LEADER GUIDE
for
MODULE FIVE

SPACE ENVIRONMENT

Chapter 1 - Space

Learning Outcomes
After completing this chapter, you should be able to:
Describe microgravity.
Identify characteristics of space.
Describe what makes up the universe.
Define constellation.
Define galaxy.
Describe nebulae.
Describe a black hole.
Describe the Van Allen belts.
Define cislunar space.

Important Terms:
black hole - a region in space where no radiation is emitted
cislunar space - the space between the Earth and the Moon
constellation - a grouping of stars, named after mythical figures and animals
galaxy - an enormous collection of stars arranged in a particular shape
interplanetary space - measured from the center of the Sun to the orbit of its outermost planet
interstellar space - the distance from one solar system to another
microgravity - small gravity levels or low gravity
nebulae - giant cloud of dust and gas
pulsar - pulsating star that flashes electromagnetic emissions in a set pattern
space - region beyond the Earth's atmosphere where there is very little molecular activity
star - a body of hot gases
universe - everything is part of the universe; stars, planets, galaxies, animals, plants and humans
Van Allen belts - radiation belts filled with charged particles

Activity Materials:
Activity One - Creating the Microgravity of Space - plastic drinking cup, large cookie sheet with at least one edge that doesn't have a rim, empty soda pop can, a large pail (catch basin), towels (old bath towels for cleaning spills), and a step ladder
Activity Two - The Can Throw - empty aluminum soft drink can, sharp nail, catch basin, water and towels
Activity Three - Surface Tension and Microgravity - water, liquid dish detergent, toothpicks, eyedroppers, wax paper squares (20x20 cm)

Activity Four - Rapid Crystallization - heat pack hand warmer (1 per group, sold at camping and hunting stores), water boiler (an electric kitchen hot pot can be used), styrofoam food tray (1 per group), cooler and clock
Activity Five - Astronomy in a Tube - an empty Pringles potato chip can with its opaque plastic lid, a 9"x12" sheet of black construction paper, some tape (Scotch brand), hammer, nail, straight pin and pair of scissors
Activity Six - Measuring the Brightness of the Stars - a piece of cardboard (or a file folder), and a strip of clear cellophane
Activity Seven - Analyzing Starlight - You must plan ahead. To do this activity you must purchase diffraction grating (Edmund Scientific, 101 East Glouchester Pike, Barrington, New Jersey 08007-1830 sells it). Their phone number is (609) 573-6250. Two sheets of diffraction grating measuring 6"x12" costs less than $10. These sheets will need to be cut; one sheet will make 18 two-inch squares. Twenty-five diffraction gratings mounted in 2"x2" cardboard slide mounts can be purchased for $21.95. These can be used straight from the package to build the spectroscopes for the cadets. You also need cardboard tubes (paper towels, toilet tissue, or gift wrapping tubes), scissors or hobby knives, cellophane tape, colored markers or pencils, typing or computer paper, and flashlights.
Activity Eight - The Expanding Universe - balloon, marker, twist tie or paper clip, measuring tape, paper, pencil

PRESENTATION

Attention: What is it like in space?

Motivation: Since some of us may be in space some day, we should know something about its environment.

Overview: There is a difference between space and the universe. Let's take some time and talk about what each means.

Lesson Outline:

1. **Space is a Place**
    a. Space – Space is part of the universe, just beyond the immediate influence of Earth and its atmosphere. Space is an area where the molecules and atoms are so far apart that they don't interact. Generally, space begins at about 80 or 90 miles from Earth. Space is characterized by a lack of oxygen, very low pressure and temperature of -273°C (absolute zero). Absolute zero is used because of lack of molecular motion in space. Also, space has very low gravity, called microgravity.
    b. Universe - Includes everything - plants, animals, humans, stars, planets and galaxies. Everything is part of the universe.

