The Space Environment

Learning Objectives Galaxy Explorer will learn about the basic environment of space to include radiation, solar particles, and nebulae. Learn what an astrolabe is and how to use it.

Discussion

(Show Intro slide)

Hello, my name is: *fill in the blank*.
Today we are going to learn the basics about space. We are going to learn a little about the space environment. Space is a very harsh environment, including: a hard vacuum, very low gravity, extremely large and frequent temperature variations, ionizing radiation, electromagnetic radiation, meteors, and hazardous manmade debris. Once a spacecraft reaches orbit, it must be able to withstand the rigors of an environment that is very different from the one in which it was manufactured.

Radiation
Let's talk a little about radiation. The sun constantly radiates energy. This energy varies in wavelength between x-ray and radio frequency, with the most intense radiation being emitted at the shorter, more energetic wavelengths. Radiation can be both beneficial and harmful to spacecraft. For example, solar panels convert radiation into electricity using solar cells. Earth-imaging instruments depend on the radiation emitted by the sun to illuminate the Earth with visible, infrared, and ultraviolet light.

However, solar radiation also has harmful side effects. Many forms or radiation can kill humans. Infrared radiation (IR) heats satellites, which in turn requires elaborate temperature control subsystems to protect temperature sensitive components. Prolonged exposure to ultraviolet (UV) radiation can degrade spacecraft coatings and harm solar cells or electronic components. During intense solar flares, bursts of radio frequency radiation can disrupt on-board communications equipment. To counter these effects, many components are radiation hardened to protect against radiation damage.

Solar Wind
Solar radiation creates a solar wind that exerts a continuous force on spacecraft. Although it is very weak, the pressure from solar radiation can, over time, affect the satellite orientation and orbit.

Solar Flares
The generally steady energy out put from the sun is broken periodically by solar flares of varying intensity that emit large bursts of X-ray, UV, and Infra Red radiation. The appearance of solar flares is difficult to predict but seems related to cycles of other solar activities, like an 11-year sunspot cycle. A solar flare may last from a few minutes to a few hours and can be extremely hazardous to spacecraft. The greatest danger from a space flare is the marked increase in solar protons that come with solar flares. These protons can have energies from 10 million to 500 million electron volts and accumulated radiation dosages can be lethal to electronic components in satellites.

Shortly after the flare occurs, there is a sudden disturbance in the Earth's ionosphere. This disturbance causes the loss of long-range (called short-wave) communications. The disruption may last from a few minutes to more than an hour. In the first few minutes of a solar flare there may also be a storm of noise over a lots of communications frequencies, disrupting all sorts of communications.

(Show slide 1.)

As the solar wind expands into space, it encounters the Earth's magnetic field lines. Earth has a magnetic field around it just like a magnet. The solar wind compresses the field on the sunny side of the Earth and expands it on the dark side.

Cosmic Rays

While solar activity is the primary source of damaging radiation to a spacecraft, another source of hazardous radiation is galactic cosmic rays. Cosmic rays are energetic particles that reach the Earth from outside our solar system. Cosmic rays pose a serious hazard. A single cosmic ray has sufficient energy to cause a malfunction in common electronic components such as microprocessors, memory chips, or transistors

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Vacuum of Space

When we first started, I mentioned the vacuum of space. How much of a vacuum is space? The further one gets from the surface of Earth, the less atmosphere there is. At only 80 kilometers above the Earth's surface, only one particle is found for every 10,000 found at sea level. At orbital altitudes (above 150 kilometers), the vacuum of space is not a “perfect" vacuum. At the altitudes at which the Space Shuttle operates, enough atmosphere remains to cause drag and orbital decay, making it necessary to perform period rocket bums in order to maintain orbit. Left unattended, a satellite experiencing atmospheric drag will first slowly descend into a more circular orbit and then begin a slow spiral into the Earth's atmosphere. Atmospheric drag – the atmosphere that can slow down a spacecraft -- becomes insignificant around 1,000 kilometers.

A problem with the vacuum of space is the toll it takes on many structural materials used on Earth. Most materials will outgas to some extent in a vacuum. While in the Earth's atmosphere, metals usually absorb and build up layers of gases on the surfaces. The lack of pressure in space allows these absorbed gases to escape. These gases often remain near the spacecraft, creating an artificial atmosphere. Polymers and other materials composed of volatile compounds can have serious out gassing problems in space and risk losing a substantial fraction of their mass, leading to changes in fundamental material properties.

INSTELLAR SPACE

Interstellar Clouds

Although the space between stars in our galaxy appears to be completely empty of matter, there exists a very dilute gas even in “empty” space. This **interstellar** (meaning “between the stars”) **medium** varies in **density** (the amount of matter within a certain volume). Typical densities in the interstellar medium are one particle per cubic centimeter (a box 2.54 inches on each sides). Since hydrogen is the most single common element in the universe, chances are, if you were to select a box of space one centimeter wide on a side, there would only be one hydrogen atom inside that box.

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There are some regions known as **molecular clouds** where the density of gas is 10,000 times greater than average. These are dark clouds of gas where it is cold enough for hydrogen to exist mostly in the form of molecules, and where young stars or **protostars** can form. In addition to gas, the interstellar medium also contains **interstellar dust grains** composed of clumps of atoms and molecules. These grains are microscopic, making them comparable in size to particles of smoke or soot. (The dust particles in your house are much larger than interstellar dust.) Interstellar dust grains are even less common in space than atoms or molecules of gas. There is 1 dust grain for every 1 trillion-gas particles. However, considering the vast distances between objects in space, the total number of dust particles between two stars can be considerable. One particle of dust on an otherwise clean windshield would not prevent you from seeing the traffic light. However, if you looked through a trillion clean windshields, each with one speck of dust, you would be looking through a trillion specks of dust, and that might obscure your view of the light.

