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Practical Illustrations of Astronomical Concepts relating to the Solar System

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This curriculum unit is intended for eighth grade students enrolled in Earth Science classes for a period of two weeks. It will encompass topics on light, optical telescopes, solar and lunar eclipses and seasons. To further increase students' understanding of astronomical concepts, a hands-on approach will be adopted in this unit hoping to spark an interest in Space Science.

For thousand of years people like the Egyptians and Chinese have been very eager to explore the universe and to explain the mysteries that surround our blue planet. Both Greeks and Romans believed that the earth was the center of the universe. The Egyptians thought that the earth was shaped like a rectangular box and the Chinese did not know whether the sun revolved around the earth or the earth around the sun. Today, with the invention of the telescope, we have been able to discover amazing objects far, far away from our planet, such as other galaxies, quasars and supernovas. To understand certain methods astronomers use to extract information about celestial bodies comes from analysis of their visible light. Other methods include X-rays, UV, IR and Radio waves.

OBJECTIVES

Students will be able to:

- o describe a ray of light and explain how light waves travels
- o identify and understand the parts of an electromagnetic spectrum
- o understand the significance of the various types of spectra
- o describe and demonstrate how mirrors reflect light

THE NATURE OF LIGHT

Significant information about celestial bodies and the universe comes from an analysis of their visible light. A basic property of an isolated light is that it travels in a straight line. This property can be demonstrated when one turns on a flashlight and observes a ray of light emitted by the flashlight. However, light can change direction under certain conditions, for example, when it is reflected from a surface. When light is not completely absorbed by an object, the light will be reflected. Placing objects, for example, a book in front of a mirror will show a mirror image of the book. A mirror therefore reflects light and forms images.

When light moves from one medium to another, the direction of light changes. The path of the light will be bent, or refracted. This concept may be demonstrated by passing a beam of light into a glass filled with water. The direction a ray of light travels changes when it passes from one medium such as air into another such as glass. This bending of light as it passes from one medium to another is called refraction.

Light is a type of electromagnetic wave. It is made up of the colors of the visible spectrum. The color with the longest wavelength is red and the color with the shortest wavelength is violet. Some electromagnetic waves have shorter and longer wavelengths than the visible spectrum. Light with a wavelength that is slightly longer than red light is called infrared light. Light with a wavelength that is slightly shorter than violet light is called ultraviolet light. Infrared and ultraviolet light are not part of the visible spectrum and cannot be seen by the human eye. Visible light is only a small part of a larger electromagnetic spectrum. The electromagnetic spectrum includes radio waves, infrared rays, visible light, ultraviolet rays, X-rays and gamma rays.

- radio waves have the longest wavelength and the lowest frequency. They are used for radio, television and radar.
- infrared rays can be felt as heat.
- ultraviolet rays are present in sunlight. They can cause sunburn and also be used to kill bacteria.
- x-rays have a very short wavelength an high frequency. X-rays have a great deal of energy and are used to make images of internal organs.
- gamma rays have a shorter wavelength and high frequency than x-rays. They are given off during nuclear reactions.

When light is not completely absorbed by an object, the light will be reflected. Reflection occurs when a wave of light bounces back after striking a barrier. When a beam of light strikes a smooth surface, the light is reflected at the same angle. For example, the light reflected from the surface of a still pond will form clear images of the objects around the pond.

There are two types of reflection: a) regular reflection b) diffuse reflection. Regular reflections are formed by a mirror which reflects light and forms images. A beam of light striking a mirror at a certain angle will be reflected from the mirror at the same angle. The mirror forms a clear image because of its smooth surface. In the case of diffuse reflection, the light will be reflected at different angles forming a fuzzy image. The rough surface upon which light strikes will also accounts for an unclear image. For example, the surface of a pond will not be smooth on a windy day. Thus the light reflected on the surface of the pond will form fuzzy images.

