USF COLLEGE OF ENGINEERING

STARS Interstellar Nano Adventure

June 11-22, 2007

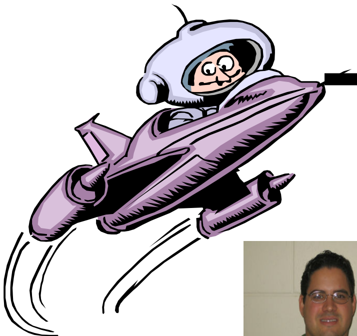
CAMP LESSONS

NAME : ______________________

TEAM : ______________________

National Science Foundation

UNIVERSITY OF SOUTH FLORIDA



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The USF Students Teachers And Resources in the Sciences (S.T.A.R.S.) program is a National Science Foundation (NSF) grant awarded to the University of South Florida to infuse higher-level science & math concepts in grades 3-5. We have partnered with 9 elementary schools, which include Berkeley Preparatory, Edison Elementary, Lawton Chiles Elementary, Robles Elementary, and Tampa Palms Elementary.

As an extension of the NSF initiative, the graduate students (Fellows) have organized a summer camp for elementary school kids throughout Hillsborough County. Students will participate in a series of lessons and activities that focus on aspects of space such as crater formations, how astronauts communicate with engineers on Earth, and much more. In addition, students will tour various engineering laboratories and get to see how research is conducted. Students will also compete in an Olympiad in which they must complete a Top Secret Space Mission. Culminating activities will include an awards ceremony on June 22, 2007.

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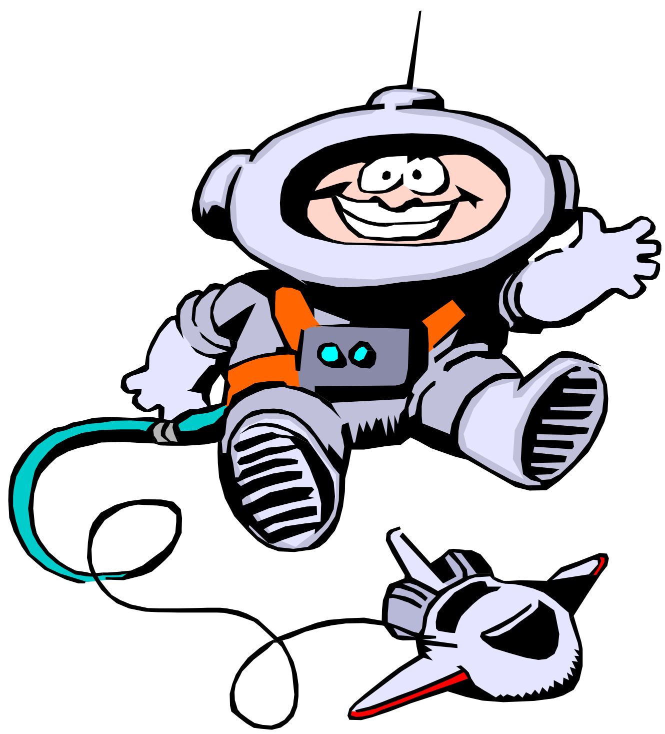
HI! GET READY FOR THE GALACTIC TRIP



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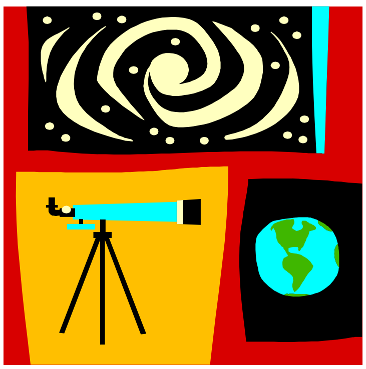
Galactic Trip

About Galaxies:

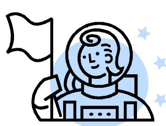
There are **billions** of Galaxies in the Universe. Some are very small with only a few million stars. While others could have as many as 400 billion stars or even more.



Galaxy: A large grouping of stars. Galaxies are found in a variety of sizes and shapes.

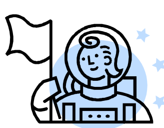
There are three kinds of Galaxies, **Spiral, Elliptical**, and **Irregular**. The only difference between the three is what shape they have.

Spiral - The most beautiful type of galaxies are Spiral Galaxies. Their long twisting arms are areas where stars are being formed.



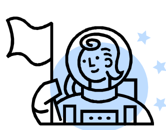
Fact: they are like star farmers, planting star seeds where ever they go.

Elliptical - The stars found in Elliptical Galaxies are often very old. This is because elliptical galaxies don't actively create new stars.



Fact: If the Earth were inside an elliptical galaxy it would be bright both day and night.

Irregular - Irregular Galaxies are simply all the galaxies which are not spiral, or elliptical. They can look like anything and have many different characteristics.



Fact: Many irregular galaxies probably used to be spiral, or elliptical until they had some kind of accident which changed them.

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Milky Way
Our Galaxy

Our own Milky Way galaxy is spiral in shape and contains several billion stars. Some galaxies are so distant that their light takes millions of years to reach the Earth.

Milky Way: The galaxy in which our solar system is located

As a galaxy, the Milky Way is actually a giant, as its mass is probably between 750 billion and one trillion solar masses, and its diameter is about 100,000 light years.

NOW… WE ARE READY TO MAKE OUR OWN CLUSTER OF GALAXIES

Galactic Mobile

Materials:

- 1 black-painted plate
- Scissors
- 2 – 1.5 ft long black string
- 4 black strings in different sizes
- 4 sequins or very small beads, black is best
- 4 patterns for galaxies
- 8 beads
- 1 skewer (optional)

Procedure:

First: Prepare Galaxies

1. Cut your 4 patterns of galaxies along the lines.
2. Make a small hole in the center of each galaxy using a punch hole

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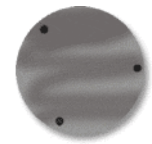
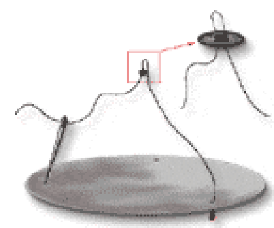
Second: Make the frame for the mobile



1. Use the black-painted plate, and make three pencil marks equally spaced around the edge of the place, about 0.5 inches (in) from the edge.

2. Using a skewer make a small hole through the three of the pencil marks on the edge of the cardboard circle. Push one of the 1.5 ft black strings through one of the holes.

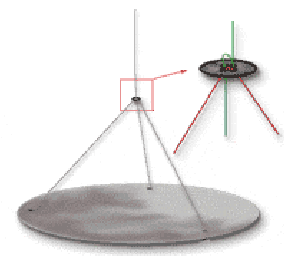


3. Then tie a fat knot in the end.

4. Take the holed button and push the string through one hole in the button and down through another.

5. Now push the thread down through another hole on the plate. Tie a fat knot at the end of the string.

6. Now, using your other 1.5 ft long string, push it up through the remaining hole on the plate. Tie a fat knot in the end.



7. Push the string up through one of the remaining holes in the button and then down through the last hole.

8. Tie a loop in the end of the thread for hanging the mobile from the ceiling.

Third: Hang the galaxies from the mobile frame

1. Make 4 marks on the bottom of the plate where you will be attaching each galaxy.

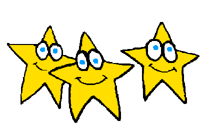
For each galaxy:

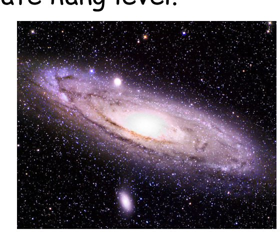
1. Take a piece of string and tie a bead to the end.
2. Push the string through the center of the galaxy.
3. Then place the string through one of the marks on the on the plate. Adjust the length of the thread so the galaxy hangs nicely and tie a bead to the end.

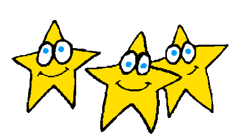
4.4: Make the galaxies hang at different levels, so they can turn freely without hitting each other.

Your galactic mobile is ready…

Hang your Galactic Mobile from the ceiling. Notice that you can adjust the string going through the button to make the plate hang level.







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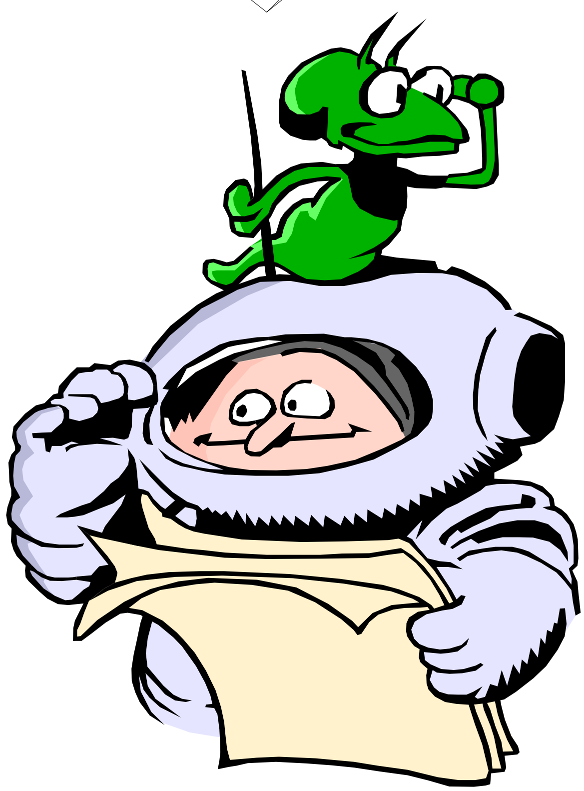
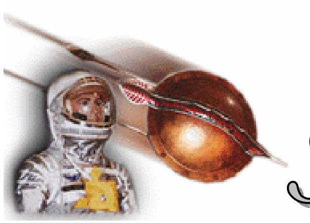
LET'S BUILD A PAPER ROCKET





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Space Transportation

Background

The twentieth century marked a turning point for mankind, from the industrial age to the space age. Some may argue that we are in the information age and if so, it was brought about through the knowledge and technology gained from our aviation, rocket and space pioneers.

Robert Goddard launched the world's first liquid-powered rocket, on March 16, 1926. He was the first of the early rocket pioneers to go beyond theory and design. He entered the realm of "systems engineering" - the complex business of making airframes, fuel pumps, valves, and guidance devices compatible. Being liquid fueled was crucial. Up until then, all rockets were based on a solid fuel, gunpowder, which dated back to China in the late third century before Christ. Solid fueled rockets did not have adequate power to do the things that Goddard wanted to do, like fly a rocket to the moon. On March 28, 1935 Goddard launched and test rockets that were pressurized by liquid nitrogen and has gyroscopic controls. It flew to a height of 4,800 feet and 13,000 feet downrange at a speed of 550 MPH.

The technological Pearl Harbor began on October 4, 1957, the USSR blindsided the United States with the launch of Sputnik I, the first man-made earth orbiting satellite. Circling the earth roughly every 90 minutes, its beeping radio signal shocked the U.S. and the world. This was followed closely by Sputnik II on November 3, 1957, which carried a dog named Laika, the first live organism launched into space. The flight brought back scientific data on the effects of weightlessness and space travel on a living animal.

Project Mercury began on October 7, 1958, one year and three days after the Soviet Union launched Sputnik 1 and was the United States' first manned space program. The objectives of the program, which was made up of six manned flights from 1961 to 1963, were specific: 1) to orbit a manned spacecraft around Earth, 2) to investigate man's ability to function in space and 3) to recover both man and spacecraft safely. Project Mercury was American's first "small steps" toward that "Giant Leap for mankind." **Launch vehicles** where used as an important transportation medium that link Earth to outer space. Launch vehicles put into space communication and weather satellites, which have a direct impact on our quality of life, as well as astronomical-observation satellites and planetary-exploration satellites.

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Explorer I was the first satellite launched by the United States of America on January 31, 1958 on top of a version of the Redstone rocket, known as the Jupiter C. On that mission the NASA scientist discovered the James A. Van Allen radiation belts around the earth. Finally, the U.S. entered the space race but had a lot of catching up to do. Nowadays, launch vehicles play an essential role in the assembly and supplying of the International Space Station.

Project Gemini was a transitional step between the pioneering Mercury Program and the actual landing a man on the moon. Its success was critical to achieving the goal of reaching the Moon and was not without its problems and difficulties. The main objectives of the ten Gemini missions over a period of 20 months from 1965 to 1966, were to learn how to "fly" a spacecraft by 1) maneuvering it in orbit and by 2) rendezvousing and docking with other vehicles, which were essential skills for the later ***Apollo missions***. One of these missions, ***Gemini VIII***, nearly killed Neil Armstrong the first person to walk on the moon.