Activity One ** - Demonstrates that free fall eliminates the local effects of gravity. It creates a microgravity environment similar to what you would find in space. If you remove the sheet quickly the cup and the water both fall at the same time. **Microgravity** is defined as very low or small gravity. The Earth has a gravitational field that attracts objects and causes them to fall toward the Earth. The greater the distance between objects the less

effect of gravity. If objects decrease in distance from one another, the gravity increases. In this activity, the cookie sheet holds the cup and water in place. Once the cookie sheet is removed, the water and cup fall together.
Activity Two ** - This activity also demonstrates microgravity. While the cup is stationary, the water pours out. However, if the cup falls the water remains inside the cup the entire time it falls.
Activity Three ** - This activity studies surface tension and the fluid flows because of the differences in surface tension. When water drops fall they are spherical. Water is composed of two hydrogen atoms and one atom of oxygen, which attract each other. When the water drop hits a surface the molecules are attracted across the surface and inward. This causes the water to try to pull itself into a shape that has the least surface area possible – the sphere. Because of gravity, the drops resting on a surface will fatten out somewhat. If liquid soap is added, the soap molecules bond better than the water molecules so the water molecules spread out more. The importance of surface tension research in microgravity is that surface tension-driven flows can interfere with experiments involving fluids.
Activity Four ** - This activity investigates the growth of crystals under different temperature conditions and is best done in groups of 2-3 cadets. When the metal disk on the heat pack is clicked or snapped, crystals begin to form and heat is released. The pack can be reused by re-heating until all the crystals are dissolved. Remind cadets that the thermometer should be placed the same way for each test. Give each group one student data sheet for each test to be performed. Begin with observation of the room temperature pack first. Cadets need to be ready because complete crystallization should take less than a minute. Crystallization of the second pack will take several minutes to complete. Cadets will discover that heat packs with higher initial temperatures will take longer to crystallize. Depending on the initial temperature, crystals may resemble needles or blades. Gravity will influence their development. Crystals are solids composed of atoms, ions, or molecules arranged in orderly patterns that repeat in three dimensions. Scientists are interested in growing crystals in microgravity because gravity often interferes with the crystal-growing process, leading to defects forming in the crystal structure.

2. **More Descriptions about Space**
    a. cislunar space - is the space between the Earth and the Moon. The average distance between the Earth and its Moon is 237,087 miles. Cislunar space is not a void, but it isn't crowded either.
    b. interplanetary space - is the space measured from the Sun to the orbit of its outermost planet.
    c. galaxy - is an enormous collection of stars, and these stars are arranged in a particular shape. Our galaxy is called the Milky Way.
    d. nebulae - giant clouds of gas and dust spread throughout the galaxy.
    e. constellation - is a grouping of stars

3. **Space Environment around the Earth**
    a. ionosphere - is a part of the atmosphere divided by its electrical activity.
    b. magnetosphere - begins at about 215 miles and extends into interplanetary space. The magnetosphere is characterized by its magnetic field of force.

Activity Five * -** This activity gives cadets an idea of some of the star patterns they are seeing in the sky. Construct a tube that will then show the cadets a few of the constellations that they can see in the night sky.
Activity Six * -** This activity is designed to illustrate the magnitude of different stars. The brightness of a star is measured in magnitude. The brightest stars have the lowest magnitude, while dimmer stars have higher magnitudes. Magnitude is measured in two ways: apparent magnitude is the brightness of a star as seen from Earth while absolute magnitude is the brightness of a star as seen from a standard distance of 10 parsecs. The differences in actual brightness of stars is caused by the temperature differences between the stars. The brightest stars are those that are blue, while the faintest stars are those that are red. Star color is determined by its temperature. It is important to remember that a bright star, very far away, may seem to be just as bright as weaker, but closer, star. The sun has a magnitude of –26, six trillion times brighter than a magnitude 6 star. There are only 22 first magnitude or brighter stars.
Activity Seven * -** This activity takes some planning and costs money. To accomplish this activity, you have to order diffraction grating. It is understandable if you do not want to spend this money. This activity is here in case anyone does want to do it. This activity uses spectroscopes built by the cadets to show the difference in wavelengths of various light sources.
Activity Eight ** - This activity simply shows that when more air is added to the balloon the dots become farther apart. The dots represent stars, so as the air is expanded the stars are farther apart. Some scientists believe that the universe is still expanding.