- o Students will study how lenses and mirrors form images.
- o Students will observe and discuss mirror images of various objects .
- o Students will list and describe as many optical instruments that use lenses.
- o Students will form images using convex lens.

As previously mentioned light travels in a straight line. However, when light moves from one medium to another, the direction of the light changes. When a beam of light passes from air into glass, the path of light will be bent or refracted. The glass is the transparent material used in most lenses that refracts light. There are two main types of lenses:- a) Convex lenses b) Concave lenses. Light passing through a convex lens is bent inwards whereas light passing through a concave lens is bent away from the lens. Within a convex lens the light rays are brought together at a focal point. As the light leaves the lens, it is also refracted. The amount of refraction depends on the curvature of the lens. The lens in our eyes is an example of a convex lens which projects a real image on to the retina of the eye upside down.

OBJECTIVES

Students will be able to :

- o explain what causes solar and lunar eclipses
- o recognize and identify the different phases of the moon
- o determine the sequence of lunar phases

Our planet's satellite, which we call the moon continues to remain an object of fascination and inquiry for astronomers and other scientists who study not only its motion but materials such as rocks brought back from its surface. The moon is the easiest astronomical object to observe with the naked eye. For many students, the moon appears to them in many different forms related to its changing appearance. They sometimes ask, " Why does the moon appear to change shape?" The moon appears to change shape because of the way it reflects light from the sun. The changing shapes of the moon are called phases. The phases of the moon depend upon the positions of the sun, the moon and the earth.

The moon's orbit around the earth once in about twenty-eight days changes what part of the moon is lighted by the sun and how much of that part can be seen from the earth. We all see the moon because sunlight reflects back to us from its surface. During the course of the month, the moon circles once around the earth. That portion of the moon facing the sun is always lit; however, this lit-up side does not always face the earth. As the moon circles the earth, the amount of its disk facing us that is lit by the sun changes, altering how much of the lunar surface appears bright and how much is in darkness. These changes, called phases repeat in a specific cycle each month. These phase range from new to waxing crescent, first quarter , waxing gibbous and full, then reversing to waning gibbous, last quarter, waning crescent and new to begin the cycle again. The focus of this section will be on the four primary phases: New moon, First Quarter, Full Moon and Last quarter.

Since ancient time, it has been known that the phases change as the angle made by lines from the Sun to the Moon to the Earth changes. As this angle changes, the fraction of the moon's illuminated side visible from earth changes. This phase changes as the angle between the Sun, Moon and Earth changes. For example, when the moon is on the opposite side of the Earth from the Sun, we see all of its illuminated surface and call it "full moon". As the moon revolves around the earth, a small part of it becomes visible. When the moon is in approximately the same direction as the sun with its dark side facing us, this is referred to as a "new moon". As the moon revolves around the earth, its visible portion increases and it is known to be waxing. The first phase is called the waxing crescent phase. Less than half of the moon is visible at this phase. When the moon has moved one-quarter of the way around the earth, it enters the first-quarter phase. At this phase one half of the side of the moon facing the earth is visible. As the moon continues in its orbit more and more of the side facing the earth becomes visible. This is called the waxing gibbous phase. More than half of the moon is visible during this phase. Finally, the moon completes half of its trip around the earth. The whole surface of the moon facing the earth is now visible. This is called the full moon. As the moon continues to move around the earth, less and less of the surface is visible. This phase is referred to as the waning gibbous phase. The last phase of the moon is the waning crescent phase. Consequently, the moon takes approximately 29.5 days to go through all of its phases.

ENGAGEMENT

Students will be encouraged to demonstrate these phases thus uncover any misconceptions they may have about how the moon's appearance changes.

- students will observe, describe and sequence "lunar phase photos".
- this activity will be extended to observing the moon in the night sky over a period of time to really see how the moon's appearance actually changes.
- students will make a daily , visual record of moon observations and try to make predictions of the moon's phases.
- students will create a "lunar calendar" identifying each of the moon's phases.