Example of Vehicles in Space

Today, rockets are more reliable. They fly on precise courses and are capable of going fast enough to escape gravitational pull of Earth. Modern rockets are more efficient today because we have a better understanding of the scientific principles behind rocketry. New technology has led us to developed a wide variety of advance rockets hardware and formulate new propellants that can be used for longer trips and more powerful takeoffs. Future transports might be driven by antimatter, fusion and electrodynamics, etc…

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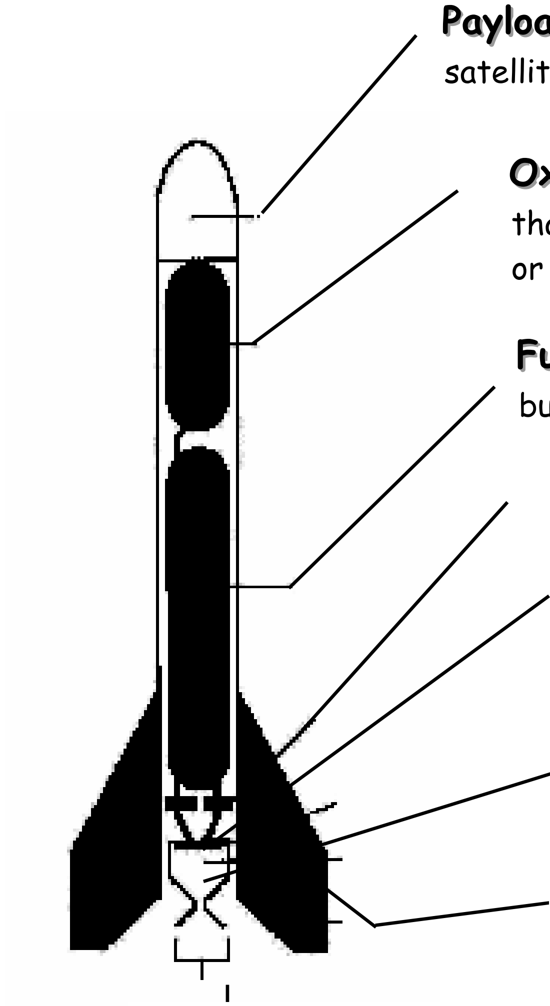
Payload – The cargo (scientific instruments, satellites, spacecraft, etc.) carried by a rocket.



Oxidizer – Chemical containing oxygen compounds that permits rocket fuel to burn either in the Earth or Space atmosphere.

Fuel – Chemical that combines with an oxidizer to burn and produce thrust.

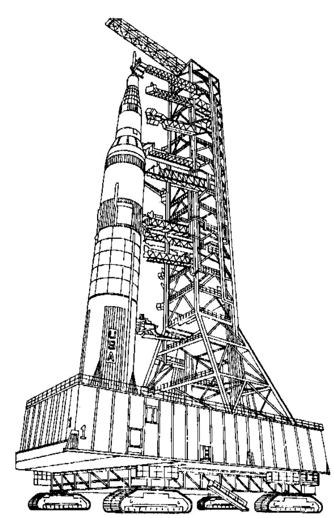
Pumps – Machinery that moves the liquid fuel and oxidizer to the combustion chamber of a rocket.

Injectors – Showerhead devices that spray the liquid fuel and oxidizer into the combustion chamber of a rocket.

Combustion Chamber – Rocket cavity where propellants burn.

Fins – Lower end wings of a rocket that stabilizes the flight.

Nozzle– A bell shaped opening at the lower end of a rocket through which a stream of hot gases are directed.



For an ideal rocket, the total mass of the vehicle should be distributed following this general formula:

- Of the total mass, 91 percent should be propellants; 3 percent should be tanks, engine, fins, fuselage and 6 percent can be the payload.
- Payloads included satellites, astronauts, or

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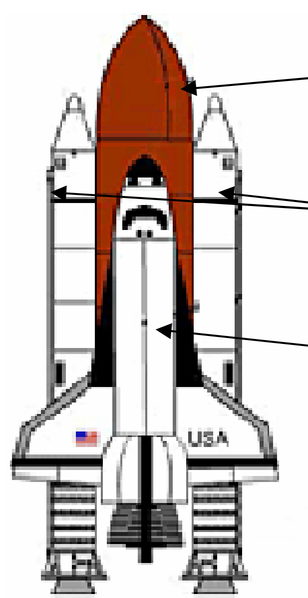
spacecraft that will travel on the mission to other planets or moons.

- The effectiveness of a rocket design is expressed in terms of **Mass Fraction**. Where it is define as the propellants of the rocket divided by its total mass.

The Space Shuttle is called the Space Transportation System (STS). It can carry astronauts into space.

These are the parts of the Space Shuttle and what they do:



External Tank This tank holds the fuel for the Shuttle.

Solid Rocket Boosters These boosters push or boost the Shuttle into the space.

Orbiter This is where the astronauts sit. It also holds everything that is going into space.

The Lunar Module is the manned portion of the space vehicle. It contains a crew compartment, hypergolic ascent engine, a behind equipment cove and tank section, and 16 reaction control engines. The **crew compartment** is used as an operations center by the astronauts during their lunar stay. Lunar descent, lunar landing, lunar launch, and rendezvous and docking with the Command and Service Module are also controlled from this compartment.

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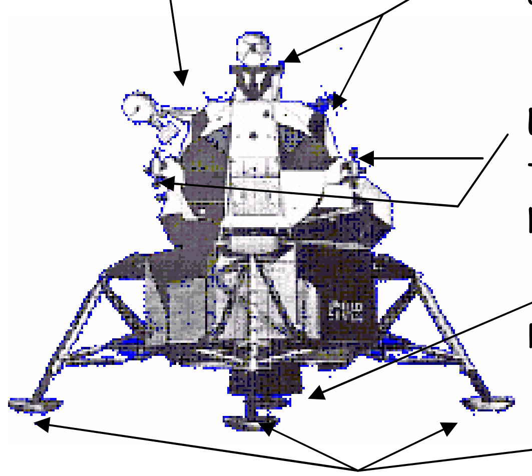
GENERAL DESCRIPTIONS AND CHARACTERISTICS

Main exterior parts of the lunar module:

Satellite or Antenna- provides communication among the module, space center and other space stations.

Guidance, Navigation & Control - guides the module trajectory pattern and behavior.



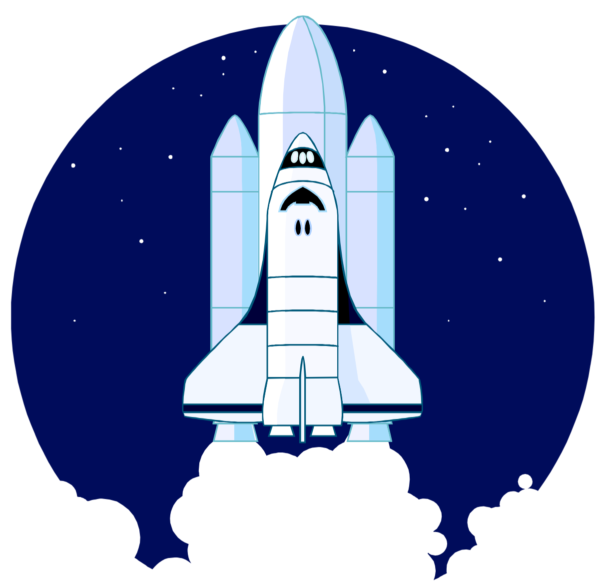
Environmental Control - monitors the temperature, solar radiation, wind, pressure and gravitational force.

Propulsion - this booster pushes or boosts the module into the air.

Suspension System – it holds the lunar module during takeoff and landing process.

Internal parts of the following subsystems that are contained in the Ascent Stage:

- Crew Provisions/Displays
- Electro-Explosive Devices
- Instrumentation
- Electrical Power
- Reaction Control



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Paper Rocket

Experiment Objective:

The students will design, construct, and fly paper rockets that will travel the greatest distance possible across a floor model of the solar system.

Background Information:

This activity will demonstrate how rockets fly through the atmosphere. A rocket with no fins is much more difficult to control than a rocket with fins. The placement and size of the fins will be critical to achieve the necessary stability while not adding to much weight.

Materials Needed:

- Scissors
- Glue
- Straws
- Metric Ruler
- Masking Tape

Scotch Tape
Pencil
Eye Protection
Protractor

Experimental Procedure:

STEP1 How to construct your rocket

1. Roll paper strip around pencil (2 inch x 11 inch trip of paper).
2. Tape tube in three places.
3. Cut off the ends
4. Cut out fins in any shape you like.
5. Fold out tabs and tape fins to tube
6. Fold over upper end and tape shut.
7. Insert straw to blow through it for takeoff launch.

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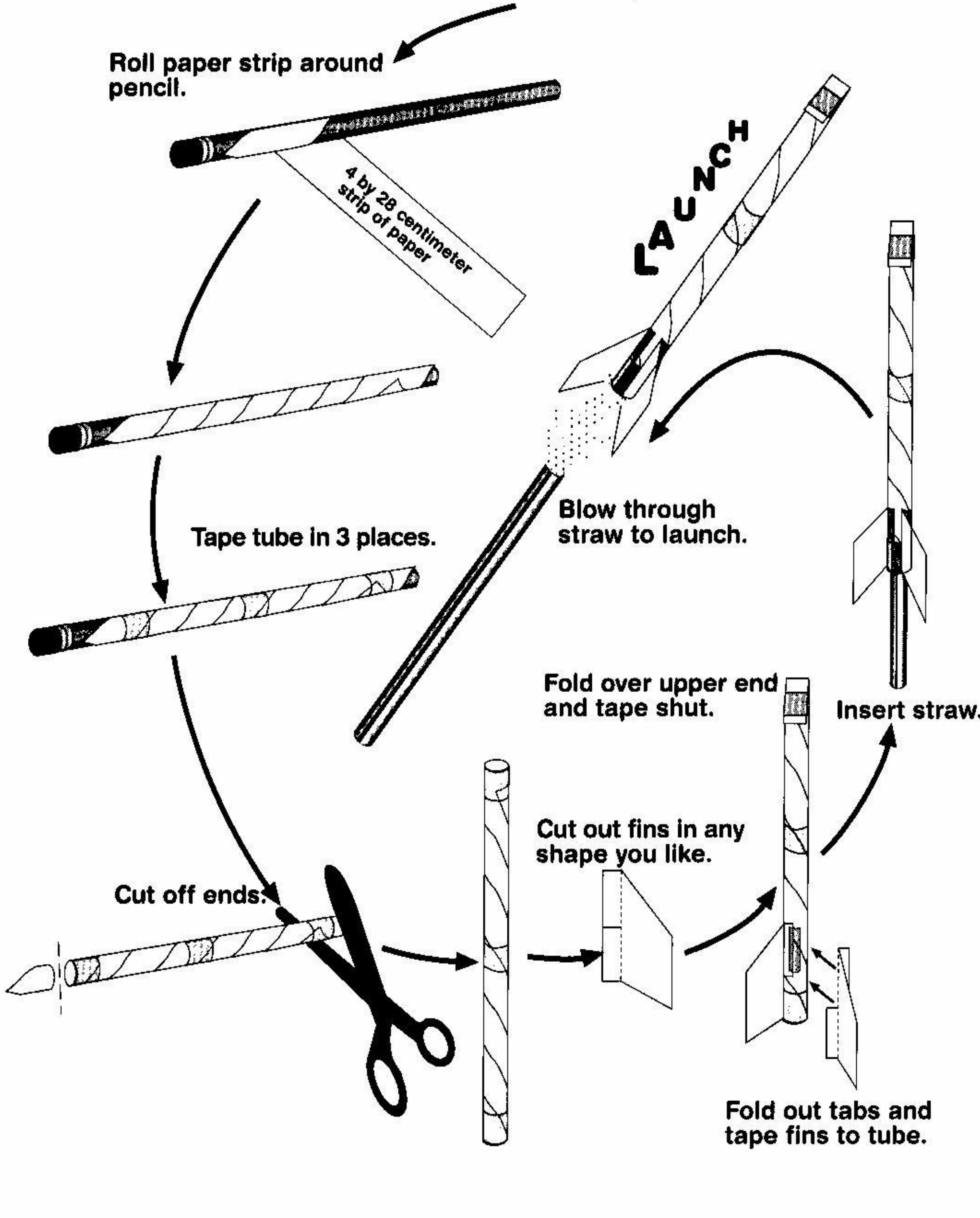
PAPER ROCKETS

Follow the arrows to build your rocket.