Answers to Review Questions: 1. b; 2. a; 3. c; 4. b; 5. c

Summary

Talk about the characteristics of space, including a discussion of gravity and microgravity. Also, be sure to differentiate between space and the universe. Be sure to reinforce the learning by going back over the important terms.

Chapter 2 - Solar System

Learning Outcomes
After completing this chapter, you should be able:
Describe our solar system.
Define a comet.
Explain the differences between an asteroid, meteoroid and a meteor.
Recall the differences between solar flares, solar prominences and sunspots.

Important Terms:
solar system - the sun and the bodies that orbit around it
comet - a small icy body orbiting the sun

asteroid - a small rocky body orbiting the sun; usually found in the asteroid belt
meteoroid - clump of dust or rock orbiting the sun

meteor - a small streak of light; when a meteoroid enters the Earth's atmosphere it becomes a meteor
solar flares - short-lived high energy discharges
solar prominences - larger energy discharges that can be thousands of miles high and last for months
sunspots - darker, cooler areas of the sun

Activity Materials:
Activity One - Build a Solar Cooker - shoe box, aluminum foil, plastic wrap, a skewer and some hot dogs
Activity Two - Seeing the Moon - a dark room, a bright light source (a table lamp), a small ball (baseball), and the experimenter
Activity Three - Earth-Moon Distance - world globe (12 inches in diameter), tennis ball and string (about 20 feet long)
Activity Four - Lost on the Moon - Survival - checklist and a pencil or pen
Activity Five - Solar System Model - 33 yards of twine or rope, 4 sheets of tagboard, pencil, black marker, drawing compass, measuring tape, cellophane tape, calculator, scissors and the chart below
Activity Six - How Old Are You? - chart provided
Activity Seven - Meteoroids and Space Debris – Take two or three raw potatoes (depending on group size) and several large diameter plastic straws. Each cadet should get a chance to participate.

PRESENTATION

Attention: We have all heard the term "solar system". What does it mean?

Motivation: Why do we care what it means? Knowledge continues to pour in from all of the exploration of space. Our satellites and space probes continually transmit valuable information about our solar system to us here on Earth. Most certainly, space travel will continue and possibly increase, so it only makes sense to learn more about what is out there in space.

Overview: This chapter will take a close look at the sun, the moon and the planets of our solar system. Let's see how this lesson will continue:

Lesson Outline:

1. **The Sun**
    a. Sun facts – The sun is a star, the central star of our solar system. It provides energy for food and oxygen for us and sustains life on Earth. All of the bodies of our solar system revolve around the sun. The sun is 93 million miles from Earth and is 300,000 times as massive as Earth. The sun is composed of 90% hydrogen and 9% helium, and the temperature ranges from 4200°C to 15 million degrees C. The thin shell of the Sun's outer layer is called the photosphere. It is the part of the Sun that gives off light.

b. Solar disturbances – These occur all of the time. They last anywhere from a few seconds to years. Sunspots are darker, cooler areas of the sun. Solar flares are short-lived high-energy discharges. Solar prominences are larger and last longer. Prominences can reach thousands of miles and last for months.

Activity One ** - This is a practical and fun way to show the sun's intensity. Hot dogs work well because they are already cooked.

2. **The Moon**
   a. Moon facts – Diameter of the moon is 2155 miles (1/4 of Earth's diameter). The moon's orbit is elliptical, so it varies from 221,000 to 252,000 miles. The moon rotates on its axis in the same amount of time it takes to orbit the Earth (27 days). So, the same side of the moon always faces the Earth. How much we see of the moon is called the phases of the moon and depends on the sunlight.