ECLIPSES

Everybody in the solar system carries a shadow along with it as it moves around the Sun. A shadow is formed when an object blocks a light source. When one body enters the shadow of another, an eclipse occurs. The moon phase activities mentioned above will stimulate students in understanding the simulation of both lunar and solar eclipses.

OBJECTIVES

Students will be able to:

- o distinguish between lunar and solar eclipse
- o model how lunar and solar eclipses occur
- o predict when an eclipse is most likely to occur

As the moon revolves around the earth, it usually passes above or below the earth's shadow. Sometimes the moon passes directly through the earth's shadow. As a result sunlight is blocked from reaching the moon. When sunlight is blocked from the moon, a lunar eclipse occurs. That is the earth's shadow falls on the moon and will darken significantly, but not disappear. The dark part of a shadow is called the umbra and the lighter part of the shadow is called the penumbra. Sometimes the moon moves entirely into the earth's umbra. When this happens, all of the sun's light is blocked. The entire face of the moon darkens. This is called a total lunar eclipse. At other times only part of the moon moves into the earth's umbra. However, sunlight can still reach the moon. As a result, only part of the moon darkens. This is called a partial lunar eclipse.

Solar eclipses occur when the moon passes between the sun and the earth, temporarily blocking sunlight over a small portion of our planet's surface. The shadow of the moon usually moves from West to East across the earth . People in the path of the shadow may see one of three kinds of solar eclipse. Namely, (a) total

eclipse , (b) annular eclipse or (c) partial eclipse. A total eclipse occurs if the moon completely blots out the Sun. If the moon is at its farthest point from the earth when a total eclipse occurs, the eclipse may be only an annular eclipse . In such an eclipse, the moon darkens only the middle of the Sun, leaving a bright ring around the edges. A partial eclipse occurs if the moon covers only part of the Sun. A solar eclipse should never be viewed directly. One must be careful to avert his or her eyes when a sliver of the photosphere becomes visible.

SEASONAL CHANGES

Students usually have difficulty understanding why seasons occur on our planet. A common response is, because the earth is closer to the sun in Summer and farther away during Winter. In an effort to dispel these misconceptions, students will be engaged in an activity to help note the factors contributing to seasonal changes.

Students will soon find out that the length of daylight and the angle of the sun in the sky at noon can affect seasonal change.

OBJECTIVES

Students will be able to:

- o explain what causes seasons
- o explain why days are longer in the Summer and shorter in the Winter

THE SEASONS

Earth rotates around its axis, an imaginary line that goes through the North and South poles. This axis is tilted 23.5 degrees. The earth's axis is tilted toward the sun for part of the year, and tilted away from the sun for the other part of the year. Therefore, the sun's rays strikes different parts of the earth at different angles. Earth has four seasons because it gets varying amounts of sunlight as it orbits the sun. The seasons therefore are a product of Earth's revolution about the sun and of the 23.5 degree tilt in the earth's axis.

When the Northern Hemisphere is tilted towards the sun, it receives direct rays. Direct rays heat much more than slanted rays from the sun. During this time, the Northern Hemisphere will experience more hours of daylight. As a result of direct heat and more daylight hours, the earth receives more heat. This increase in temperature causes Summer. At the same time the Southern Hemisphere is tilted away from the sun. The sun's rays are slanted and cause the heat to spread over a greater area. There are also fewer daylight hours. The combination of less daylight hours and slanted rays cause the earth to receive less heat. This drop in temperature causes Winter.

About June 21, Earth's axis tilts most toward the sun. Summer officially begins above the Equator, on the northern part of the world. On the same day, sunlight hits the southern part of the world at a slant, delivering less heat where Winter officially begins. Six months later, Earth's axis tilts most away from the sun. About December 22, the seasons are reversed in the world. Winter starts in the Northern Hemisphere while Summer starts in the Southern Hemisphere.