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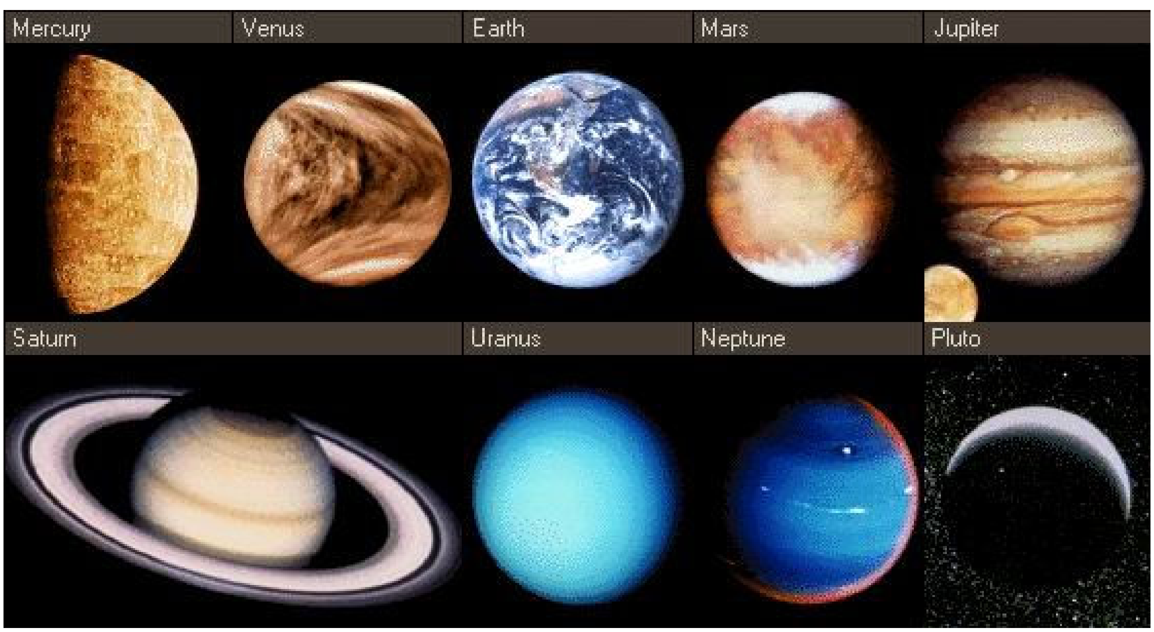
STEP 2: What you should do next?

After constructing the paper rocket a location for testing your rocket will be set. A room with an open floor space or a hallway is preferable. Prepare the floor by marking 8 to 10 meter test range with the pictures of the nine planets of our Solar system as targets. Launch your rocket from planet Earth, Venus or Mars at a 30° angle and determine the farthest distance you are able to reach with your rocket. Record the results 3 attempts per four angles 30, 45, 60, 75. Next, adjust the angle of your launch to 45° and record the farthest planet you are able to reach with your rocket. Repeat this exercise three times using 45, 60 and 75 degrees. Record the results in your experimental data log. Repeat for the first attempt.

The Planets



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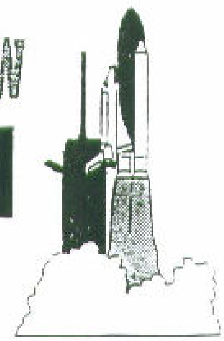
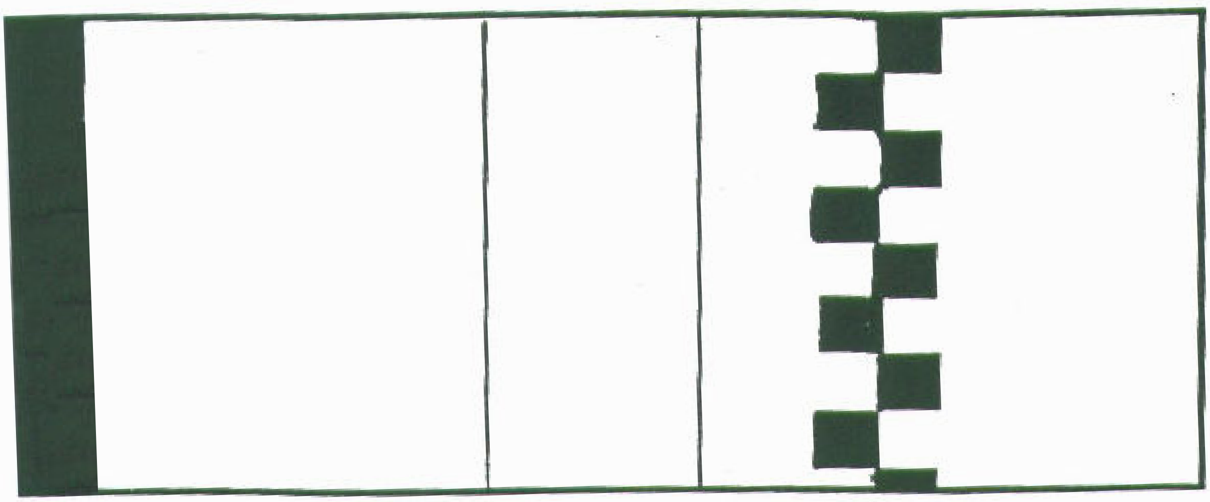
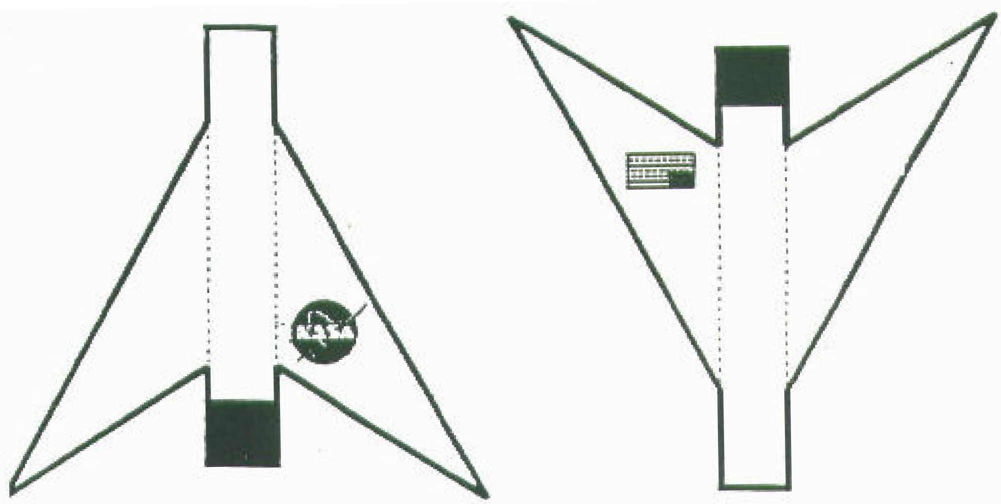
ONE-STRAW ROCKET







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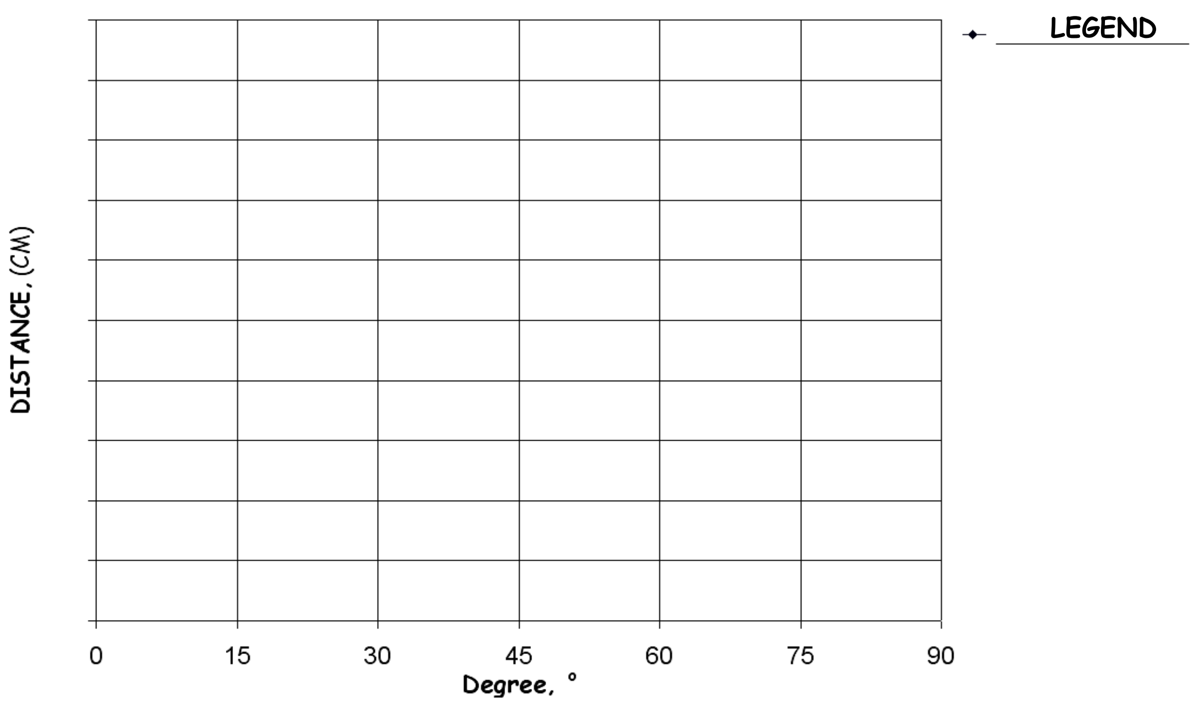
STEP 3: Scientific Data Log

Angle	Base	Distance (cm)	Average Distance (cm)
30°	Earth		
45°	Venus		
60°	Mercury		
75°	Mars		

STEP 4: Graph your results

HOW THE ANGLE COULD AFFECT THE DISPLACEMEN OF A ROCKET



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STEP 5: Draw your conclusions

1. As the angle increases, what happened with the travel distance?

____

____

____

2. What was the maximum average distance including all angles?

____

____

____

3. Enumerate the factors that affect the takeoff of your rocket?

A.	D.
B.	E.
C.	F.

4. What is a propellant?

____

____

5. Enumerate the main parts of a rocket?

A.	E.
B.	F.
C.	G.
D.	H.

6. Enumerate the future mechanism in Space transportation?

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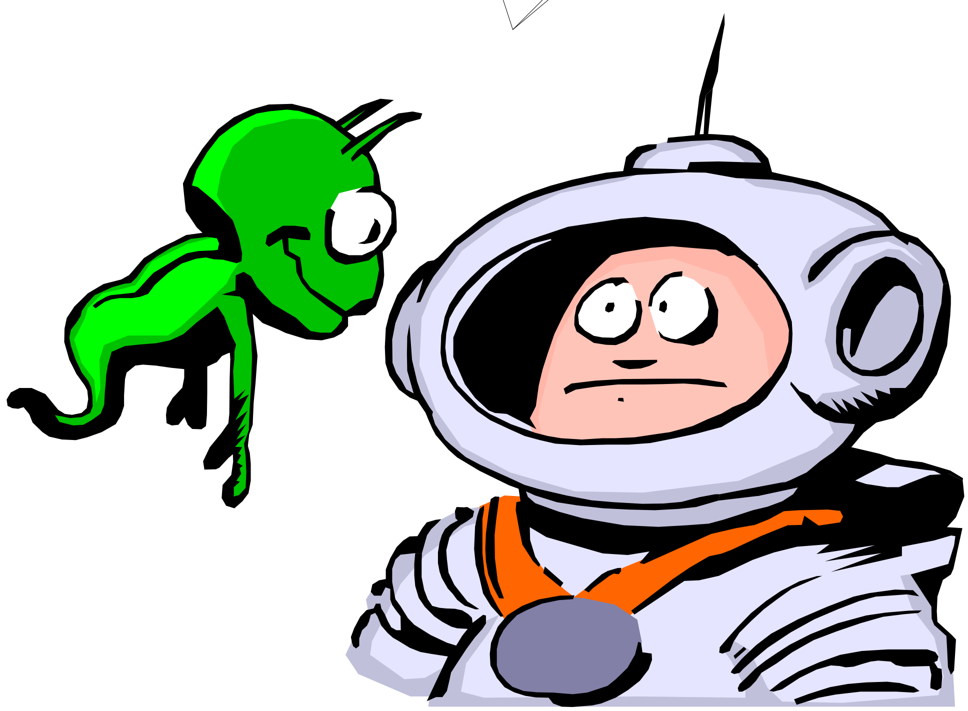
WHAT IS IN YOUR BRAIN ?