Interstellar dust has the same effect on light or radiation that passes through the vast distances of space. Just as you have trouble seeing very far in a thick fog here on Earth, interstellar dust can make it impossible to see light from distant stars. The intensity of the star's light is reduced significantly. You can observe dark patches in telescope pictures of parts of the sky. These dark regions are not devoid of stars; they're simply places where there is so much dust in dark dust clouds that the starlight coming from more distant stars is completely blocked out.

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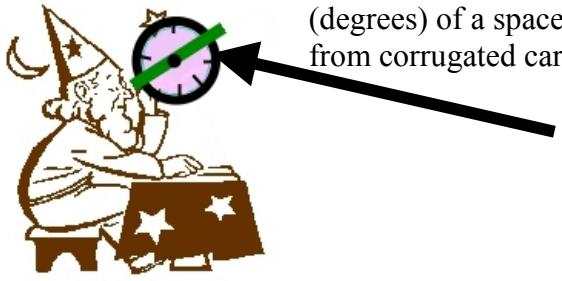
Another type of feature found in interstellar space is the **emission nebula**. These appear to the naked eye to be fuzzy patches of brightness in the nighttime sky. When examined with a telescope, they show up as spectacular clouds of gas lit up by nearby stars. Ultraviolet radiation from stars can **ionize** or knock loose electrons in the gas atoms of the nebula. When the electrons recombine with the naked atomic nuclei, light is emitted that we see as the glow coming from these nebulae.

Mission Team Leader's Notes

Several graphics are shown to students during this lesson. They can be shown on overhead projector, on a computer, or distributed in hard copy. Each has a description on the notes area.

ACTIVITY

Just looking at all the objects in space is an adventure. But how do you know exactly where each object is when you want to see it again? The answer is you use an **Astrolabe.** Astronomers began to use Astrolabes in the 1st century AD. Sailors used them later to help navigate ships.



An Astrolabe is a simple handheld device for measuring the distance (degrees) of a space object above the horizon. We will make an Astrolabe from corrugated cardboard cut into a 6-inch diameter circle.

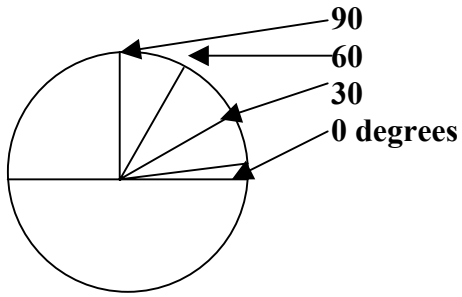
The Astrolabe has degree markings starting with "0" degree pointing level with the horizon and 90 degrees pointing straight up.

For each Astrolabe you will need a few things:

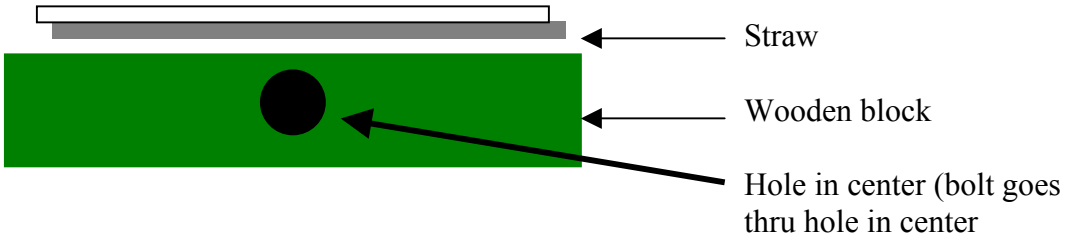
1. Corrugated (thick) cardboard cut into shape of a 6 inch disk
2. Two pieces of heavy 8 inch string- *one metal nut to tie to one string end*
3. One protractor and a black marker (to mark off degrees)
4. One block of wood, approx 5 inches long, ½ inch wide and ¾ inch thick; a similarly sized piece of Styrofoam or plastic can also be used.
5. A ¼ by 1inch bolt, wing nut and 2 washers.
6. Wood or craft glue
7. A hand drill if using wood block.
8. A plastic drinking straw.

How to build it.

1. draw a straight line across the middle of the 6 inch disk
2. lay the protractor along the line and mark off every 30 degrees



3. To make the sighting arm, first drill a hole in the center of the wood block. Styrofoam or plastic should be easier to make a hole with a sharp object**. Mission Team leader's note** – be careful with this part of the project.
4. Glue the drinking straw along the top (long thin side) of the wood block



5. Make a hole in the center of the disk. Now place the bolt, with washers on opposite sides thru the holes in the circle and wood block (note the straw should be on the top with the degree markings) and secure with nut.
6. To finish, make a hole at the 90 degree mark on the top of the Astrolabe and one exactly opposite on the bottom. Tie a piece of heavy string to the top and the other piece – with the nut (weight) to the bottom

You are now ready to use your Astrolabe. Hold it steady by the top string with the sighting straw at eye height. Point the straw at the proper height to see celestial objects. Look thru the straw to see your target object in space. A compass will help you get an accurate location of the object you are watching.