



MAKE TEN

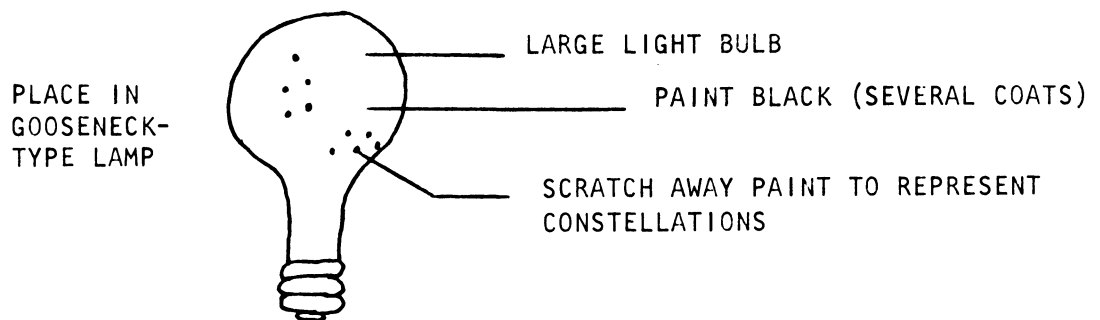
Attach the flaps of the triangles and five-sided figures together with spread staples to form a dome. One of the five-sided figures is the top. To this piece a length of clothesline rope can be attached by using the gummed rings made to hang pictures on plaster walls without driving in nails. The dome could be suspended from the ceiling using the adhesive picture hanging rings if necessary. Paint the inside of the dome a flat black by using tempera paint.



This dome is large enough to seat 12 pupils in a circle under it at one time. The room must be darkened when the planetarium and dome are being used.

Making the Planetarium

Paint the light bulb with several coats of black paint so that all of its light is stopped. (The larger the bulb the better but be sure to use a type of paint that is not affected by heat, ie. tempera, or paints for metals). Starting with Polaris at the top of the bulb and, by referring to a star chart, scratch very small amounts of the black paint from the light bulb to represent the various constellations. If an error is made, simply apply more paint to the spot, wait until it dries and try again. When the bulb is turned on the light will travel through the holes to dome and small star-like spots of light will be seen.



By rotating the lighted bulb or by changing the angle, the positions of the constellations at different times in the night or at different seasons can be discovered.

A second light bulb representing the main constellations of the Southern Hemisphere, which we never see, could be constructed by interested pupils.

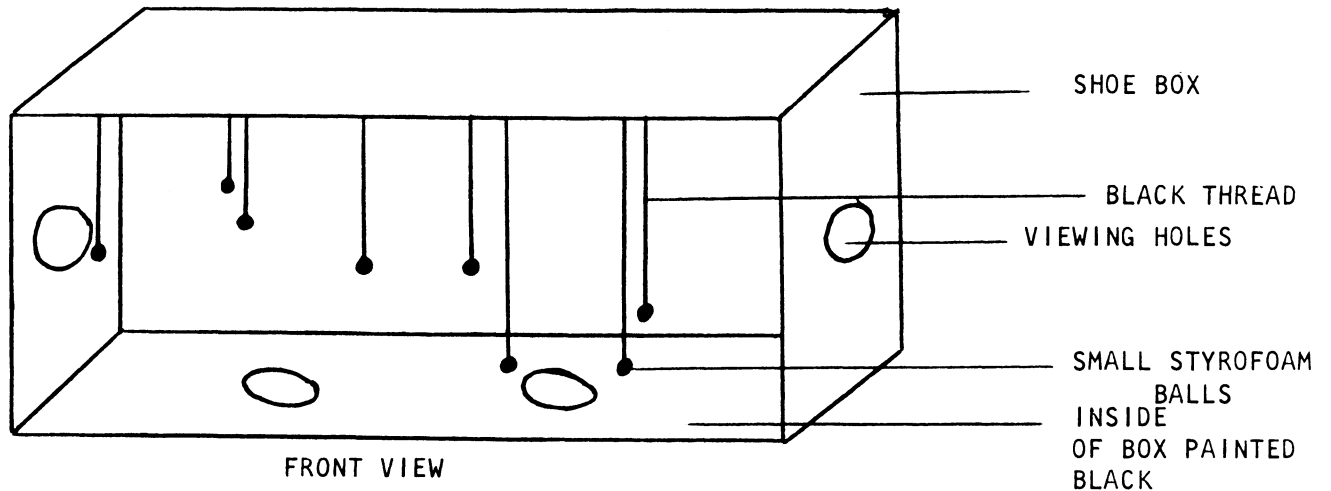
Use a pen-lite type flashlight for a pointer when the planetarium is in operation.

40. How can a constellation be shown in three dimensions?

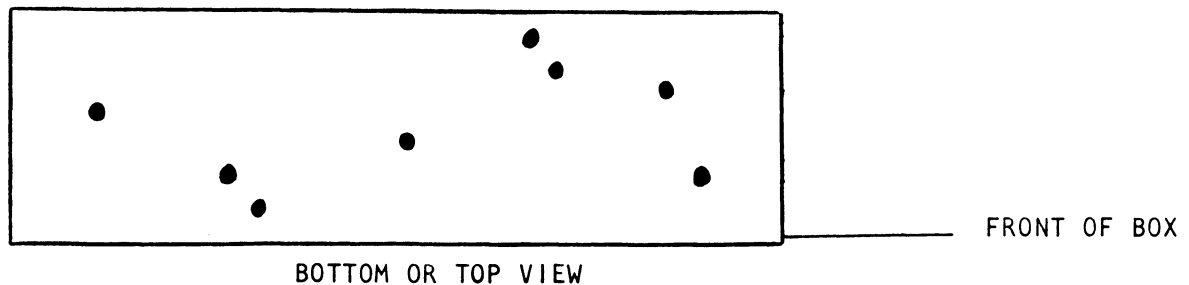
You need a shoebox, a piece of white styrofoam, some black thread and some black paint. Break or cut the styrofoam into pieces about the size of a 1/2 inch cube and use sandpaper to round them into a spherical shape. Turn the shoebox on its side. Use a knife to cut viewing holes from the ends and bottom so the constellation can be viewed from other angles. Use glue to attach various lengths of thread to the balls and to suspend them from the roof of the shoebox. When viewed from the open front the pattern made by the stars in the constellation as it is seen from earth should be viewed. Because not all of the stars in a constellation are the same distance from the earth the balls should be suspended at different distances from the front of the box. For the exact distances which can be used when constructing this model, send a stamped, self addressed envelope with your request to: Centennial Observatory, 93 Currie Street, Hamilton, Ontario.

Possible layout for Big Dipper

(i)



(ii)