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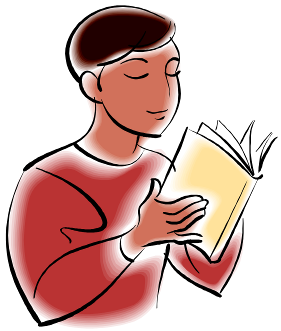
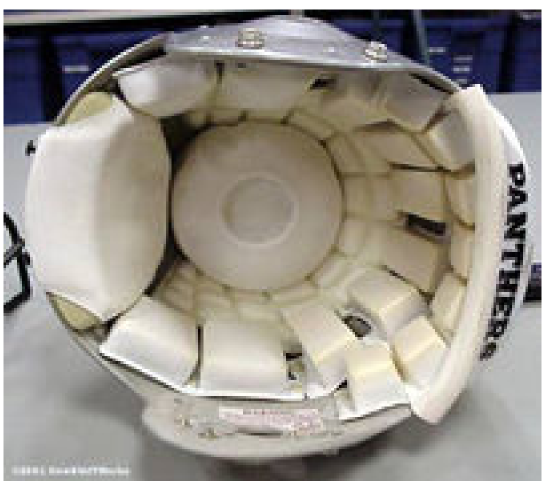
It's A No-Brainer!



Lesson's Objective:

To identify the **parts of the brain** and **their functions**, and to understand **the effects of pressure at the point of contact**.

Background Information:



The brain is the control center of your body. We now know that destruction of even small areas of the human brain can have devastating effects on behavior. Different sections of the brain control different body functions. There are five main functions controlled by the brain: vision, speech, balance, sound, memory, emotion, motor, and other senses. It is very important to protect the brain during activities that could cause trauma to the head.

Helmets work very well, as long as they are fitted securely and buckled when you crash. They can prevent up to 88 per cent of cyclists' brain injuries. Many helmet users are not securing their helmets level on the head and adjusting the straps carefully. Helmets have also been shown to offer substantial protection to the forehead and mid face.

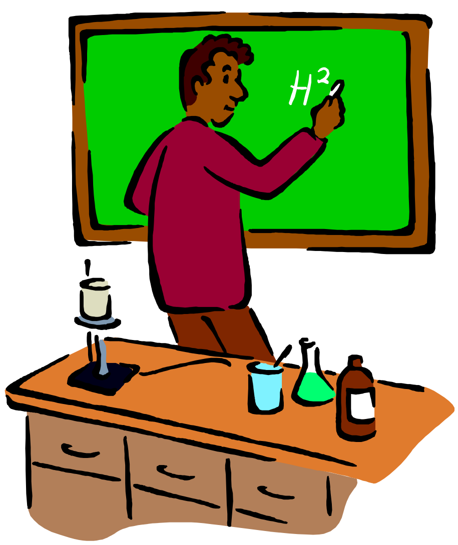
Advanced technology figures into almost everything scientists do, and athletics is no exception. At the Super Bowl, you may not see the defense wearing space suits, but there is an element of aerospace research being used by just about every player on the field.

Take the helmets, for instance; the padding in the helmets was developed from NASA research, and the plastic in the shell is the same material used by astronauts on space walks. When it comes to the rough-and-tumble game of football, helmets are one of the most crucial pieces of safety equipment. Having well-padded headgear is essential to the safety of athletes involved in the game.

The outer shell of today's football helmets is made from the same plastic material used in astronaut helmets. It's a lightweight polycarbonate called Lexan. It helps reduce the impact of a tackle by spreading the force over a greater area of the head.

Materials:

- **Per Student**
- Puzzle sheets
- Color pencils, crayons, or markers
- Scissors



- **Per pair of students**
- Pieces of foam cushioning
- Raw chicken eggs
- Tape
- String
- Paper towels
- Self-sealing plastic bags

- **For teacher demonstration**
- Block of wood
- Two nails
- Hammer
- Paper Towel

Pre-Lesson Instructions:

1. Divide students into partners to complete this lesson.
2. Prepare a self-sealing plastic bag for every pair of students prior to the activity. Alternate the following items:
    a. A plastic bag with just a raw egg in it

b. A plastic bag with a raw egg, a piece of foam cut to cover half of the egg, and a piece of string long enough to tie around the foam and the egg. Tie the string around the egg and foam loosely.
c. A plastic bag with a raw egg, a piece of foam cut large enough to completely cover the egg, and a piece of string long enough to tie around the foam and the egg. Tie the string around the egg and foam loosely.
d. A plastic bag with a raw egg, a piece of foam cut to cover half of the egg. Tape the foam to the egg.
e. A plastic bag with a raw egg, a piece of foam cut to cover the egg completely. Tape the foam securely around the egg.

3. Make groups with the pairs that have the same materials in their plastic bag.
4. Make egg demonstration and explain.
5. Make hammer and nail demonstration.
6. Explain that they are going to see how important it is to wear a helmet correctly. Use the following as representations.

    - The eggs in the bags represent a person's head, and the foam represents a helmet.
    - The students with just the raw eggs are not wearing a helmet.
    - The students with the small piece of foam and string are representing a person wearing a helmet that does not fit properly and is not fastened with the strap.
    - The students with the small piece of foam taped to the eggs are representing a person wearing a helmet that does not fit properly, but the strap is fastened.
    - The students with the foam that covers the egg and string represent a person wearing a helmet that fits but is not fastened with the strap.
    - The student with the foam that covers the egg and is taped around it is representing a person wearing a helmet that fits and is strapped on properly.

7. Explain the rules of the egg-toss experiment and take the class outside.

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8. Before going inside, have the partners form a large circle and one at time, have them explain which bag they had, when they dropped their bag, and if their egg cracked.
9. Have students dispose of the plastic bags in a trash bag.

Data and Observations:

1. How many times did you toss the egg before it fell?

____

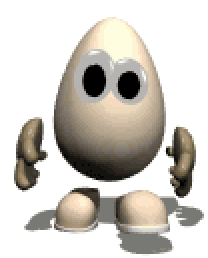
2. What type of egg did you have?

____

3. What type of surface did your egg fall on?

____

4. Draw your egg with the cracks observed.



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Discussion Questions:

1. Which provided the best protection? ____________________

____

____

____

2. Did having the foam loosely on the egg help protect it from cracks? ____

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____

____

3. Did the impact surface have an effect on the amount of damage? ____

____

____

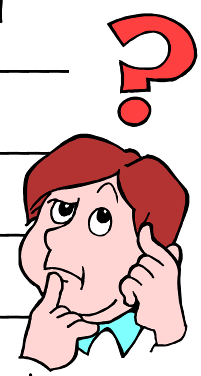
____

4. Do you think wearing a helmet will protect you from a head injury? ____

____

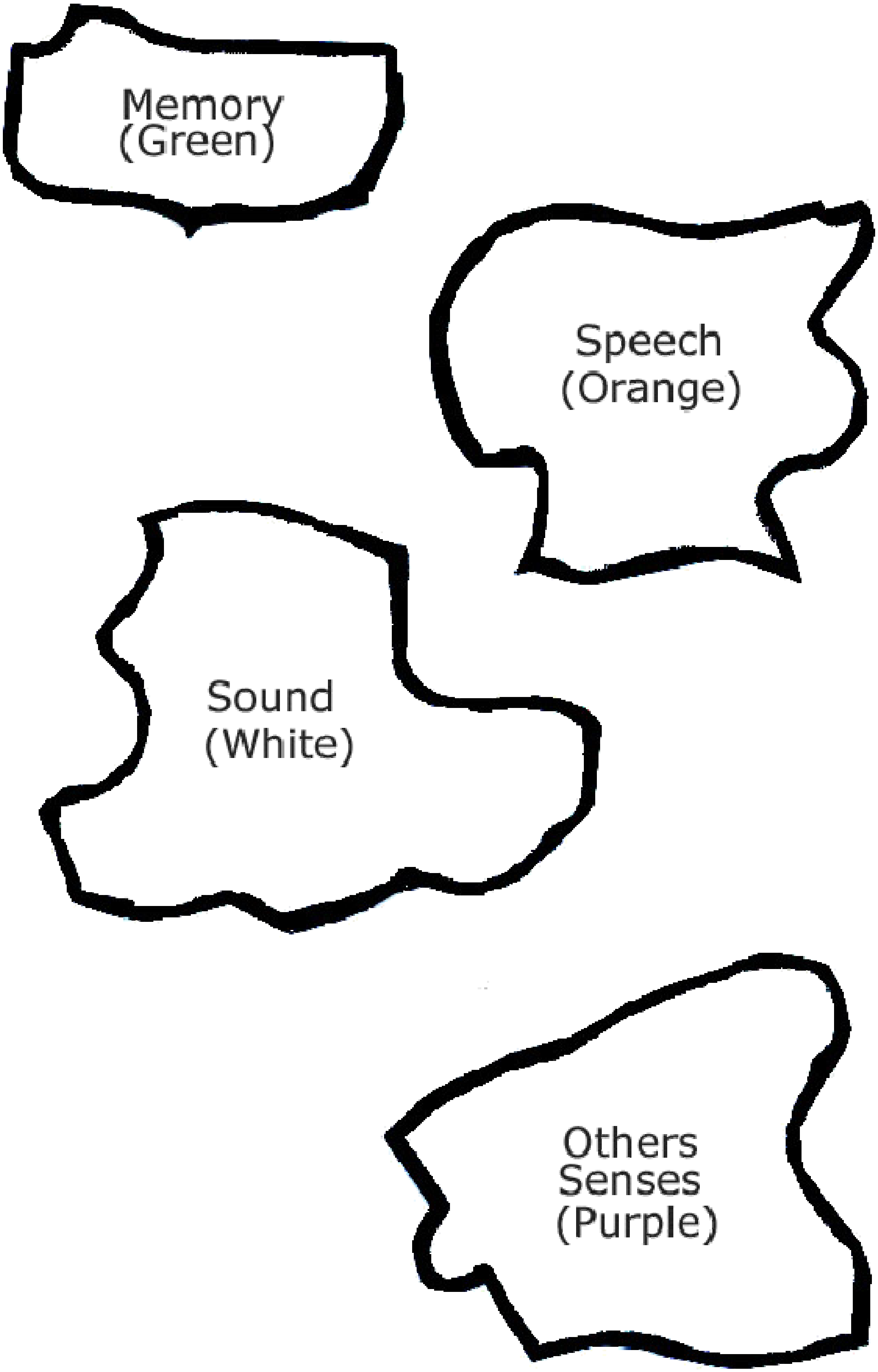
____

____

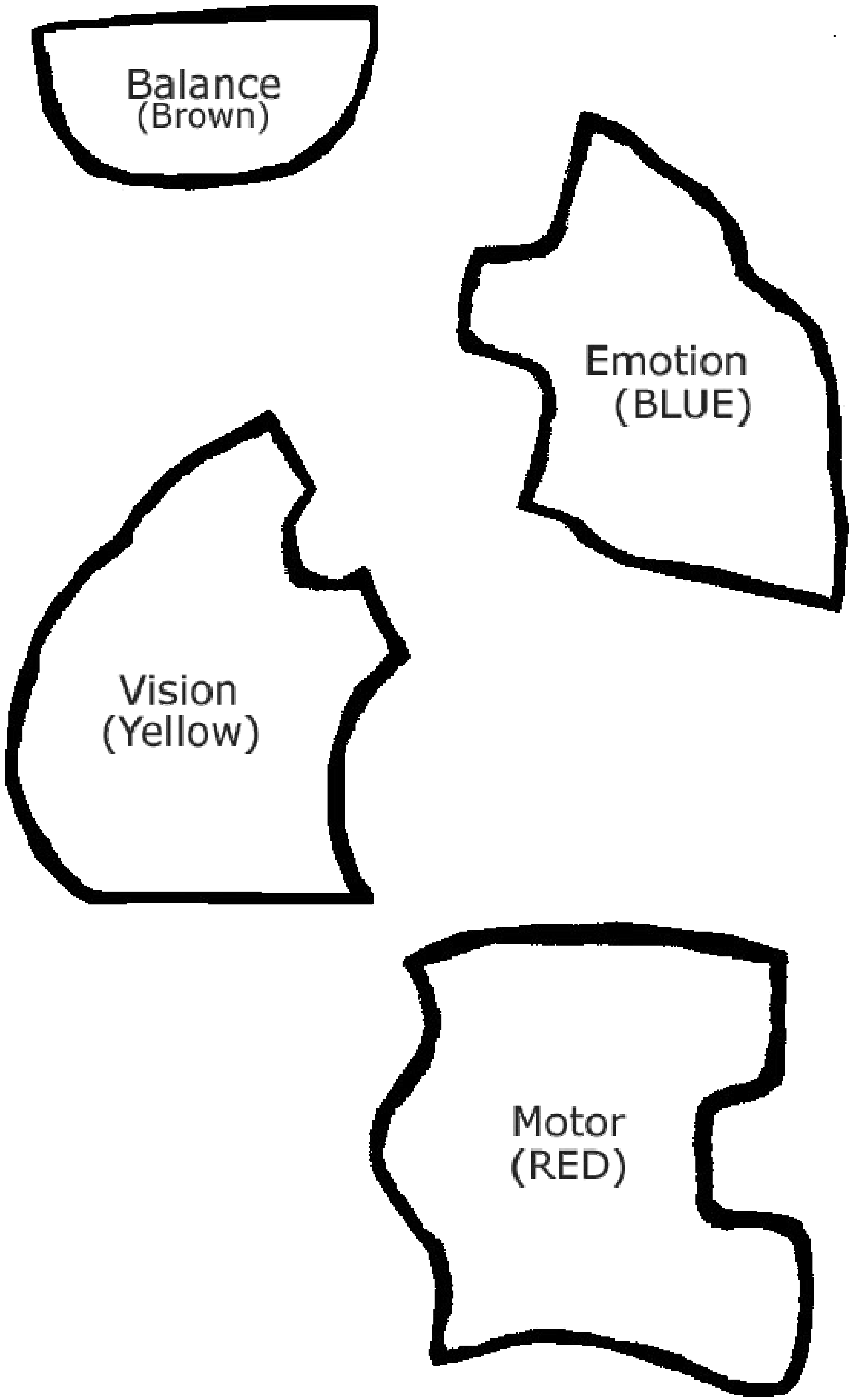


Instructions: Color, Cut, and connect the puzzle pieces on the next page to build your brain.