Twice a year, around March 21 and September 23, the sun shines directly over the equator. All parts of the world have equal day and night. These days are called the equinoxes.

OPTICAL TELESCOPES

Our eyes can see only a few of the wonders of space, but we can see many more with the use of a telescope. Even a small telescope can help us to see distant stars and galaxies that are too faint to see with our naked eyes.

Space exploration is a great pathway by which scientists gain knowledge about the earth and answer many questions about the universe. Orbiting telescopes will allow scientists to observe distant galaxies which may provide information about the past. This scientific tool has the function of resolving celestial bodies and bringing new and more distant objects into view.

OBJECTIVES

Students will be able to:

- explain how a reflecting and refracting telescope works
- compare and contrast a reflecting and refracting telescope

Perhaps the most obvious advantage of a telescope is that it magnifies far away objects, making them seem very close. However, large modern are built to gather a large quantity of light from faint objects. In addition to its ability to magnify an object and to gather light, a telescope also has resolving power, the ability to separate two close objects of moderate brightness. Viewed through a small telescope, the blurred images of two close stars may seem like a single bright object. Viewed through a larger telescope, however, the same bright object may appear to be two distinct and separate stars. Therefore the larger the telescope, the better its resolving power.

Elements of the Telescope

The telescope has either a lens or a mirror to collect the light from an object and form its image. This is accomplished by permitting the light to pass through the lens or to be reflected by the surface of the mirror. Where the light is brought to a focus and the image is formed is called the focal point. Its distance from the center of the lens or the surface of the mirror is the focal length.

The ratio of the focal length to the diameter of the objective is called the focal ratio (f-ratio). For example, a 10-inch, f-9 telescope has an objective with a diameter of 10 inches and a focal length of 90 inches. The f-ratio for refracting telescopes is about 15 and for reflecting telescopes is about 6. The image formed at the focal point is examined with an eyepiece which is simply a magnifying glass of short focal length.

The image that is formed by a telescope has three important properties: size, brightness and resolution. The size of the image depends on the focal length of the objective. Therefore the size of the image increases as the focal length increases. A 10-inch f-5 telescope whose focal length is 50 inches forms a smaller image than a 10-inch, f-8 telescope whose focal length is 80 inches.

The amount of light collected by a telescope is proportional to the square of the diameter of the objective. The light-gathering power of a 2-inch telescope is 4. When the diameter of the objective is doubled, the light-gathering power is increased four times. The brightness of a star's image depends upon the amount of light collected by the objective. As the size of the objective is increased, the image becomes brighter, and more of the dimmer stars become visible. Two telescopes with objectives of the same diameter collect the same amount of light, regardless of their focal lengths.

A telescope does not reproduce the geometrical shape of a star; it simply produces an image called a diffraction pattern. This image consists of a bright central spot containing about 85% of the total light surrounded by faint concentric rings. The size of the star's image depends on the diameter of the objective and actors the wavelength of the light and has no relation to the brightness of the star.

The two general types of optical telescopes in use today are refractors and reflectors. In both types, the objective which produces the image is a fixed part of the telescope. In a refractor telescope, the objective is a lens and in a reflector telescope, the objective is a mirror. The eye-piece which is a magnifying lens of short focal length is easily interchangeable. The essential features of a refracting telescope are two lenses separated by a distance equal to the sum of their focal lengths. The larger lens serves as the objective and the smaller lens as the eyepiece of the telescope. Light from an object is collected by the fixed objective which it receives in parallel rays, focuses it and forms its image at the focal point. The moveable eyepiece then receives the light from the focal point, magnifies it and transmits it to the eye in parallel rays.

In a reflecting telescope, the objective is a mirror, which reflects the parallel rays of light it collects from an object and focuses them at the focal point where the image is formed. See diagram below.

LESSON PLAN # 1 - MAKING A SIMPLE TELESCOPE

ENGAGEMENT

Students will look at distant objects through magnifying glasses, creating a simple telescope. This activity will help students understand how a refracting telescope works.