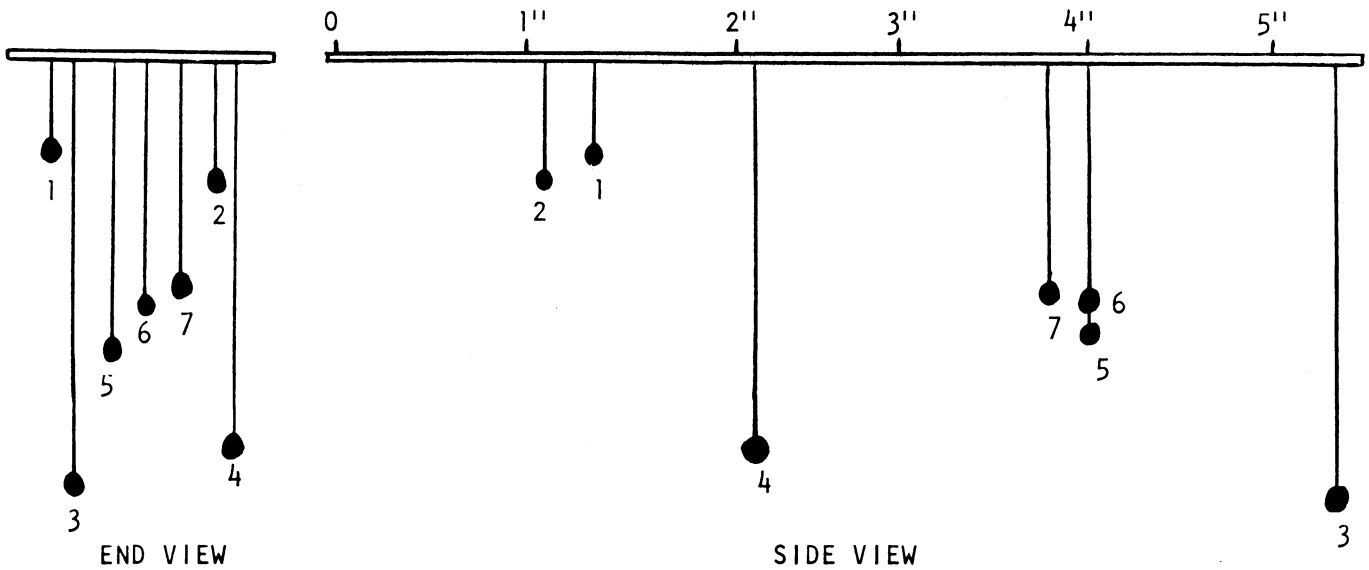


Pupil Discoveries

- a different pattern of the constellation is obtained by looking through each peep hole.
- we can only view the stars from one side here on the earth.
- the great distance from the earth to the stars doesn't allow us to see which stars are closer and which are farther away.

Orion

Use cardboard strings and beads to construct this model.



<u>No. and Name of Star</u>	<u>Distance in Light Years</u>	<u>Scale Distance in Inches</u>	<u>Length of Strings</u>
1. Betelgeuse*	520	1 3/8	1/2
2. Bellatrix	470	1 1/8	5/8
3. Saiph	2,100	5 1/4	2 1/4
4. Rigel*	900	2 1/4	2 1/8
5. Alntak	1,600	4	1 3/8
6. Alnilam	1,600	4	1 5/16
7. Mintaka	1,500	3 3/4	1 1/4

41. What constellations can be viewed?

Once the pupils have made a constellarium or umbrella planetarium and are familiar with the use of the star chart or finder, they could proceed outdoors to find and identify some of the following constellations.

Spring

Leo, the Lion (or The Sickle)
 Auriga, the Charioteer
 Gemini, the Twins
 Corvus, the Crow
 Cancer, the Crab

Summer

Lyra, the Lyre
 Cygnus, the Swan
 Scorpio, the Scorpion
 Aquila, the Eagle
 Bootes, the Herdsman
 Corona Borealis, the Northern Crown
 Draco, the Dragon
 Serpens, the Snake

Fall

Andromeda, the Maiden
Pegasus, the Horse
Perseus, the Knight
Hercules, the Hunter

Winter

Orion, the Hunter
Canis Major, Big Dog
Canis Minor, Little Dog
Taurus, the Bull
The Plaiades, Seven Sisters
Lepus, the Hare
Aries, the Ram
Cepheus, Andromeda's Father
Cassiopeia, Andromeda's Mother

NOTE: These constellations shift a little each night so their position in the sky changes. The relationships of one constellation to another, however, always remains constant. There are about 90 named constellations.

Extended Activity

Learn the legends of the constellations by doing research in the following:

- (a) The Myths of the Greeks and Arabs
- (b) The Legend of the North American Indian
- (c) Bartlett's - Dictionary of Familiar Quotations, for references to legends in the Literature.

The constellations can be used to locate bright stars.

Constellation

Star

Perseus	Algol
Boates	Arcturus
Scorpio	Antares
Cygnus	Denib
Lyra	Vega
Auriga	Capella
Leo	Regulus
Gemini	Pollux
Orion	Rigel
Orion	Betelguese
Canis Major	Sirius

These and other bright stars are used by ships and planes to help with navigation.

NOTE: When pointing out stars or constellations at night use a flashlight with a strong beam whose lens has been covered with red cellophane.

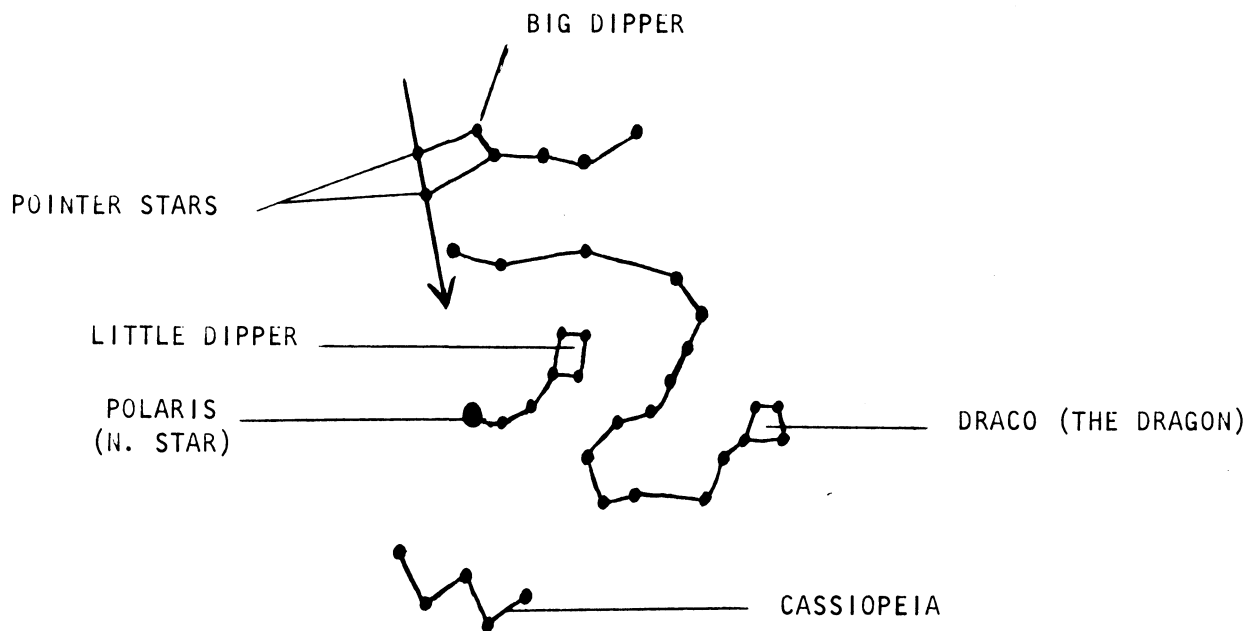
42. How can the North Star be located?

Select a cloudless night.

- (i) Find the big dipper. Locate the pointer stars. Draw an imaginary line through the pointer stars and extend it outwards from the spout of the dipper to 5 times the distance between the pointer stars to the nearest bright star you see.

- (ii) Use a compass to locate north. Face north and look half way up the sky (45°). Point to this spot and the nearest star will be the M. Star.
- (iii) Examine the north Star with a pair of binoculars and look at the other stars very near to it.