Date____________________________


Memory
(Green)
Speech
(Orange)
Sound
(White)
Others
Senses
(Purple)

Date____________________________



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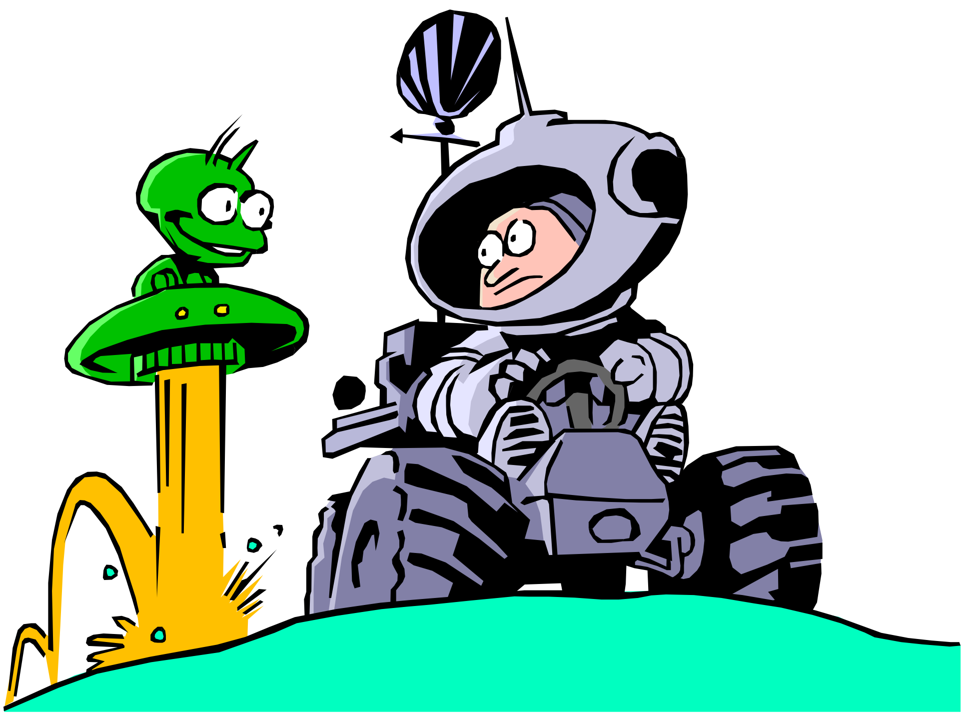
NEXT SPACE CODE 101



Date____________________________

Space Code 101

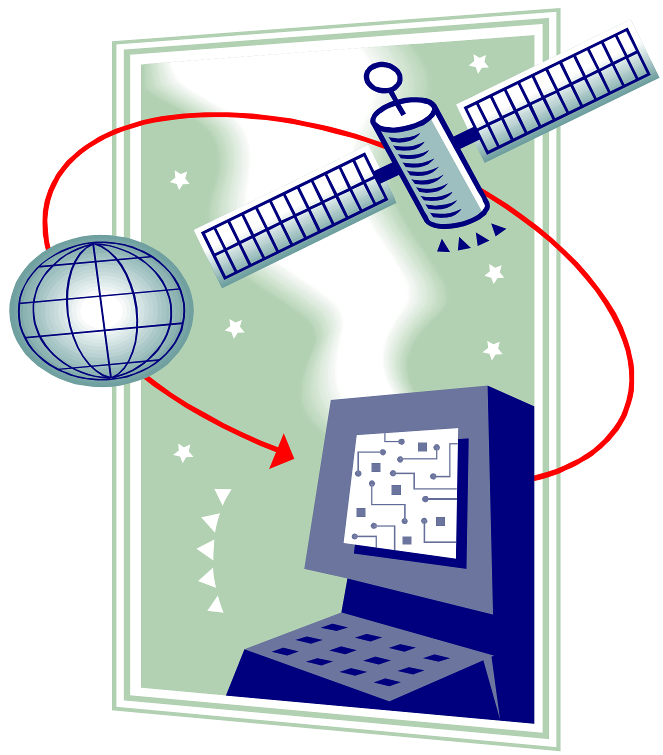
Objective:

To show how messages are sent into space using radio telescopes with the hope that the messages will be received and understood by intelligent life in other solar systems.

Activities:

The students will:

1. Decode a message that is written in binary code.
2. Study an actual message that was sent by the Arecibo radio telescope.
3. Design a simple picture on graph paper and code it in binary.



Materials:

For each student:

graph paper, pencil
copy of 10 by 10 binary code chart
copy of message sent from Arecibo

For the lesson:

Arecibo message with the explanations of some of the symbols
drawing of key to show what binary chart looks like uncoded

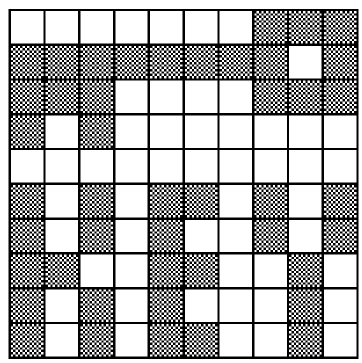
Previous Knowledge Necessary:

Knowledge of binary code (ties in with a lesson about computers)
Some background about radio telescopes, which are used to send and receive radio signals. They can be used to communicate with our deep

space exploratory probes and with possible extraterrestrial life, although they are most commonly used to listen to the radio noise of outer space.

Procedure:

1. Using a copy of the binary code chart, each student transfers the binary lines onto her graph paper, leaving the square blank if the number is "0" and filling in the square if the number is "1."



(The finished product is a drawing of a key with the word KEY underneath.)

2. Have the students look at the picture that was actually sent by radio telescope. Explain the message is coded in binary, but if any intelligent extraterrestrials find the message, they may be able to figure out that they can decode the binary by doing exactly what the students did actually the with the "key" message. See if anyone can guess about the meaning of the symbols portrayed in the picture. (A copy of the symbols with simple explanations of the meaning is enclosed.)
3. The students can then draw a simple picture on graph paper. Then they can code the picture in binary by assigning "0" to the blank squares and "1" to the colored squares.
4. Binary code message can be traded with friends or by lot and decoded by transferring the binary message onto graph paper. (This activity is the same as the first procedure.)

This activity was taken from a book by Harold R. Jacobs titled Mathematics - A Human Endeavor. It was published by W. H. Freeman and Co., San Francisco in 1971.

The Arecibo Message, 1974

The Arecibo message of November 1974 consisted of 1679 characters (ones and zeros).

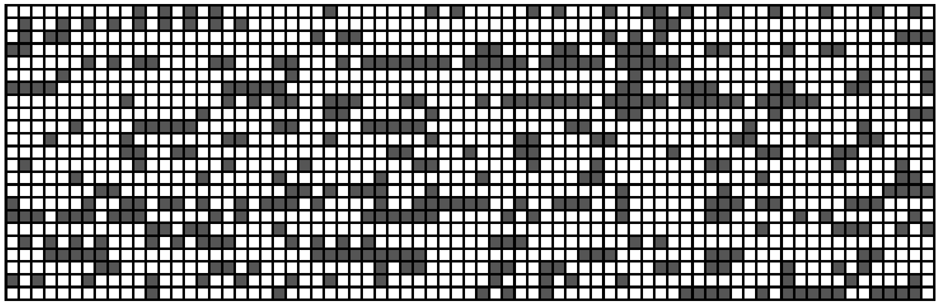
0000001010101000000000000101000001010000000100100010001000100101100101010101010101
0101001001000000000000000000000000000000000000000110000000000000000000110100000000
0000000000110100000000000000000001010100000000000000000011111000000000000000000000
000000000000011000011100011000011000100000000000000110010000110100011000110000110
1011111011111011111011111000000000000000000000000001000000000000000001000000000
0000000000000000001000000000000000001111110000000000000111110000000000000000000000
000110000110000111000110001000000010000000001000011010000110001110011010111111011
111011111011111000000000000000000000000001000000110000000001000000000001100000000
000000001000001100000000001111110000011000000111110000000000110000000000000100000
00001000000001000001000000110000000100000001100001100000010000000000110001000011
000000000000000110011000000000000001100010000110000000001100001100000010000000100
00001000000000100000100000001100000000100010000000001100000000010001000000000100000
00100000010000000010000000100000001000000000000110000000001100000000011000000000100
0111010110000000000001000000010000000000000010000011111000000000000010000101110100
101101100000010011100100111111101110000111000001101110000000000101000001110110010
000001010000001111110010000001010000011000000100000110110000000000000000000000000
000000000011100000010000000000000011101010001010101010100111000000000101010100000
0000000000010100000000000000011111000000000000000011111111100000000000000111000000000
1110000000001100000000000011000000011010000000001011000001100110000000011001100001
0001010000001010001000010001001000100100010000000010001010001000000000000100000100
0010000000000000100000000010000000000000010010100000000000001111001111101001111000

1679 is 23 times 73. These are prime numbers therefore it would seem reasonable to think of the Arecibo message as 23 groups of 73 characters or as 73 groups of 23 characters.

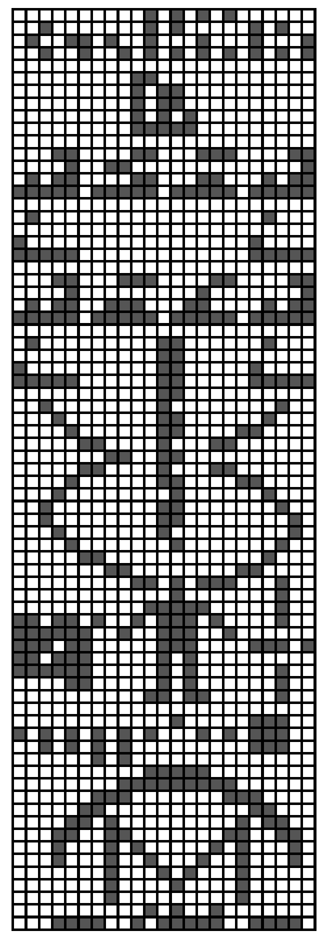
The binary message may be transferred to graph paper, by leaving a square blank if the number is "0" and filling in a square if the number is "1." Starting in the upper right corner and working from right to left going down the page you can decode the 23 by 73 character message and the 73 by 23 character message.