Activity Two * - This is a good easy way to demonstrate the phases of the moon. Also, helps when thinking in terms of light and shadows.
Activity Three ** - This activity provides a visual demonstration of the distance between the Earth and the moon. It gives some meaning to some very large numbers concerning the Earth-moon relationship. Use 25,000 miles for the circumference of the Earth. Use 240,000 as the distance to the moon (use this average because the distance varies). When you divide the distance by the circumference you get 9.6, round down to 9.5.

   b. Physical facts about the moon – It is a dry and barren place. There is no atmosphere, no water. The moon is solid rock covered with dust. There are two types of terrain - highlands and lowlands. The highlands are filled with craters surrounded by mountains. The lowlands are filled with craters flooded by molten lava. A moon day lasts 27 Earth days. Temperatures range from 250°F to -250°F. The gravitational attraction between the Earth and the moon causes movement in the Earth's tides. When the moon is closer the attraction is stronger and the tides are higher. Because the Earth rotates faster than the moon, there are two high tides a day.
   c. Moon rocks – Anorthosite is the most common rock on the Moon. It is composed almost entirely of one mineral, feldspar, and is found in the highlands of the Moon. Another Moon rock is basalt. It is a dark gray rock with tiny holes from where gas has escaped.

Activity Four * -** This activity accomplishes several things; it encourages your cadets to begin thinking about the moon's atmosphere and what's important while you are visiting there. Also, they must think about the differences between the Earth's and the moon's atmospheres. It also helps their critical thinking skills and gives them a chance to compare their evaluation with NASA's official answers. This exercise can be done individually or in small groups. Small groups have the advantage of allowing the cadets to work together with others and come up with a team answer. This, of course, takes cooperation and compromise. You can talk about team building, interpersonal relations and listening skills.

Look at the actual content of their answers and their process for getting their answers. Be sure they calculate their error points and see who is the closest to NASA.
The error points are calculated by comparing each item's ranking with NASA's ranking, get the difference, then add up each difference for your total score. **Attachment 1 contains NASA's priority and the rationale for it.**

3. **The Planets**
   a. Mercury – It is the closest planet to the sun, 36 million miles. It revolves around the sun in 88 days and its temperature ranges from 800°F to - 300°F. It is a rocky, crusty surface with craters. There is no atmosphere, except for small amounts of helium and hydrogen.
   b. Venus – It is the closest planet to Earth, 67 million miles from the sun. It revolves around the sun in 225 days and its temperature reaches over 850°F. It is the only planet known to rotate in a clockwise manner. It is covered with clouds made up of water vapor and sulfuric acid. The atmosphere is 96% carbon dioxide and 4% nitrogen. Because of the thick layer of carbon dioxide and clouds, the temperature on Venus changes very little, in fact, it is the hottest planet.
   c. Earth – The Earth contains 78% nitrogen and 21% oxygen. Clouds absorb some of the sun's radiation. The Earth is covered with 67% water. It revolves around the sun in 365 days and rotates on its axis in 24 hours.
   d. Mars – Mars is the red planet, which can even be seen with the naked eye. The red color is due to rock and dust, which cover the surface of Mars. It has high iron content and is covered with deserts, mountains, craters and volcanoes. Temperatures on Mars range from -20°F to -130°F.
   e. Jupiter - It is the largest planet in our solar system. It is 11 times larger than Earth, yet rotates in about 10 hours. This fast rotation creates high winds and giant storms. Jupiter is a gas giant. The most prominent gas is hydrogen, then helium, methane and ammonia. Jupiter has a giant red spot and 16 known moons.
   f. Saturn - The rings of Saturn are its distinguishing feature. The rings are about 1 mile thick and extend about 250,000 miles from the planet. Saturn has an icy rock core surrounded by metallic hydrogen with an outer layer of hydrogen and helium. Saturn rotates in 10 hours but takes 29 years to revolve around the sun. The fast rotation creates strong winds that have reached 1,100 miles per hour. Temperatures range from 130°F to -330°F. Saturn has 18 known moons.
   g. Uranus – Uranus is 1.7 billion miles from the sun. It has a rocky core surrounded by water, ammonia and methane, both in ice and liquid form. Uranus is bluish greenish in color. It rotates in about 18 hours and revolves around the sun in 84 years. Its axis is tilted 60°, so daylight lasts 42 years, followed by 42 years of night. Temperatures stay at about -340°F.
   h. Neptune – Neptune is 3 billion miles from the sun and takes 165 Earth years to complete an orbit. Neptune rotates in 19 hours. Water, ammonia and methane surround its rocky core. Its atmosphere consists of hydrogen, helium and methane. Methane gives the planet a bluish color. Neptune is the windiest planet in the solar system. It has recorded winds of 1500 miles per hour.

i. Pluto – It is the smallest planet and farthest from the sun. It is 4 billion miles from the sun. It has a rocky core with water and ice above the core. Its surface is made of methane frost. It has one moon, and it is half the size of the planet. Pluto has a very elongated orbit that sometimes, actually brings Pluto closer to the sun than Neptune.