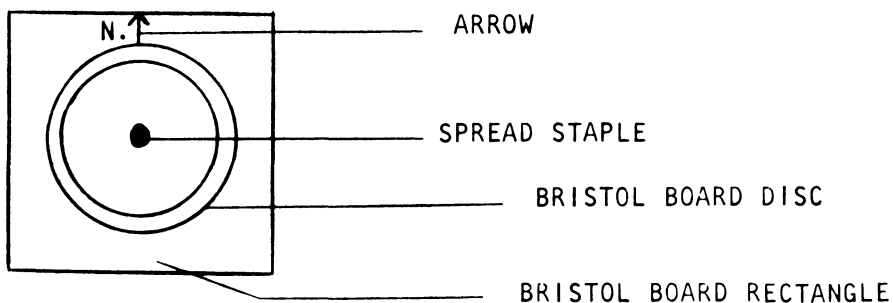
Pupil Discoveries



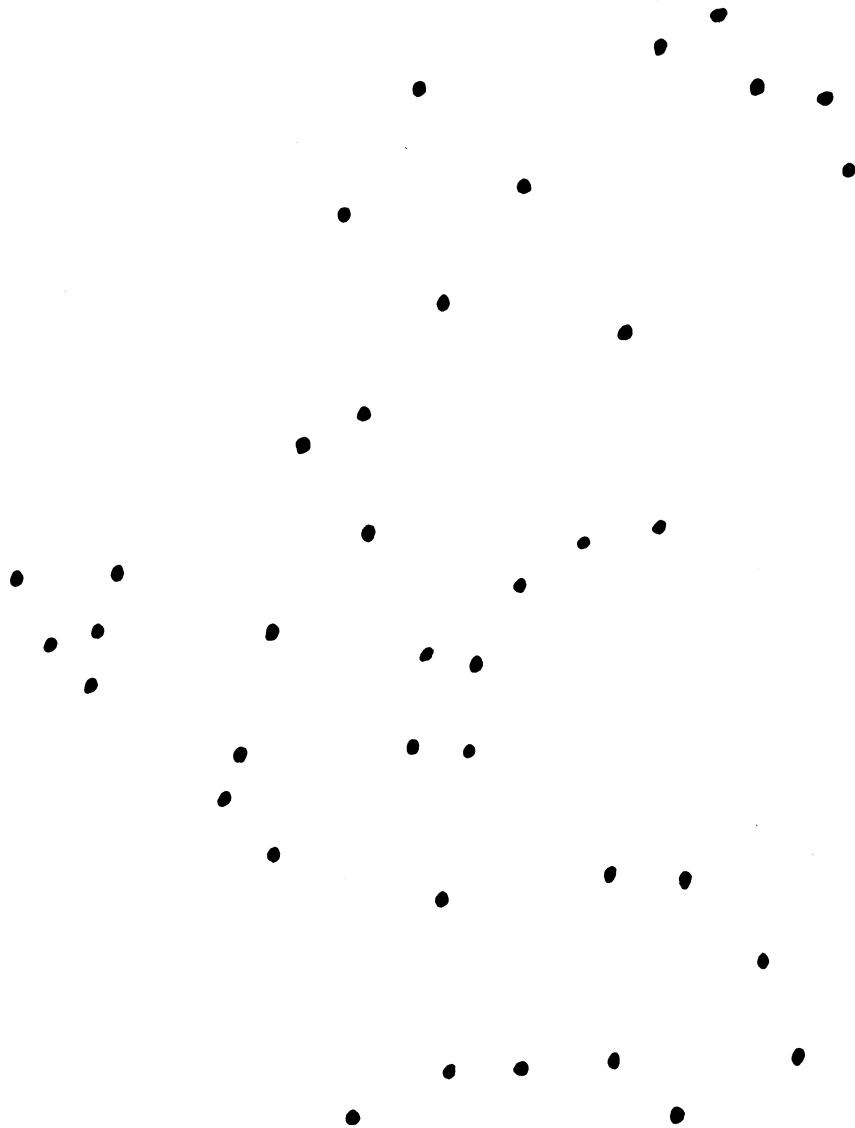
- Polaris, the north star is the first star in the handle of the little dipper.
- An imaginary line drawn through the earth at the poles (the earth's axis) and extended outward from the north pole would point to Polaris.
- Polaris is really two stars, a large one and a smaller one close by.
- Polaris can be used to help locate other constellations such as Cassiopeia, and Draco.

43. How can a simple star finder be constructed and used?

Use either a star chart or the outline which follows to mark the pattern of the constellations on a circle of bristol board. It is wise to start with the North Circumpolar constellations as they are always visible in a clear sky and relatively easy to locate in relation to the Big Dipper's position. A larger finder showing more stars could be constructed once the pupils become familiar with the principle behind this simple type. Attach the circle to a rectangular piece of bristol board using a spread staple. Place an arrow in the middle of the one side pointing to the edge.



CAN YOU IDENTIFY THESE CIRCUMPOLAR CONSTELLATIONS



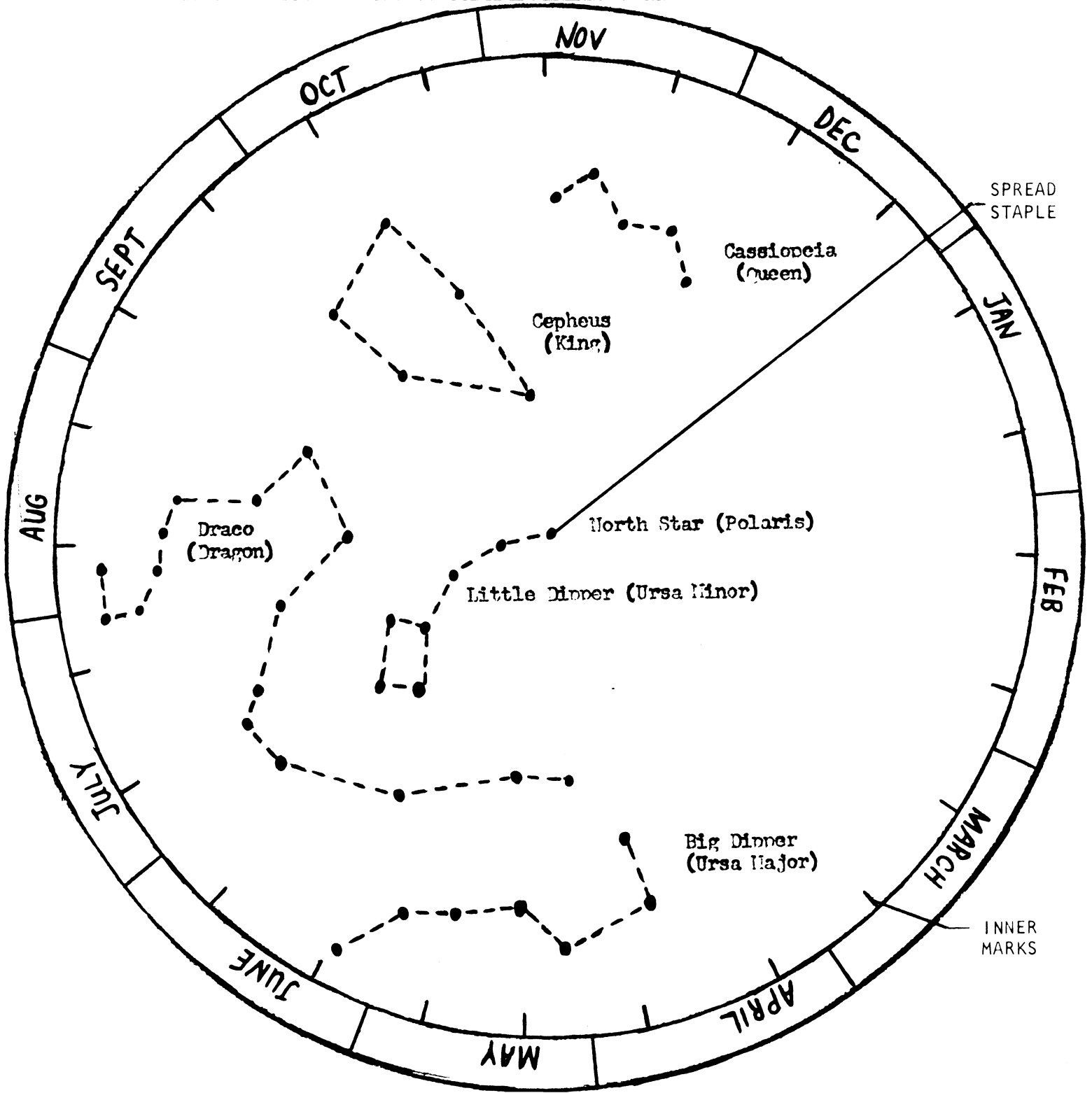
Using the Star Finder:

- 1) Face North and hold the star finder so that the arrow points to the North.
- 2) Rotate the circle until the approximate date on which the observation is being made coincides with the arrow. The map and the sky above it should correspond at about 9:00 p. m.