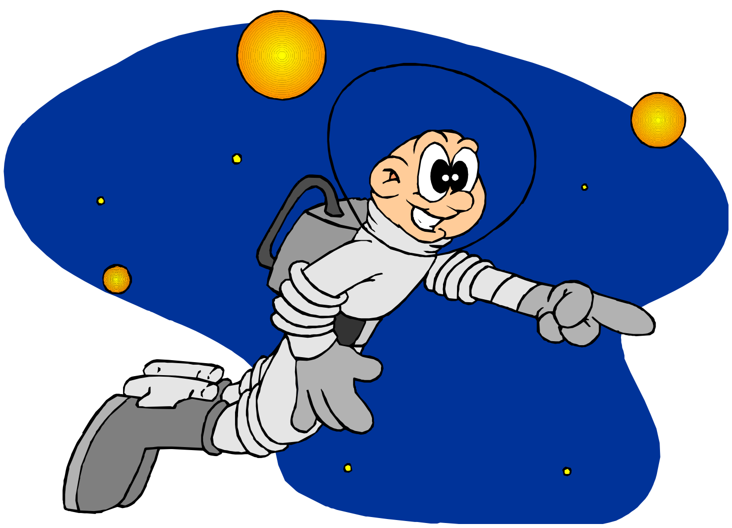
Date____________________________

The Arecibo Message
as a 23 by 73 character message



The Arecibo Message
as a 73 by 23 character message

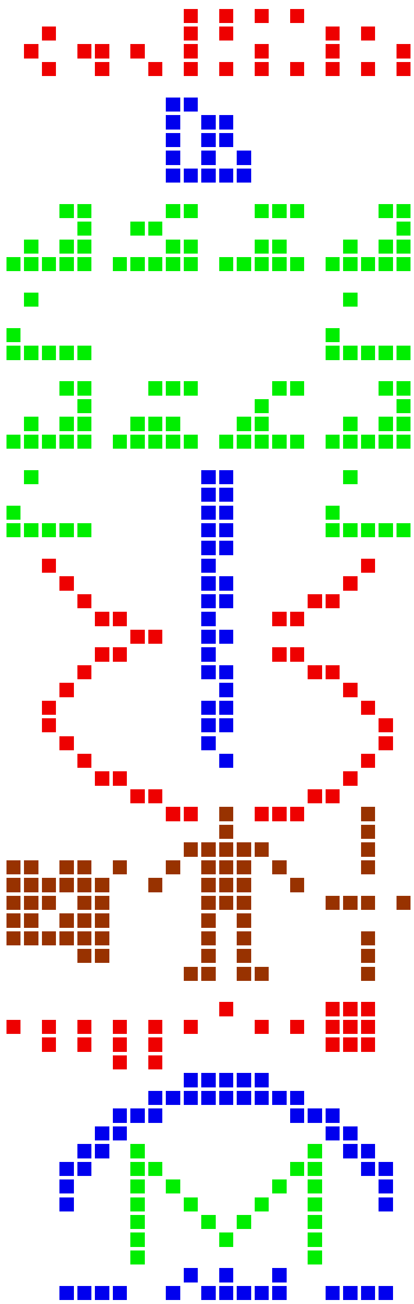




This picture seems to be meaningful, so let's look at the explanation of some of the symbols.

Date___________________________

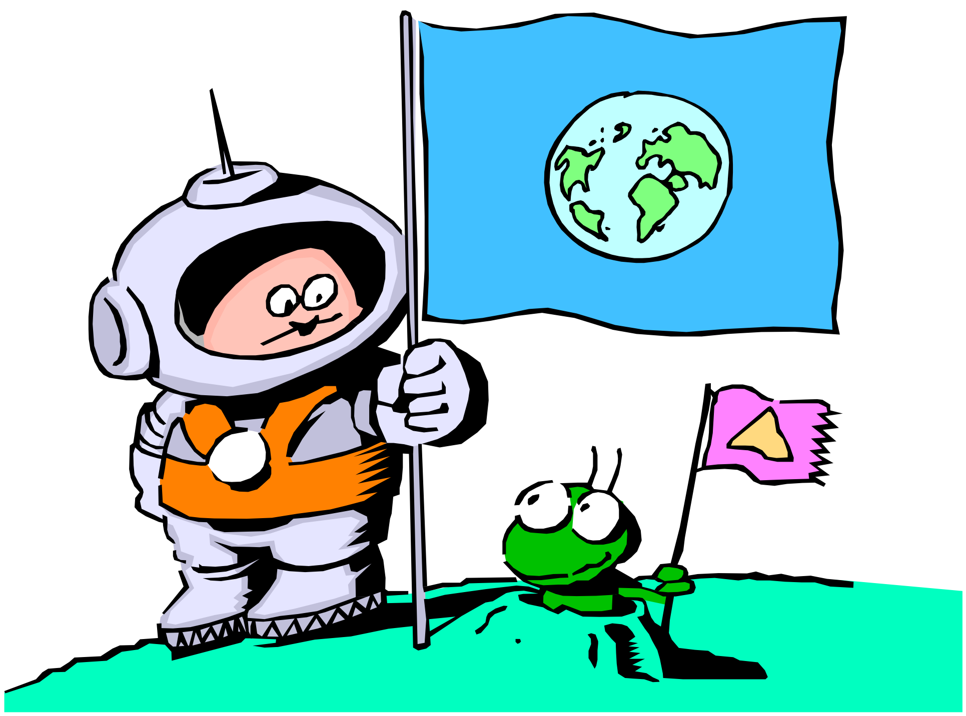
The Arecibo Message Explained



1. The first set of symbols (colored Red) represent the numbers from 1 to 10 reading from right to left.
2. The cluster in the center (colored Blue) codes the atomic numbers for certain elements.
3. These (colored Green) patterns represent formulas for sugars and bases in nucleotides of DNA.
4. The (colored Blue) vertical bar in the center specifies the number of nucleotides in DNA.
5. The double helix of DNA is represented by the (colored Red) curving lines that go from the (sugars/bases) formulas to the human figure.
6. The next set of symbols (colored Brown) represent the human population (on the left) on Earth, a figure of a human (in the center) and (on the right) the height of a human.
7. Our Solar System (colored Red) is displayed next. The dot representing Earth is displaced toward the human being.
8. The Arecibo telescope dish (colored Blue) is transmitting the message (colored Green) near the bottom of the picture. The last set of symbols (colored Blue) give the diameter of the Arecibo Radio Telescope.

Date______________________________

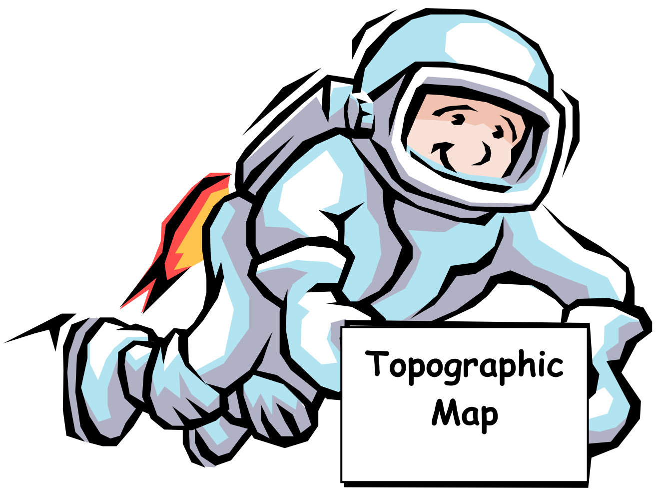
LET'S BUILD A TOPO MAP



Date____________________________

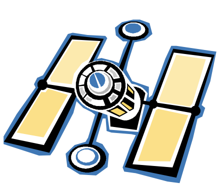
What is a Topographic Map?

A topographic map, or "topo map," is a way to show mountains and valleys on a flat piece of paper. Topo maps are handy and necessary for many uses, including building roads and hiking trails in the mountains. The map shows where the hills and valleys are and how steep they are. (Slope: be at an angle; "The terrain sloped down")



What Do "Topo" Maps Have to Do with Space?

We can use a technology called imaging radar to help create a picture of the terrain on Earth--or any other planet. Imaging radar instruments are flown over the land (or water) in an airplane, flown in space on the Space Shuttle, or put on a spacecraft and launched into orbit around the planet.

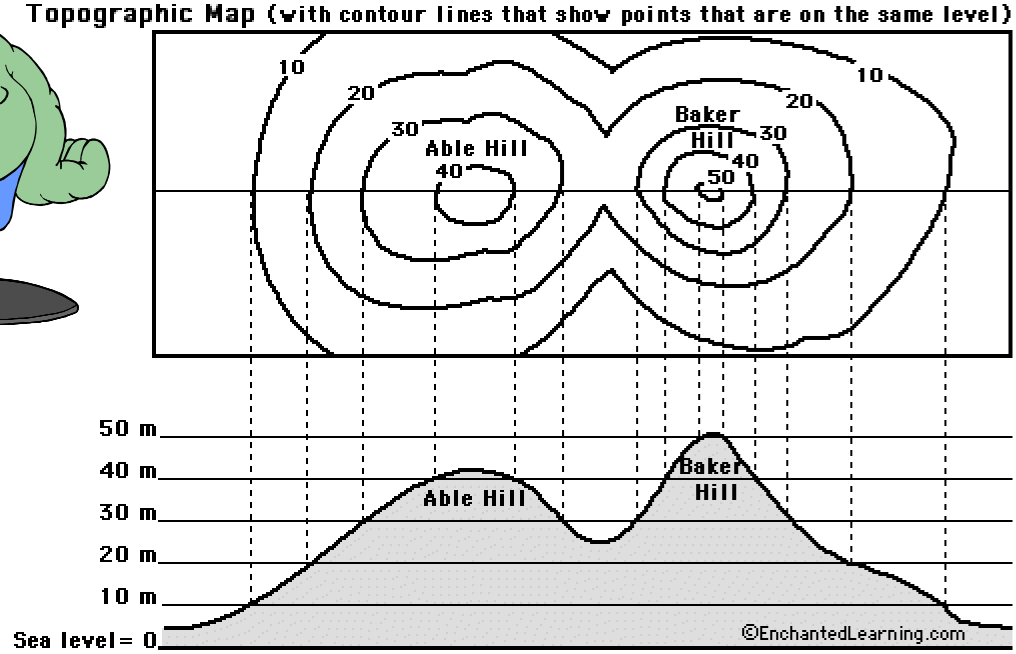


Fact: It will take scientists a long time to study all the image data and up to two years to make a map.

Date____________________________

Topographic Maps Understanding Activity

Topographic Map (with contour lines that show points that are on the same level)



The two hills seen from the side, with elevations marked and dotted lines pointing to the corresponding contour lines.

Color the elevations on the topographic map as follows. Red: 50m and higher, Orange: 40-50m, Yellow: 30-40m, Light green: 20-30m, Dark green: 10-20m, Purple: 0-10m.

Answer the following questions using topographic map shown above.

1. Approximately how tall is Able Hill? ______________________________

2. Approximately how tall is Baker Hill?______________________________

3. Which mountain is taller, and by about how much? __________________

____

4. How many meters of elevation are there between contour lines on the topographic map? ____

5. Which mountain has steeper slopes? _____________________________

6. Are the contour lines closer together on Able Hill or Baker Hill? ______

____

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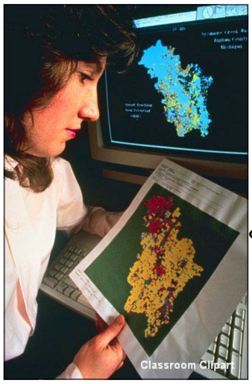
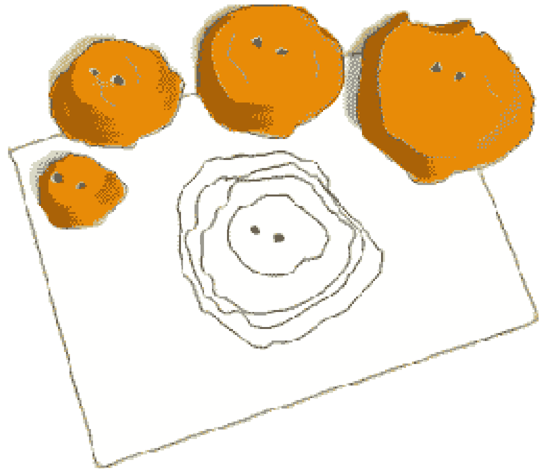


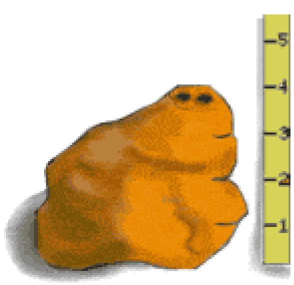
Let's Build a Topo Map



Materials:

- A lump of clay or Play-Doh® about the size of a coffee mug.
- Piece of cardboard or large tile on which to work the clay
- Piece of dental floss, about 2 feet (around 60 centimeters) long
- Ruler
- Piece of plain, white paper
- Long pencil
- 2 toothpicks
- Crayons

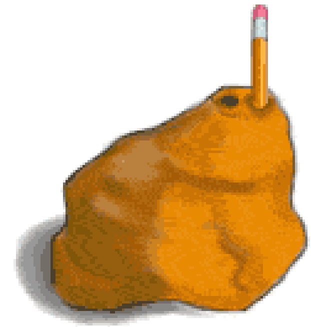
Step by Step Directions:

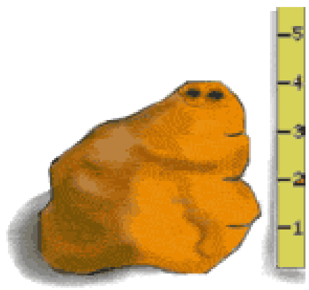


1. Put the lump of clay on the cardboard and shape a mountain about 4 inches high. Making the map is more fun if you make your mountain a little lop-sided or oddly shaped. However, the mountain should be flat on the bottom.