4. **Other Bodies**
   a. Asteroids – Asteroids are chunks of rock that range from particles of dust to some that are a few hundred miles across. Most asteroids travel in orbit between Mars and Jupiter. This is called the asteroid belt, and scientists know the orbit of more than 15,000 asteroids. There are probably millions more out in space. The closest any asteroid has come to Earth is 100,000 miles.
   b. Comet – A comet is a giant dirty snowball composed of frozen gases and icy lumps. A comet is usually a few miles across and generally travels the outer regions of our solar system. Sometimes they get bumped off their orbit and head toward the sun. As comets move, they shed parts of themselves and leave a long tail.
   c. Meteoroids – They are tiny particles of dust and sand leftover from a comet. If a meteoroid enters the Earth's atmosphere it is called a meteor. If it actually hits the Earth it is called a meteorite.

Activity Five * -** This activity creates a model of the solar system. You need an open field, a park or a ball field for this activity. Please realize that the planet sizes are not proportionate.

Activity Six ** - This activity allows you to compare your age if you lived on the other planets. Just a little game, but it does put the concept of rotation into perspective. It also indicates a real difference between the planets.

Activity Seven ** - The actual activity requires very little time, but it affords an opportunity for a discussion about spacecraft, meteoroids and space debris. This activity shows the penetrating power of a projectile with a small mass and how it differs depending on the velocity. Even a small mass can penetrate many things if its velocity is high enough. Discussion - meteoroids strike our satellites all of the time, but most are very tiny and only cause pitting and sandblasting of the outer covering of the satellites. Of greater concern to the astronauts and space engineers is space debris. Space debris can be parts of launch vehicles, or paint chips or other equipment pieces. Most are small, but are traveling at very fast speeds. They pose significant hazards particularly to space walking astronauts. This comes into play also when and if space walking astronauts drop a nut or a bolt when they are repairing a piece of equipment.

Answers to Review Questions: 1. b; 2. a; 3. a; 4. b; 5. c

Summary

This chapter contains lots of information about the planets, the sun and the Moon, as well as, asteroids, meteoroids and comets. Be sure to review pertinent facts about all of these with your students.

DOWN ON THE MOON
RANKINGS

	ITEMS	NASA RANKING	REASON			
1	Box of matches	15	no air on the Moon so matches will not light			
2	Food concentrate	4	efficient means of supplying requirements			
3	50' of nylon rope	6	useful in scaling cliffs or in case of injury			
4	Parachute silk	8	possible use as a sun shield			
5	Solar powered heating unit	13	not needed unless on dark side			
6	Two 45 caliber pistols	11	possible means of self propulsion			
7	One case of Pet Milk	12	bulkier duplication of energy source			
8	Stellar map	3	primary means of navigation to the Moon base			
9	Two 100-pound oxygen tanks	1	the most pressing survival requirement			
10	Self-inflating life raft	9	Carbon dioxide bottle in raft might be used as a propulsion source			
11	Magnetic compass	14	magnetic fields of Moon are not polarized so compass is useless			
12	Five gallons of water	2	replacement of tremendous liquid loss on lighted side of Moon			
13	Signal flares	10	distress signal when Moon base is sighted			
14	First aid kit containing injection needles	7	needles for medicine and vitamins fit special suit aperture			
15	Solar powered FM transceiver	5	for communication with Moon base in line of sight			
	TOTALS					

Calculate error points for the absolute difference between the NASA ranking and the individual or group ranking. Scoring: 0-26 Excellent
26-32 Good
33-45 Average
46-55 Fair
56-112 Still lost on the Moon

Attachment 1