- 3) By turning the circle counter-clockwise, the change in position of the stars during the night can be seen. (They will seem to move in the space of one month for every two hours.)
- 4) If the star finder is to be used before 9:00 p. m., turn the dial clockwise one inner mark for each hour. If it is to be used after 9:00 p. m., turn the dial counter-clockwise one mark for each additional hour.

NOTE: The star finder should not be used until the pupils have performed other activities with constellations such as making constellariums or planetariums.

Can you identify these Circumpolar Constellations?



- 3) By turning the circle counter-clockwise the change in position of the stars during the night can be seen. (They will seem to move in the space of one month for every two hours.)
- 4) If the star finder is to be used before 9:00 p. m., turn the dial clockwise one inner mark for each hour. If it is to be used after 9:00 p. m., turn the dial counter-clockwise one mark for each additional hour.

NOTE: The star finder should not be used until the pupils have performed other activities with constellations such as making constellariums or planetariums

VI OTHER THINGS TO DO

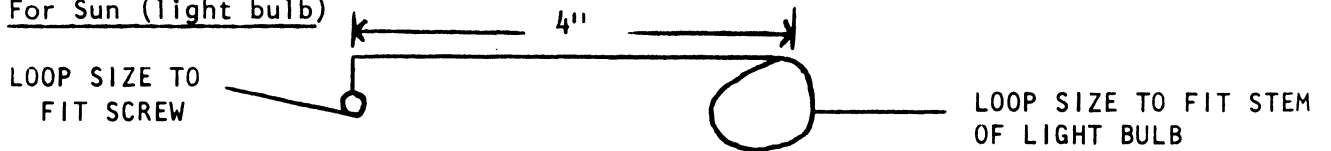
44. How can an orrery be constructed?

An orrery is a three-dimensional model of the earth, moon, sun and possibly the planets which duplicates their movements in relation to each other.

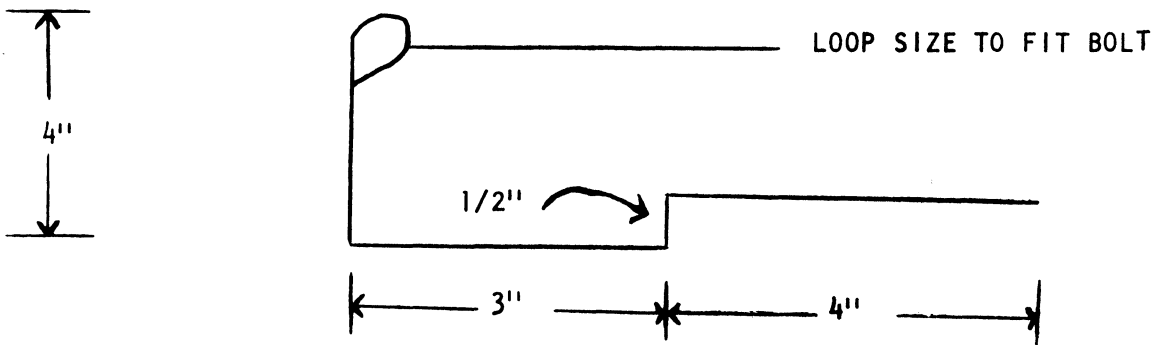
You need a ping pong ball, a large styrofoam ball, a light bulb, coat hangers, a nut and bolt, a long screw, a spool and a pair of pliers.

Cut and bend the coat hanger wires according to the following patterns.

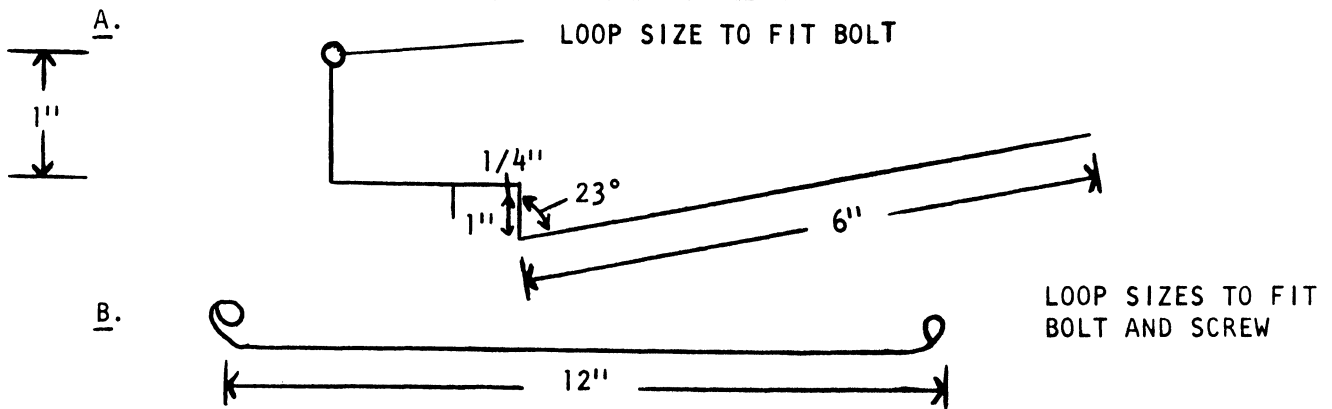
1. For Sun (light bulb)



2. For Moon (ping pong ball)



3. For Earth (larger ball, approx. 4" in diameter)



NOTE: Other wires of various lengths with balls of various diameters could be added to simulate other planet's orbits.

Paint the styrofoam ball to simulate the earth and paint one half of the ping pong ball black.

Assemble the parts as shown in the following diagram:

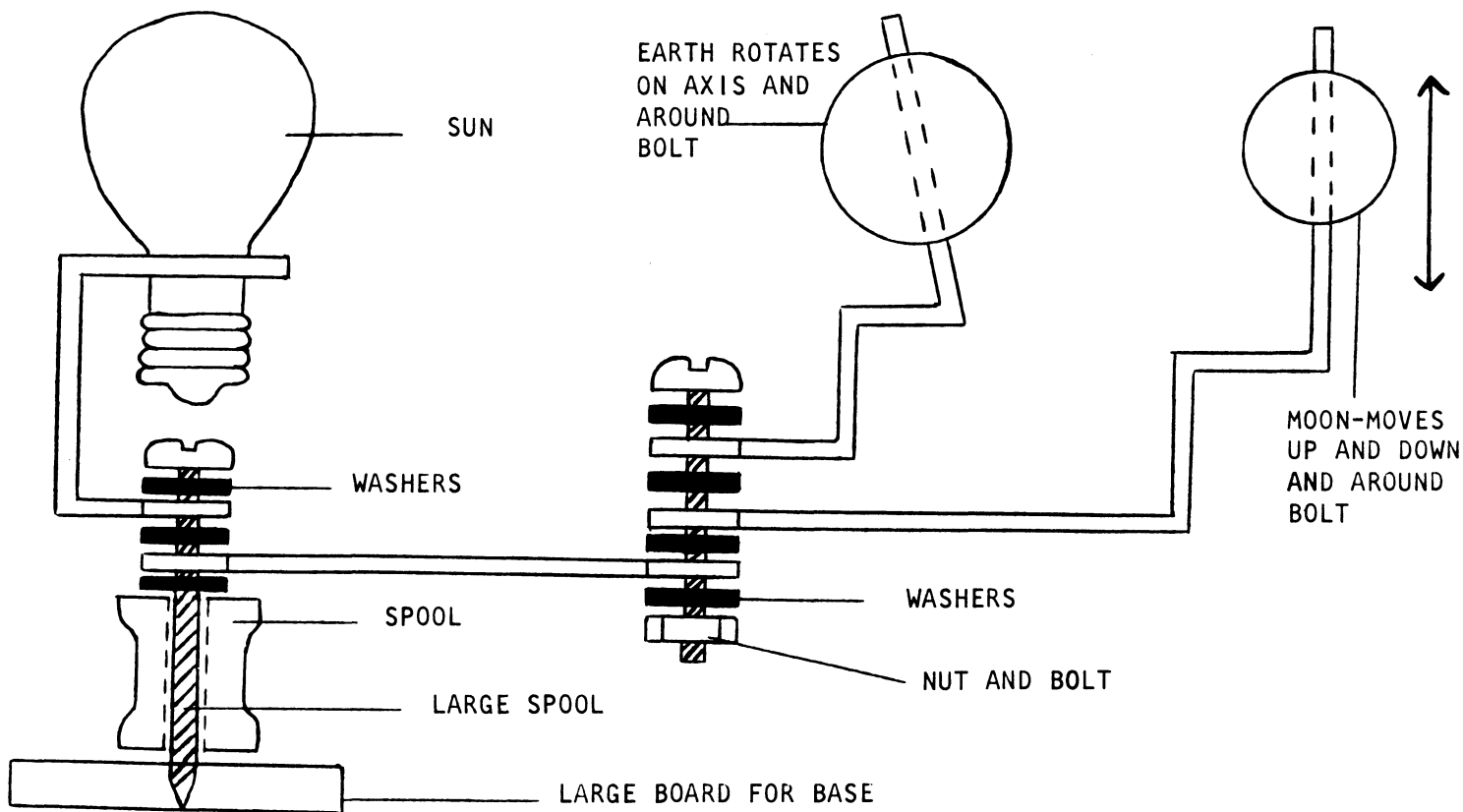


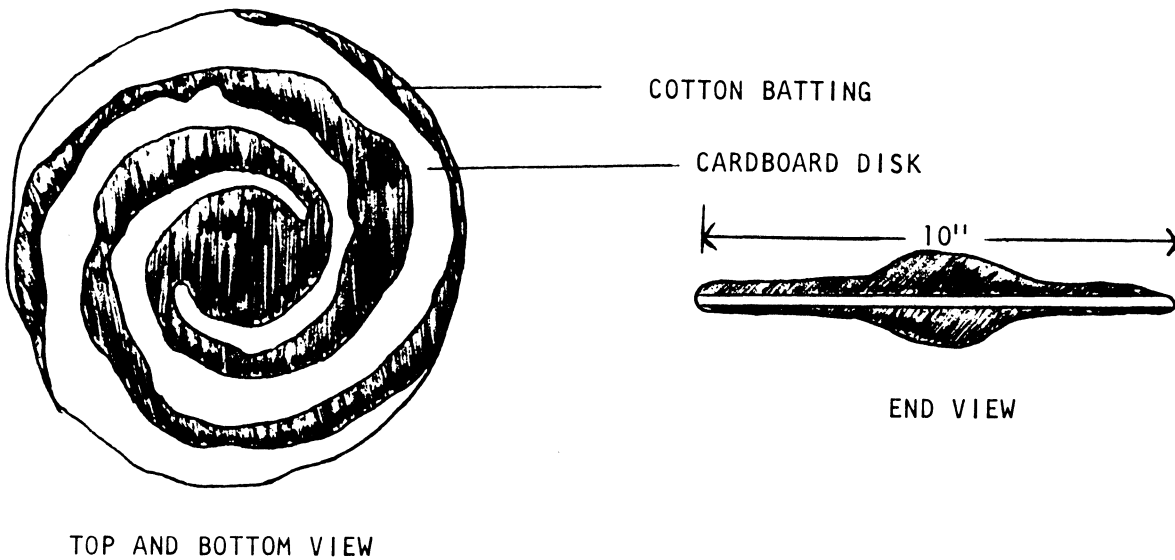
DIAGRAM IS NOT DRAWN TO SCALE

The orrery can be used to show:

1. The movements of the earth relative to the sun.
2. The movements of the moon relative to the earth.
3. The cause of the seasons.
4. The causes of eclipses.

45. How can a model of our galaxy be made?

You need a piece of bristol board, some surgical cotton and some glue. Cut a circle approximately ten inches in diameter from the bristol board. Glue the cotton to the top and bottom of the bristol board as shown in the diagrams. Tease the cotton into shape when the glue is dry.



Our galaxy is called the Milky Way. We are looking along the plane (the cardboard in the model) when we look at the Milky Way so we see a cloud-like belt of stars across the sky. Our galaxy is called a spiral galaxy.

Find the sword of the constellation Orion. Look at it with binoculars. You will see a large glowing star. This is a spiral galaxy similar to but much larger than ours. Locate the galaxy in the constellation of Andromeda 2,800,000 light years away.

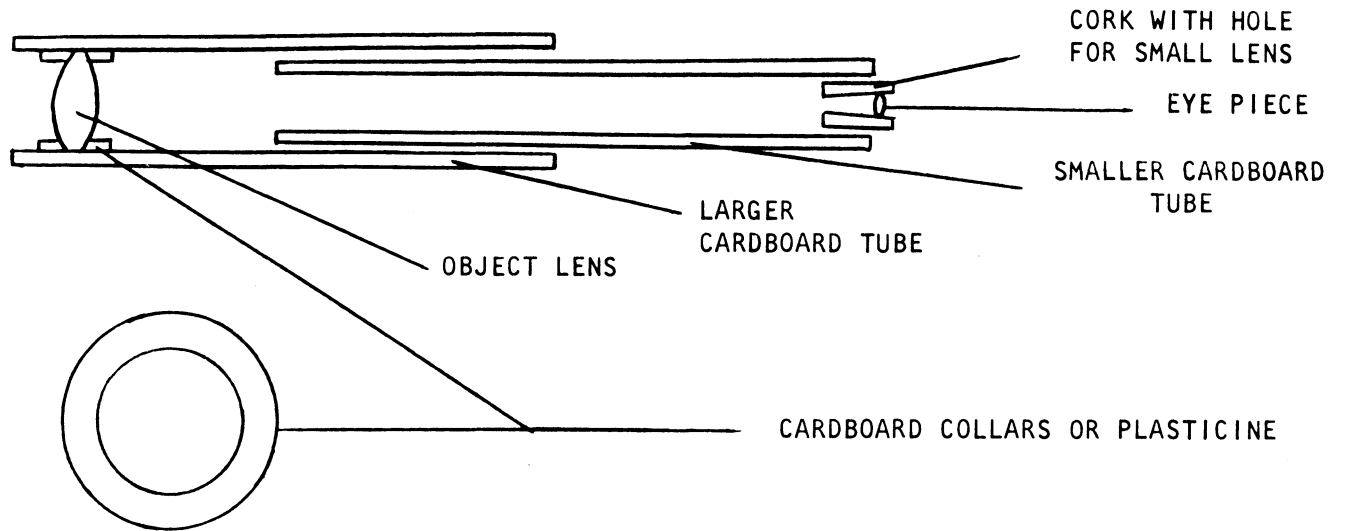
How Big is our Galaxy?

Use the information from the activity on units that astronomers use to convert these distances into miles.