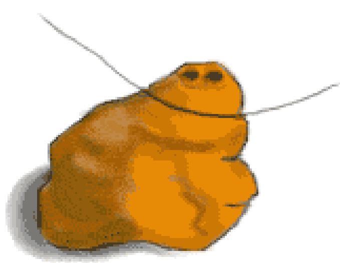
Date_________________________

2. Use the long pencil to poke two holes straight down through the center of the mountain. Make sure your two holes go all the way through the mountain.



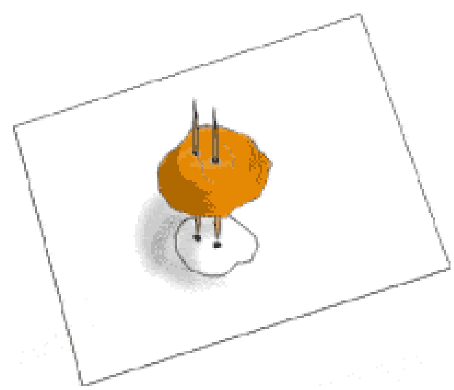


3. With the ruler, measure down about 1 inch (2.5 centimeters) from the top of the mountain and make a little dent mark with the pencil. Make two more dent marks lower down on the mountain about 1 inch apart. Or, without using the ruler, just make three marks to divide your mountain into four slices all about the same thickness.



4. Stretch the dental floss until it is taut, wrapping the ends around your fingers so you have a good grip on it. Use the dental floss to cut through the mountain at top-most mark you made. Hold the floss as horizontal (level with the table or floor) as you can.

5. Remove this clay slice and place it on the paper. Use the pencil to carefully trace around it. Push the pencil through one of the holes in the clay and make a dot on the paper; do the same with the other hole. Put the slice aside, but don't squash it. You'll need it again later.



6. Cut a second slice at your next mark down from the top. Lay the second slice over the tracing of the first one, being careful to place the holes in the second sick over the dots on the paper. To line up the holes, poke the two toothpicks through the holes in the slice and line them up with the two dots on the paper. Carefully trace around the second slice. Your tracing will form a circle outside the tracing of the first slice. (If you have "outcroppings" on

your mountain, the second circle could cross into the area of the first circle).

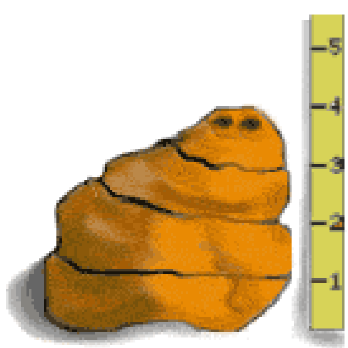
7. Cut another slice at the next mark down. Line up the holes with the dots and trace it as you did before. Finally, place the bottom slice on the paper, line up the holes, and trace it.

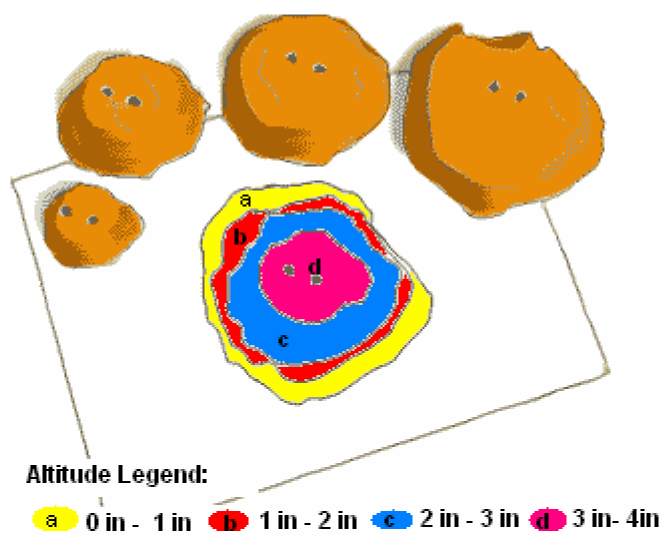
8. Stack the slices back up in order on the cardboard. Be sure the holes line up.

9. Admire your topo map!

10. Compare the topographic map you have just made to the model mountain.

11. Finally, let's create a legend for our topo map, since we make the mountain's cut based on height, our legend will be describing the possible height of each areas in the topo map. For example;





Conclusions:

1. Why are some of the traced lines closer together than others? _____________

____

____

Date__________________________

____

2. On your topographic map, where are the steepest slopes? __________________

____

____

____

3. Looking at your map, where would be the best place to build a trail to climb to the top of the mountain? ____

____

____

____

4. Do you think the topo maps are useful? If yes, why? ____________________

____

____

____

References:

http://www.enchantedlearning.com/geography/mapreading/topo/

http://spaceplace.nasa.gov

Date____________________________

WHAT DO YOU KNOW ABOUT SOLAR AND FUEL ?

Date______________________________

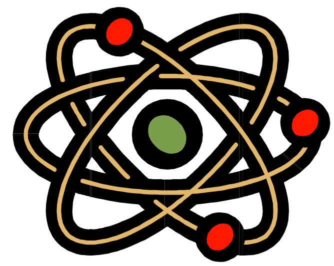
Water Electrolysis/ Fuel Cell Cars

Students will recognize and/or understand:

1. Specific aspects of the atomic theory
2. Water as a molecule
3. The theory and applications of water electrolysis
4. The design and theory of a car powered by a fuel cell

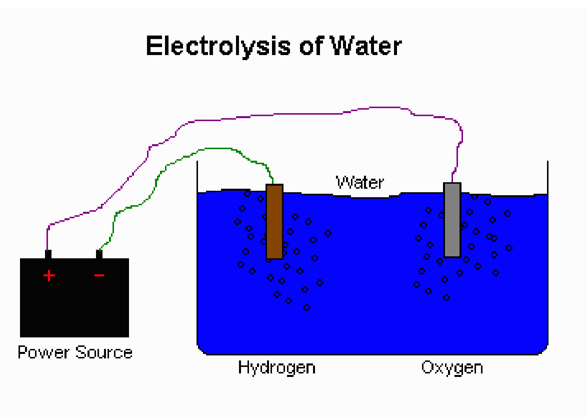
1. Atomic Theory

- Components of the atom
  - Nucleus
  - Protons
  - Neutrons
  - Electrons



2. Atoms and Molecules

- How atoms form compounds
- Compounds as molecules
- Water molecule



3. Water Electrolysis

- HOW? and WHY?
- Electrolysis Apparatus (9V battery, water, and platinum wires as electrode)

4. Fuel Cell

- What is it?
- How does it work?
- Theory/Applications
- Design of fuel cell powered car

5. Set-up

- First 20 minutes will involve an introductory lecture on powerpoint discussing atomic theory, atoms, molecules
- The next 15 to 20 minutes will be a combination of lecture and activity on water electrolysis.
- The next 1 hour will involve discussion of fuel cell technology and the construction of the fuel cell car.

6. Materials

- Five Fuel Cell kits
- Gum drops/toothpicks
- Water electrolysis kit

Note: This kit is reusable and includes many options for other experiments that will be developed for the future and included in a fuel cell oriented module.

Date____________________

SOLAR AND FUEL Cells

Pre-lab Activity

Think about the following questions and be prepared to discuss them with you teacher:

- Describe an atom and a molecule and give examples?

____

____

- What is the difference between atoms and molecules?

____

____

- How many atoms are in a water molecule?

____

____

Give two examples in history where people used water as a source of energy?

Example 1: ____

Example 2: ____

Date____________________________

Lesson Notes:

Date____________________________

Experiment objectives

Today's experiments will explore the use of Solar energy to dissociate break water molecules. You will also explore the use of Hydrogen (H_2) and Oxygen (O_2) in a fuel cell. This lesson will help you understand how NASA scientists use solar power to run many systems in space.

Question/Hypothesis

1) Think about which parts of the water molecule are involved in "breaking" the chemical bonds between atoms.

Materials

Fuel cell kit

Date___________________________

TOPIC QUESTION:

PURPOSE:

HYPOTHESIS:

PROCEDURE:

MATERIALS LIST:

VARIABLES:

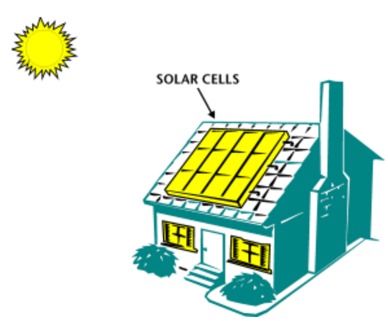
MANIPULATED VARIABLES:

RESPONDING VARIABLES:

VARIABLES HELD CONSTANT:

Date___________________________

DATA:



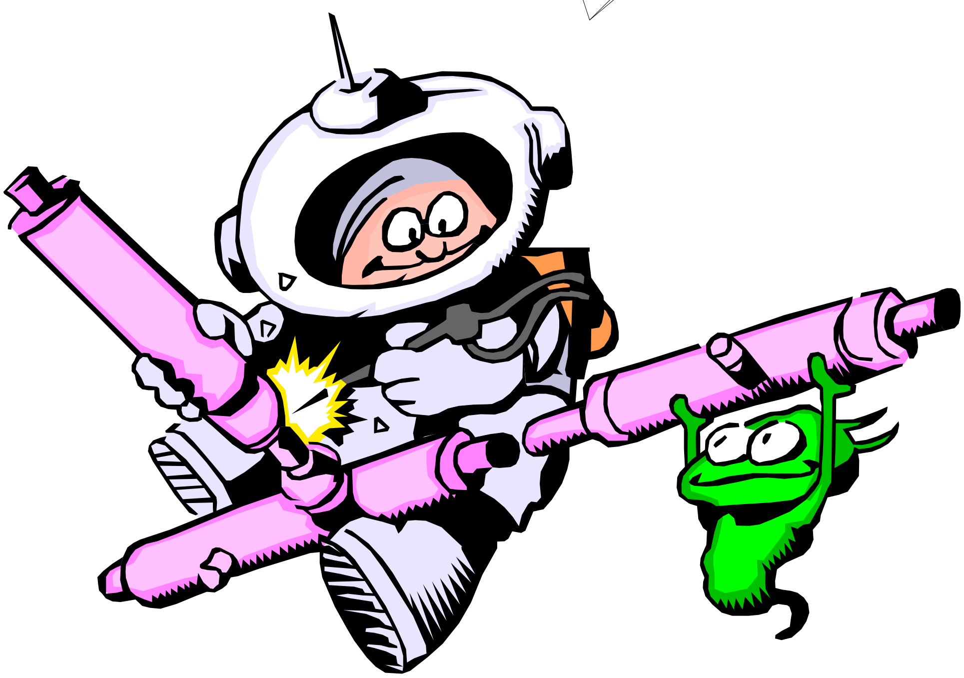
Date____________________________

GRAPH:

CONCLUSION:

Date____________________________

LET'S LEARN ABOUT ROBOTIC ARMS



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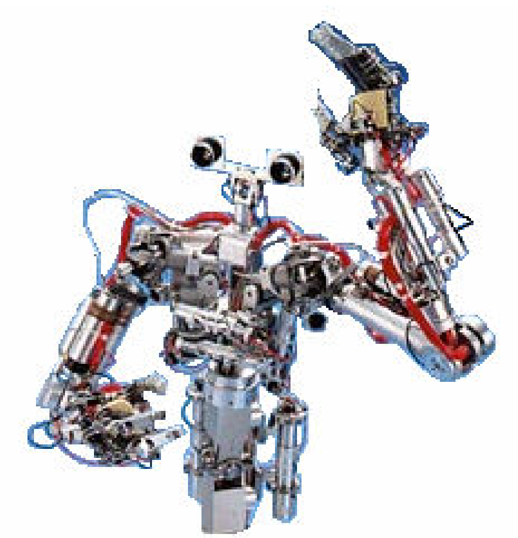
Robot Schematics

Objective



The purpose of this lesson is to stimulate students to discover what is behind a robot. The science that studies the robots is acknowledged as robotics. During this experiment the student should be able to recognize different type of robots and applications. In addition, the students will be able to identify different types of robot, joins and mechanism. This will also give the student the basic knowledge of robotics design and understand the benefits and advantages of robots.