MATERIALS: 2 magnifying glasses or 2 convex lenses

PROCEDURE:

Students will look at distant objects through one of the lens provided move the lens back and forth slowly. Stop when the object appears clearly through the lens. Without moving the first lens, hold the second lens close to your eyes. Move the second lens back and forth slowly. Stop when you can see the distant object clearly through both lenses.

DISCUSSION

At the end of the observation, students should discuss the function of each lens and how the image appear through each lens.

ACTIVITY #2

There are two types of eclipses: Solar and Lunar. A Solar eclipse happens when the Sun, as seen from Earth is covered up by the Moon. A Lunar eclipse is when the Moon passes through the Earth's shadow.

Have students create a model to show :

a) Solar Eclipse
b) Lunar /Eclipse

Approximate time : 2 class periods

OBJECTIVE: Students will observe and describe what happens during a solar and lunar eclipse.

MATERIALS:

A bright lamp to represent the Sun

A globe to represent the Earth

A baseball to represent the Moon

HOW TO CREATE A SOLAR ECLIPSE

PROCEDURE

1. Place lamp on a smooth surface e.g. (table top) at eye level and turn lamp on. Turn off all other lights in the classroom.

2. Set the globe on the table to receive maximum light from the lamp, representing the Sun.

3. Hold the baseball, representing the Moon between the lamp and the globe so that the moon's shadow falls on the Earth.

Explain to students that if they were standing on the part of the globe where the shadow falls, they would not be able to see the Sun as the Moon will be blocking the Sun.

HOW TO CREATE A LUNAR ECLIPSE

Using the same materials as in the above activity, move the baseball representing the Moon behind the globe representing the Earth into the earth's shadow. Explain to students that if they were on the dark side of the globe, they would see the moon becomes very dark as it passes into the Earth's shadow. Also point out that everyone who lives on the side of the Earth facing the Moon can see the moon in eclipse. But during an eclipse of the Sun, only the people inside the shadow see the Sun being eclipsed.

ACTIVITY # 3

HOW TO CREATE PHASES OF THE MOON

The Moon looks a little different every night Its shape seems to change because of the way the Sun illuminates the surface of the Moon as it orbits the Earth.

PROCEDURE

1. Using the materials listed in the above activities, place the lamp in the middle of the table and turn off all the other lights. This time the students themselves will represent the Earth and the baseball will be the Moon.

2. Allow each student to take turn to perform the following tasks:
- face the Sun, holding the Moon in front of him or her. Tell students that the lamp (Sun) will illuminate the side of the ball (Moon) they cannot see. They will only see the dark side of the ball. This is what happens when the moon is between the earth and the sun. This phase of the moon is called a New Moon. When the moon is New we cannot see it in the night sky. However, the moon is not all dark. One half of it is lit up by the Sun but we just cannot see it from the earth.

3. Tell students to keep facing the sun holding the ball in their left hand. With the ball held in their left hand, ask students to hold their left arm with ball, straight out by their sides. Half of the lighted surface of the moon is now visible. This is called a First-quarter Moon, because the moon has traveled one-quarter of the way around the Earth.

4. Tell students to turn their back to the Sun and hold the Moon in front of them. The Moon should be held high enough so that it receives light from the Sun. This is known as a Full Moon, when the lighted half of the Moon is now visible. The moon has now traveled half-way around the Earth. If the Moon is held lower so that it does not receive sunlight, it is called a lunar eclipse, when the moon passes through the Earth's shadow.

5. Students will face the Sun again with the ball in their right hand. Students will hold their right arm with ball, straight out by their sides. The moon has now traveled three-quarters of the way around the Earth. This is known as the Third-Quarter moon. Within another week the moon will complete one full orbit. Then it will be a New Moon again.