Distance across or diameter of our Galaxy -- approximately 100,000 light years
Thickness at widest point of our Galaxy -- approximately 10,000 light years
Distance of Earth from centre of our Galaxy -- 30,000 light years

46. How can a refracting telescope be made?

You need two cardboard mailing tubes. One tube should be able to just fit inside the other. The tubes from paper towels or wrapping paper could also be used. Two good lenses are required. These could be obtained from magnifying glasses. If lenses are to be purchased from scientific supply houses they should be achromatic (corrected for colour distortion). The eyepiece should have a focal length of 2 or 3 centimeters while the object lens should have a focal length of 25 to 30 centimeters. The lenses can be mounted in the tubes by using plasticene, making holes in large corks or making cardboard collars. Some careful adjustment will be required to get the lens perpendicular to the sides of the tubes. The telescope is focused by sliding the tubes.

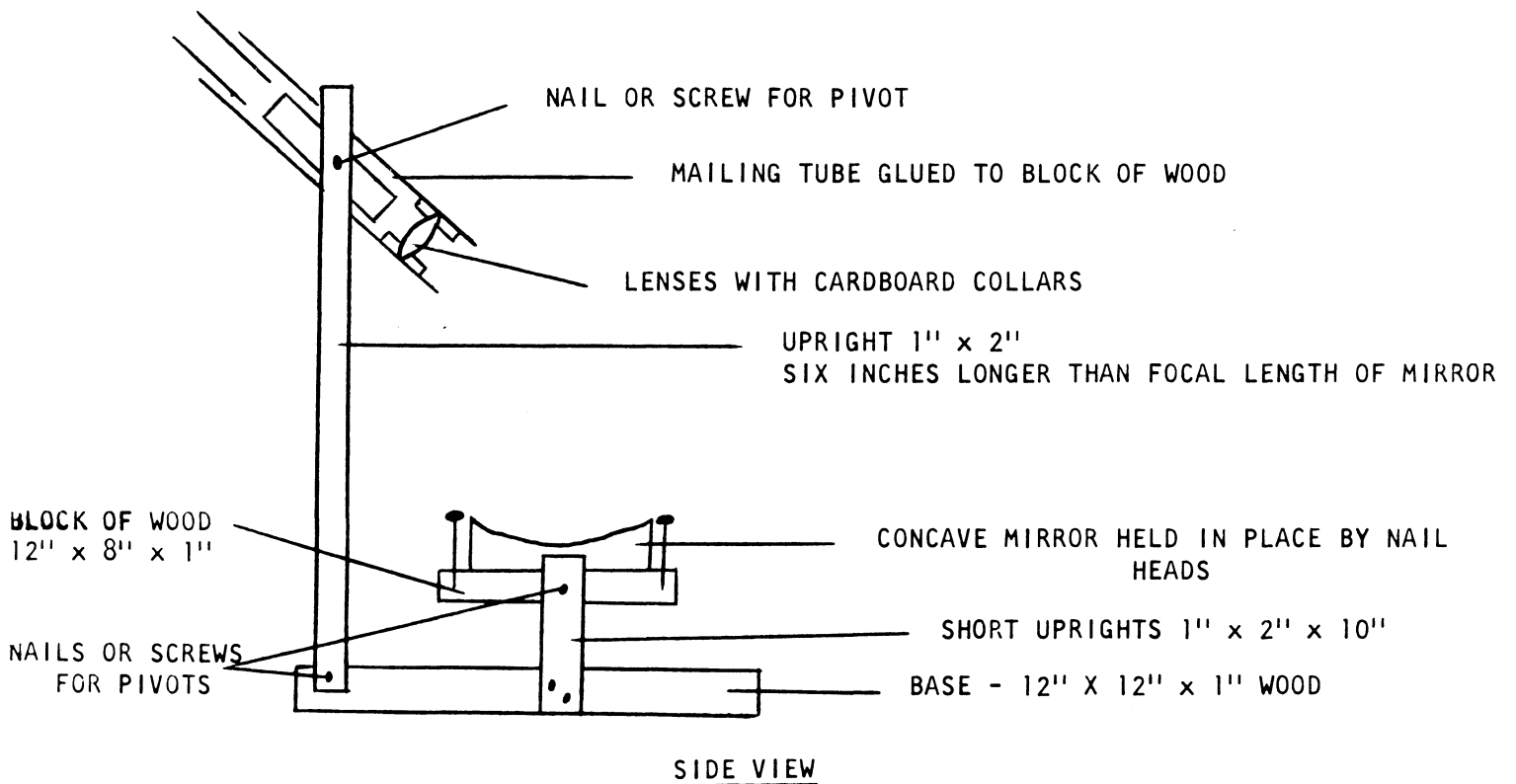


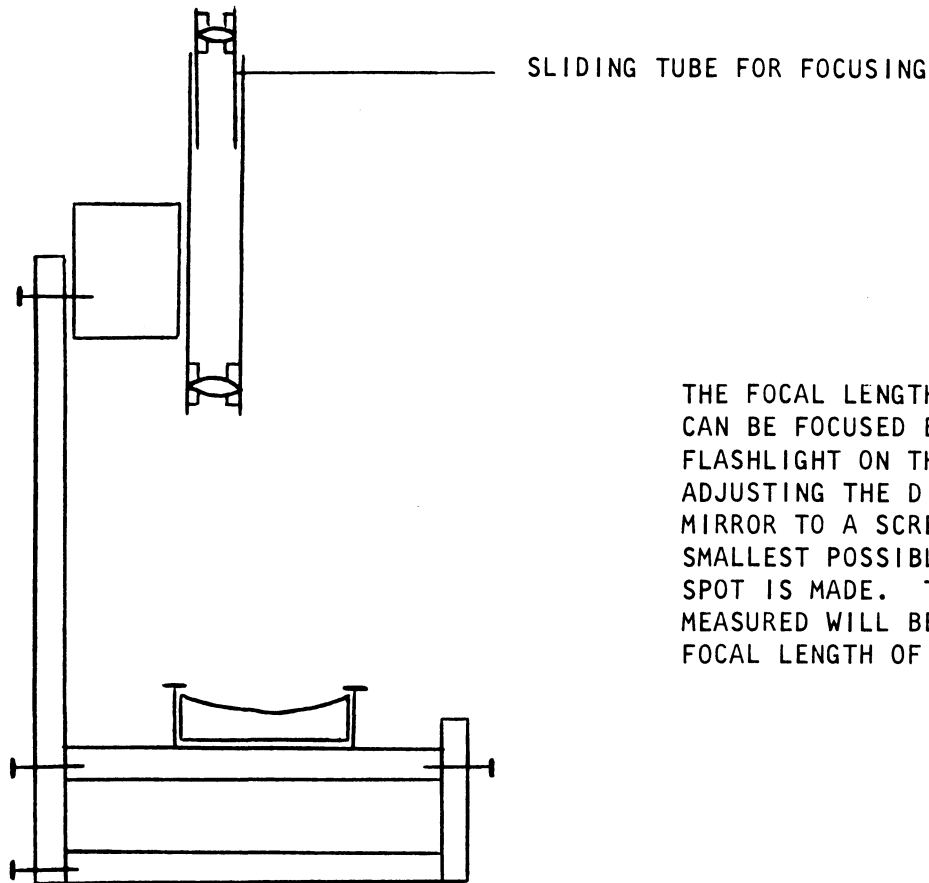
A telescope such as this is suitable to observe the surface of the moon, Jupiter's moons but not Saturn's rings.

47. How can a reflecting telescope be made?

You need a concave shaving mirror, two mailing tubes, two lenses with short-focused lengths, some nails and several blocks of wood.

Assemble the parts as shown in the diagram.





THE FOCAL LENGTH OF THE MIRROR CAN BE FOCUSED BY SHINING A FLASHLIGHT ON THE MIRROR AND ADJUSTING THE DISTANCE OF THE MIRROR TO A SCREEN SO THAT THE SMALLEST POSSIBLE IMAGE OF THE LIGHT SPOT IS MADE. THIS DISTANCE WHEN MEASURED WILL BE VERY CLOSE TO THE FOCAL LENGTH OF THE MIRROR.

FRONT VIEW

To use the reflecting telescope tilt the mirror and turn the stand so that the mirror is perpendicular to the light coming from the object to be viewed. Tilt the upright arm and the cardboard tubes so that the object can be seen in the mirror. Slide the smaller mailing tube so that the object becomes as clear as possible.

48. What are some units used by astronomers?

(a) A Light Year

A light year is the distance that light would travel in one year.

Light travels at the speed of approximately 186,000 miles each second. The number of seconds in a year can be calculated (60 sec. x 60 min. x 24 hours x 365.25 days). Multiply this number by 186,000 miles and your answer will be in miles (approximately 6,000,000,000,000).

If this answer is used to find the distance in miles to the nearest star (Alpha Centauri 4.3 light years) the need for these units will become obvious.

(b) The Astronomical Unit

An astronomical unit is the average distance from the earth to the sun which is 93 million miles (93,000,000).

The pupils might like to work out Bode's Law which is an easy way to find the distances from the sun to the planets.

Write down the following series of numbers:

0 3 6 12 24 48 96 192 384

Now add 4 to each:

4 7 10 16 28 52 100 196 388

Divide by 10:

.4 .7 1.0 1.6 2.8 5.2 10.0 19.6 38.8

The resultant series of numbers represents the distances from the sun of the planets, in astronomical units (1 Ast. Unit = 93 million miles).

Example: The Earth is 1.0 A.U. from the sun. Mars is 1.6 A.U.

Please note that the 2.8 represents the asteroid belt between Mars and Jupiter. Sorry -- this doesn't work for Pluto as this planet was not discovered when Bode made this little mathematical discovery.

49. What research could be done?

(a) The Bibliography of a Famous Astronomer

The lives of such people as Aristotle, Ptolemy, Copernicus, Tycho, Halley, Herschel, Foucault, Newton, Kepler could be investigated. In many cases, attempts could be made to duplicate the findings of the earlier astronomers.

(b) A Picture Collection of Celestial Objects

The following might be included:

Galaxies, Nebulae, Comets, Meteors, Asteroids, Planets, Novae, Cepheids, Binary Stars, Star Clusters as well as types of telescopes and observations.

Write to the California Institute of Technology Book Store, 1201 East California Blvd., Pasadena, California 91109 and request their catalogue of Photographs and Slides for the Mount Wilson and Polaris Observations and also for Space Exploration.

(c) Space Exploration and Astronomy

Recent rocket flights to Mars, Venus and the Moon could be investigated to discover the methods used and new information learned by Surveyor I, Mariner IV and others.

50. What trips and visits can be organized?

1. Visit the David Dunlap Observatory, Richmond Hill, Ontario. It is open Tuesday mornings 10 to 11 A. M.
2. Visit the Planetarium at McMaster University. Telephone the University, Extension Department for reservations.
3. Visit Centennial Observatory. Write for reservations to Centennial Observatory, 93 Currie Street, Hamilton for groups of up to ten people at one time.
4. Teachers -- attend a meeting of the Royal Astronomical Society of Canada, held on the first Thursday of every month from October to May in Room 143 of the Physical Sciences Building at McMaster University.
5. Have a team of Royal Astronomical Society members visit your school some evening. They will present a slide talk and other demonstrations. Telescopes will be brought and actual observations made weather permitting. Write to the Director of Public Service, Royal Astronomical Society of Canada, P. O. Box 272, Hamilton, Ontario. This service is free in Hamilton and district. Transportation costs will be charged for visits to other points.

51. When can meteor showers be observed?

Meteor showers occur annually at approximately the same dates every year. They are named according to the constellation near which they appear in the sky. ie. To see the Orionides look near the constellation of Orion on or near the date suggested below.

1. Quadrantids	January 4	6. Orionids	October 21
2. Lyrids	April 22	7. Taurids	November 5
3. Aquarids	July 29	8. Leonids	November 17
4. Perseids	August 12	9. Geminids	December 13
5. Giacobinids	October 9	10. Ursids	December 22

When astronomers observe meteor showers they record the following:

1. Constellation in or near which shower originated.
2. Date
3. Time
4. Number seen
5. Direction (ie. E. to W. etc.)

For more precise dates and times, send a stamped self-addressed envelope to Centennial Observatory, 93 Currie Street, Hamilton.

52. What is the sun's position in relation to the stars?

You need a piece of bristol board, a box lid, a spread staple and a paper clip.

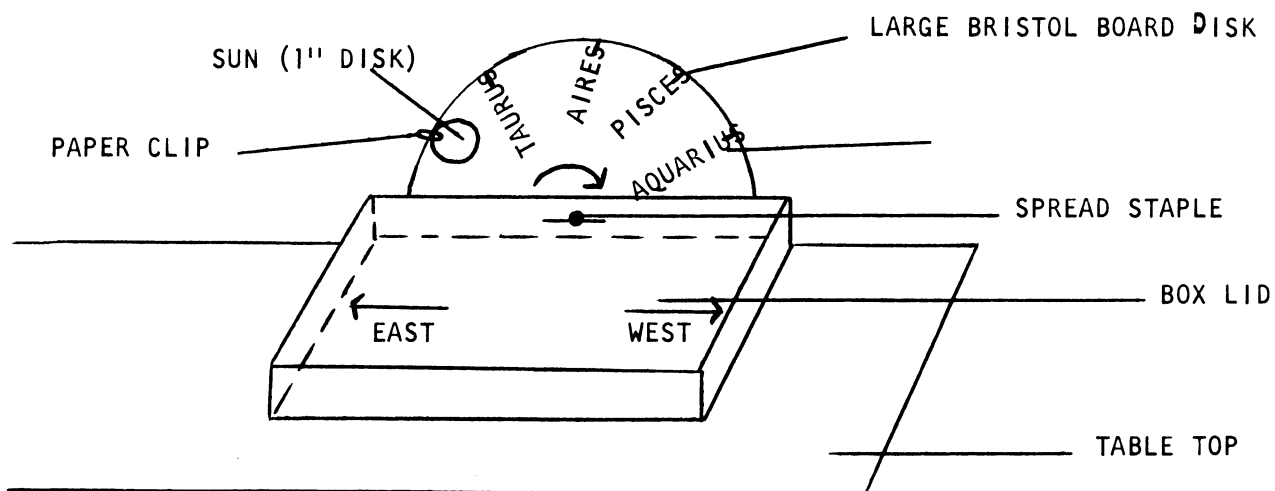
Cut a disk slightly smaller than the width of the box lid from the bristol board. Divide the edge of the disk into twelve equal parts. Write the names of the following constellations beside each mark proceeding in a counter-clockwise direction and in this order: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius and Pisces.

Mount the disk on the edge of the box lid with a spread staple placed through a hole in the lid and the centre of the disk. Place the lid on the edge of a table so that the disk can be turned freely.

The box lid represents the horizon and should be labelled EAST AND WEST as shown in the diagram.

Cut out a second disk about one inch in diameter and attach it to the large disk with a paper clip so that it will cover any one of the names of the constellations.

Face the disk and rotate the constellations from East to West to simulate the apparent motion of the sun. When the sun is visible above the box lid (the horizon) the stars are invisible because they are blocked out by the sun's light but they are really still there.



Pupil Discoveries

- The pupils can discover which constellation will precede the sun's rise or the sun's set by rotating the disk.
- The sun is seen near a different constellation each month as shown in the following table.

September	LEO	March	AQUARIUS
October	VIRGO	April	PISCES
November	LIBRA	May	ARIES
December	SCORPIO	June	TAURUS
January	SAGITTARIUS	July	GEMINI
February	CAPRICORNUS	August	CANCER

These constellations were used by early astronomers to trace the sun's apparent motion through the sky from month to month. These constellations form what is called the signs of the zodiac. They are used in the false science of Astrology by astrologers to predict a person's future.