Remind students that it takes one whole month (29.53 days) for the Moon to go around the Earth. During the month there is one time when there might be an eclipse of the moon and one time when there might be an eclipse of the sun (at New Moon) . An eclipse of the sun lasts only for a few minutes. Only those people directly under the shadow can see it. That is why eclipses of the Moon are seen more frequently than eclipses of the Sun.

ACTIVITY #4

OBSERVING PARALLAX

Most distances on the earth can be measured in meters or kilometers. The distances of objects in space are quite far which makes it very difficult to predict or imagine. Astronomers have found that the distance to even the nearest star is even too great to measure in kilometers. The distances are so great that the numbers are too large to work with easily. For example, the star Proxima Centauri is the closest star, other than the sun, to the earth. (Proxima Centauri is 40 km from the earth.) With such a huge number, astronomers had to invent special units to measure distances in space. Astronomers often measure the distance to an object in space in 'light-years'.

A 'light-year' is equal to the distance light travels in one year. Light travels through space at a speed of about 300,000 km/sec. A 'light-year' is equal to almost 10 trillion kilometers. Light from the sun reaches the earth in a little more than 8 minutes. Light from the North Star, Polaris, takes about 300 years to reach the earth. The Sun is about 150 million km from the earth. This distance is referred to as an astronomical unit or 1 AU which is equal to 150 million kilometers.

Astronomers can use parallax to find the distances to the closer stars. Parallax is the change in the position of a distant object when seen from two different places. A nearby star seems to move against a background of distant stars. By measuring how much the star appears to move, astronomers can calculate how far away the star is. Nearby stars have a large parallax whereas distant stars have a smaller parallax.

MATERIALS:

metric ruler
drinking straw
transparent tape
3 sheets of computer paper (continuous feed)

PROCEDURE

1. Remove the edges with holes from the computer paper. Tape this strip of paper with holes to a wall in the classroom.

2. Tape the drinking straw upright on the metric ruler at the 15cm mark.

3. While standing about 2 meters from the wall with stripped paper, hold the ruler horizontal to the floor.

4. Tell student to close the left eye and line up the straw with the left end of the strip of computer paper.

5. Tell student to open the left eye and then close the right eye. Student should count the number of holes the straw appears to move along the strip.

6. Students will then move the strip to the 30cm mark on the ruler. Repeat steps 3-5.

QUESTIONS

1. What does the strip of paper with holes represents in our galaxy?

2. At the 15cm mark, how many holes did the straw appear to move?

3. At the 30cm mark, how many holes did the straw appear to move?

4. Why does the straw appear to change position?

5. Which has a greater parallax, a nearby star or a more distant star?

ACTIVITY #5

PLANET TRIVIA GAME

Approximate time: 40 minutes

OBJECTIVE: Students will be able to

a) Review the features and characteristics of each planet.
b) To improve students writing and research skills as they prepare questions on the Trivia Cards.

MATERIALS:

3x5 index cards
Pen/colored pencil
Earth Science Text
Directions/Rules of the game

PROCEDURE

1. Divide students into teams of four players each. Shuffle cards before dealing.

2. Each team is given a set of 16 cards face down and a ruled sheet (Questions on cards must be prepared ahead of time.) The team with the most cards at the end of the playing time wins.

3. Set remaining cards aside.

4. Teams take turns asking questions of the opposing team. (Allow teams about 20-30 seconds to confer before giving an answer. Only one answer may be given.

5. The team that answers correctly gets to keep the card. If an incorrect answer is given, the correct answer is read and the question is placed in the "discard pile".

6. Play continues until all the teams use all sixteen cards. The team with the most cards, wins.

ADDITIONAL ACTIVITIES

Interdisciplinary unit : Students will write creative essays and/or myths about different constellations.

Plan a Star Party and observe the night sky for planets and constellations.

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a) http://www.exosci.com/news/42.html

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Reading List for Students

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TRIPS: Students may visit the planetarium at Southern Connecticut State University. Contact Person: James Fullmer at 1-203-392-5841.