53. Games

Science can be not only informative and fascinating for children, but fun as well. This does not presuppose that science knowledge is acquired only by games. However, used wisely, they can enrich and supplement any science program.

MINUS TWO:

Grade Level: 5 - 6

Number of Players: Class

Area: Astronomy

Suggested Purposes:

1. To evaluate the class on their understanding of astronomy.
2. To enable the child to put his knowledge of astronomy to work.

Materials: None

Instructions:

Divide the class in half and make two Teams, A and B. Each will have 100 points. Each member of Team A thinks of an answer to a possible question concerning astronomy. One member of Team A will repeat his answer twice. Team B has 30 seconds to formulate an appropriate question for the answer. If Team B can devise an acceptable question, Team A loses 2 points. If Team B can not, it loses two points. Each member on Team A should have one turn before Team B's opportunity to give answers. When Team B finishes, the game ends. The team with the most points wins.

CONSTELLATION QUICKIE:

Grade Level: 3 - 6

Number of Players: Class

Area: Astronomy

Suggested Purposes:

1. To introduce a lesson on constellations.
2. To review past knowledge of constellations.

Materials: Twenty-five 3 x 5 cards with a different constellation drawn on each card.

Instructions:

One person will be the leader. He will flash a card to each member of the class individually. If his classmate identifies the constellation correctly he may have another turn. If he names the card incorrectly, he is out. The last five children should be declared the winners.

QUESTIONS AND ANSWERS:

Grade Level: 5 - 6

Number of Players: Class

Area: Astronomy

Suggested Purposes:

1. To review information for a test.
2. To further develop scientific skills of concentration, thinking, and listening.

Materials: Write a question pertaining to astronomy on a 3 x 5 card. Make separate answer card.

Instructions:

Form two teams (A and B). Make two stacks of cards, one for questions and one for answers. Give one pile to Team A and one to Team B. Pass out one question card and one answer card to each student. The teacher calls on a member of Team A to read one of his cards. If he reads a question, the person on Team B who has the answer to that question reads it. If the Team A member reads an answer, the Team B member would read the question. If the wrong person answers, or two or more answer, or no one answers, the other team gets five points. If the team replies correctly it gets five points. The team that won the previous round reads its card next.

OBSERVATORY:

Grade Level: 5 - 6

Number of Players: Class

Area: Astronomy

Suggested Purposes:

1. To help the child become more observant of his environment.
2. To provide an alternative lesson when teaching observation skills in astronomy.

Materials: Enough 6 x 12 cards for the class. On each card write a different name of a planet, star, or constellation. Write the word "astronomer" on one card.

Instructions:

Pass out the cards to the class. At the front of the room, draw a circle with a three foot diameter. This circle will be the "observatory". Select one child to be the "astronomer" who will stand or sit in the observatory. The astronomer will study the class which is called "universe". Then he closes his eyes. The class members change seats. The teacher selects one member to leave the room. On a signal from the teacher the astronomer will open his eyes and try to guess the name of the member of the universe that is missing. Allow the astronomer three chances and then change astronomers. (The astronomer should not give the child's real name but the name on the 6 x 12 card which he thinks the child held.)

CONCENTRATION:

Grade Level: 5 - 6

Number of Players: Class

Area: Astronomy

Suggested Purposes:

1. To evaluate children's spelling ability.
2. To develop the children's power of concentration.

Material: Twenty to thirty 6 x 12 inch cards. Each card should have one word on it with two or three of its letters missing. All of the words must be related to the astronomy unit. For example:

Z--ith Zenith -o-p-s- compass
--ri-on Horizon

Instructions:

Have ten children stand in front of the class each holding a card. The class will have three minutes to study the cards. They should not write anything during the three minutes. On a signal from the teacher the ten card holders will leave the room. The class will have two minutes to write the ten words on the cards on their papers. They must spell the words correctly (filling all missing letters) and put them in the proper order. After two minutes, the teacher will have the class exchange papers and then call the ten card holders back in. The children will then correct their papers. The students, with the highest numbers correct, win the game.

PLANET, CONSTELLATION, OR STAR:

Grade Level: 5 - 6

Number of Players: Class

Area: Astronomy

Suggested Purposes: 1. To provide the teacher with an idea of the background in astronomy that the class may already have.
2. To provide a review and evaluation.

Instructions:

Have the class form a circle and choose one student to be leader. He stands in the centre of the circle. He says, for example, "Planet, Constellation, or Star,--Star," and then points to a class member and counts to five. If the person pointed to gives the name of a star (or of a planet or of a constellation), he remains the leader. If the person pointed to gives a wrong answer or no answer they exchange places.

ASTRONOMY SPELLER:

Grade Level: 5 - 6

Number of Players: Class

Area: Astronomy

Suggested Purpose: 1. To review vocabulary in astronomy unit.

Materials: Two sets of alphabet cards.

Instructions:

Divide the class into Team A and B. Give a set of alphabet cards to both teams. Then distribute the cards among the team members. The teacher says a word related to the study of astronomy, such as "gravitation," "moon," etc. The team members that have letters in the word called **must rise** quickly and form the word (standing in back of their team). If the letter appears twice in a word (like "t" or "a" in gravitation) the child must go back and forth between the two spots. The first team to form the word correctly wins five points. The cards should be held with the letters visible.

VII REFERENCE MATERIALS

Books:

Henessey, Elementary Teachers' Classroom Science Demonstrations and Activities, Prentice Hall, Chapter 10.

Hone, Joseph, Victor, A Sourcebook for Elementary Science, Harcourt, Brace and World, Chapter 10.

Johnson and Adler, Discover the Stars, Sentinel Books.

Rockcastle, Earth and Beyond, Cornell Science Leaflet, Vol. 52 #1, Cornell University.

Serviss, Astronomy with an Opera Glass, Chatham Press.

Unesco, Source Book for Science Teaching, Unesco, Chapter 6.

Victor, Science for the Elementary School, Macmillan, Chapter 9.

Books You May Want For Your Class:

Barlow - "A Child's Book of Stars" -- Ryerson Press.

Freeman - "Fun with Astronomy" -- Random House.

Hood - "Let's Look at the Stars" -- Houghton Mifflin.

Moore - "Amateur Astronomer's Glossary" -- Lutterworth Press

Moore - "Exploring the Planetarium" -- Odham's

Moore - "Exploring the Moon" -- Odham's

Moore & Brinton - "Exploring Other Planets" -- Odham's

Olcott - Field Book of the Stars -- Putnam's Sons

Zim - "The Sun" -- McLeod

Zim & Baker - "Stars" -- Moyer

Magazines, Charts, Periodicals:

Sky and Telescope - A monthly magazine for advanced amateurs. Subscription is \$8 per year. Sky Publishing Corporation, 49 Bay State Road, Cambridge, Mass., U.S.A., 02138.

Planetarium - A quarterly publication for the layman. 2 shillings 6 pence per copy (about 30¢), The Planetarium, Armagh, Northern Ireland.

Orbit - 5 times per year. At present free of charge. A newsletter published by the Hamilton Centre of the Royal Astronomical Society of Canada. A self-addressed stamped envelope should be sent to: Orbit, R.A.S.C., P. O. Box 272, Hamilton Ontario.

National Aeronautics and Space Administration (NASA) - Publications are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Catalogue of Publications - Sky Publishing Corporation, 49 Bay State Road, Cambridge, Massachusetts, U. S. A. 02138

Catalogue of Optical Parts - Available free of charge from: Optics of Canada, P. O. Box 4, Station C, Hamilton, Ontario.

Films:

Exploring the Night Sky

Gravity - How It Affects Us

This is the Moon

Trip to the Moon

Beyond our Solar System

Universe - 1. Our Solar System
2. Beyond the Planets

Day and Night

Reaching into Space

Understanding our Universe

Why Seasons Change

* These films can be obtained from the Audio Visual Department.