Background

The components to build a robot are numerous according to each **physical configuration**. Every **physical configuration** promotes a working space and this breathing space is limited according to the **degrees of freedom** or possible movement. The flexibility of motion is increase when different types of joints are link to his structure. At least six degrees of freedom are necessary to emulate the motion of a human arm and wrist. In this lesson the students are going to be able to operate an **Articulated Robotic Arm** on class. They will be able to see the movement and possible applications of this type of robot. The advantages and disadvantages of the articulated arm configuration will be outlined next.

Advantages:

1. All joints are rotary.

2. Maximum flexibility since any point in the total workspace volume can be reached.
3. Joints can be completely sealed and protected.
4. This is very useful in dusty or corrosive environments, or under water.

Disadvantages:

1. Very difficult to visualize and control.
2. Restricted volume coverage.

Robots are capable of performing many applications; the complexity involved with using a robot to perform the application may require too much time and effort to allow justification of the robot. This can only be evaluated on a case by case basis, based on the complexity of the application, the run length and the cost of support. Articulated Robotic Arm is perhaps the most widely used arm configuration because of its capability to reach any part within the working envelope.

Due to the flexibility, this robot type can be used in such advanced applications like:

1. Spray painting
2. Weld sealing
3. Assembling

This **Articulated Robotic Arm** offers five axes of motion that can be define as follow:

1. Base Right / Left 350 degrees
2. Shoulder 120 degrees
3. Elbow 135 degrees
4. Wrist rotate clockwise & counter clock wise 340 degrees
5. Gripper open and close 50 mm (2 in)

General Arm Motion

1. Vertical movement. Up and down motion of the arm. May be caused by moving the whole robot body vertically.

2. Extension and retraction of the arm allows the effective length of the arm to be changed.
3. Rotation about the base of the robot.

Possible Wrist Motion

1. Wrist pitch, which is up and down movement of the wrist.
2. Wrist roll, rotation of the wrist clockwise or counterclockwise. Rotation and pitch can together produce yaw as described below.
3. Wrist yaw, movement of the end-effectors to the left or right.

Note: Alligator clips are recommend for those children who have physical disabilities with their hands.

Materials

- Robotic Arm kit
- Remote Control box
- 4 batteries size D
- Screwdriver (+) (M3)
- Long - nose Pliers
- Small Hammer
- Diagonal Cutter
- Pencil
- Pen Knife
- Ruler
- Protractor

Student Procedure

Students group will begin the experiment verifying first if they have all the materials required to proceed with the experiment. They will follow the teacher instruction all the time. Follow these steps when conducting the experiment:

1. Place students in groups of 4 or 5.
2. Set-up stations for each group with all necessary materials.
3. The students should check the instruction manual and classify all the materials require per step. So they will have the opportunity to get familiar with the **Articulated Robotic Arm.**

Date________________________

Fig.2 The previous image illustrate the final assembly of the **Articulated Robotic Arm** (OWI-007) and Remote Control Box

4. Each group has to provide a list of materials at the end of the experiment.
5. After the assembling process it is necessary to set the computer software to program the robot movement. This could be done by the teacher or someone with enough experience with this type of equipment.
6. Test the remote control box and robot motion according to the manual of instruction.
7. Proceed to answer the experimental data sheet once each group gets familiar with the control movement.
8. Discuss your findings and answer the entire experiment sheet question.

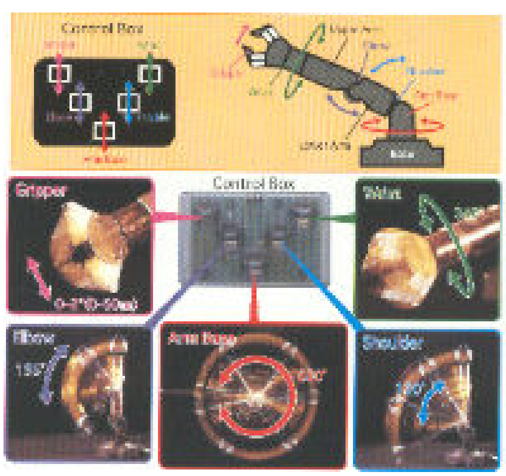


Fig.3 Illustrate all the possible movement of the **Articulated Robotic Arm** (OWI-007) using Remote Control Box

Date____________________________

I. Experimental Data Sheet

A. How many Servo motors and Joints are parts of the Robotic Arm? Explain your answer.____

____

____

____

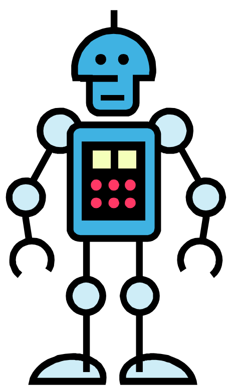
B. What is the voltage of your source? ______________________________

____

____

____

____



C. Enumerate degrees of freedom existing in OWI-007.

1. ____________________ 2.____________________
3. ____________________ 4.____________________
5. ____________________

D. Measure the displacement of the Arm when it is oriented at 180 or 90 degrees the distance is the same yes or no? Write your results in inches (inch.) and centimeters (cm.) and explain you answer.

____

____

____

____

E. Measure the gap of OWI-007 grip if there is any when is close? Write your results in inches (inch.) and centimeters (cm.).

____

____

____

____

F. Measure how wide OWI-007 grip can be open?

____

Date___________________________

____

____

____

G. Measure how many degrees of movement can be achieve by the following components:

Mechanism	Degrees	Type of Angle
Shoulder		
Elbow		
Base		

II. Outline and Engineer Drawings

A. Draw a diagram and identify the main components or parts and reference frame of the Articulated Robot Arm.

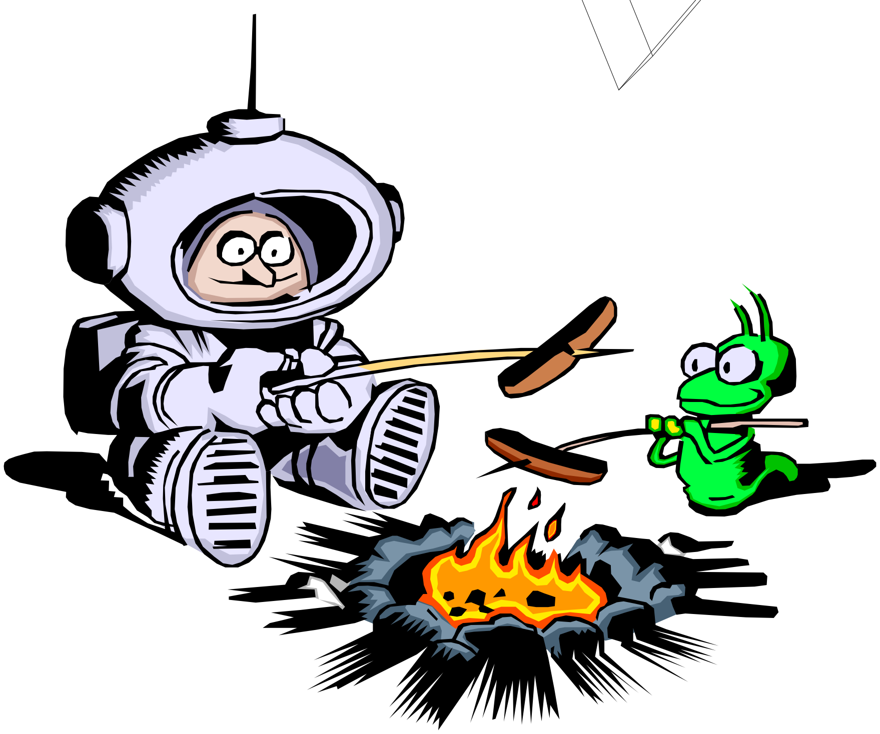
Date___________________________

B. Draw the Workspace Envelop of this type of robot?

C. How you determine if this breathing space represents the correct answer? Explain in your own words.

Date____________________________

LET'S TRY SOME SPACE FOOD



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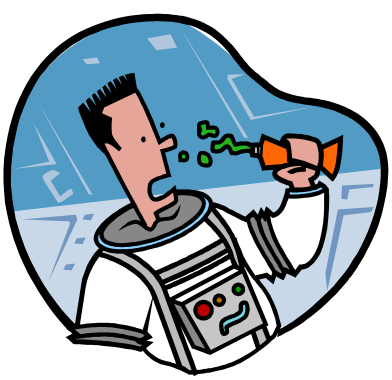
First Objective:

Students will determine the acceptability of food products for space flight by participating in a sensory taste panel.

Background Information:

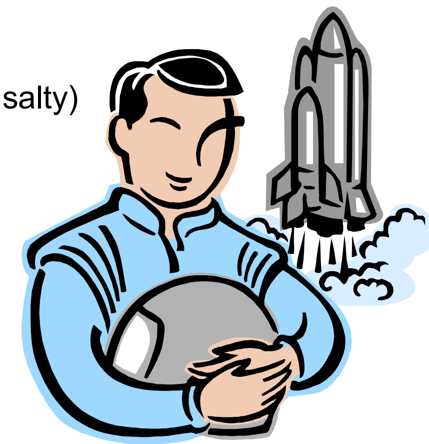
Astronauts select their menus for space about 5 months before they fly. For the



Space Shuttle, they select a menu that will serve them through the duration of their flight. They store the food in the galley of the shuttle. A special taste panel is set up for the astronauts to taste a variety of foods when they are selecting their menus. This lets the astronauts know whether they like the food before going into space. Foods are tested for appearance, color, odor, flavor, and texture. It does not help astronauts to take foods into space if they will not eat them. This taste panel helps in the selection of a desirable menu and reduces waste of uneaten portions.

Materials

- Paper plates
- Food samples (ranging from bitter, sweet, sour, and salty)
- a Taste Panel Evaluation Form
- Water



Procedure

1. Answer the following questions:

- What is your favorite food?

____

- Would it be considered bitter, sweet, sour, or salty?

____

- If you were going into space, what foods would you take with you?

____

- Why do you think it is important to test foods before you take food into space?

____

2. Choose a food item and rate it on a scale of 1 to 3 according to appearance, color, smell, taste, and texture.
3. Repeat step one until you have tested all of the food items.
4. Total the scores for each food and list them on the form.
5. Be ready to share your findings with the rest of the class.

Date_______________________

Questions

1. Which food got the highest score?

____

____

____

2. Which food got the lowest score?

____

____

____

3. Which sense of taste is the food you liked best considered?

____

____

____

4. Which sense of taste is the food you liked the least considered?

____

____

____

Date____________________________

Taste Panel Form

Food Item				
Appearance				
Color				
Smell				
Taste				
Texture				
Total Score				

Rating Scale:

1 - Bad **2 - Good** **3 - Great**

Date___________________________

Second Objective:

Students will plan a nutritious 3-day flight menu for astronauts in space.

Background Information:

In the past, space food was not that great. Astronauts had to eat dried food from metal tubes that squeezed out like toothpaste. It was not very tasty. Space food has become more like the food we eat on Earth.

All weight going into space raises the fuel consumption at liftoff. It is important to eliminate as much weight as possible. Because the fuel cells on the Space Shuttle produce water as a byproduct, water is easily attainable. Therefore, taking foods along that can be rehydrated with this water makes sense because this reduces the amount of weight on liftoff. The **rehydrated** foods also take up much less space, and space is a valuable commodity onboard the Space Shuttle.

Planning food for a space flight can be tricky. It is the job of the meal planners at **Johnson Space Center's Space Food Systems Laboratory** to create healthy meals for astronauts. They use the same food pyramid guide we use here on Earth. Foods such as soft drinks don't work because of **microgravity**. Ice cream can't go up without freezers. Fresh fruits and vegetables have to remain at room temperature. This limits how much can be taken. The food can only be heated to room temperature. Pizzas have not been perfected yet. Beyond that, astronauts can eat anything you might order from a typical menu.

It is important for astronauts to eat a balanced diet while in space. They have to be able to keep their energy up and stay focused. It is the job of the meal planners at Johnson Space Center to plan these nutritious meals. The planners use the Food Pyramid when making their space flight menu.

Date___________________________

Materials:

- USDA Food Pyramid Guide
- Food list
- 3-day menu chart

Procedure

1. Answer the following questions:

   - *How many groups of food are there?* ________________

   - *How many servings of each group do you need a day?* Refer to the Food Pyramid sheet.
     ____

     ____

   - *What is your favorite food group?*

     ____

2. Read over the list of food items available for the 3-Day space flight. Some menu items may contain more than one food group. For example, Banana Pudding is part of the fruit group and dairy group.

3. Using the Food Pyramid and Food List, select three meals for Monday (breakfast, lunch, and dinner). Make sure you include all the servings you need for the day.

4. Write your selections down in the 3-Day Space Menu Chart.

5. Repeat steps two and three. Try not to repeat the same foods. Make your menu have a good variety.

6. Write down your favorite meal.

   ____

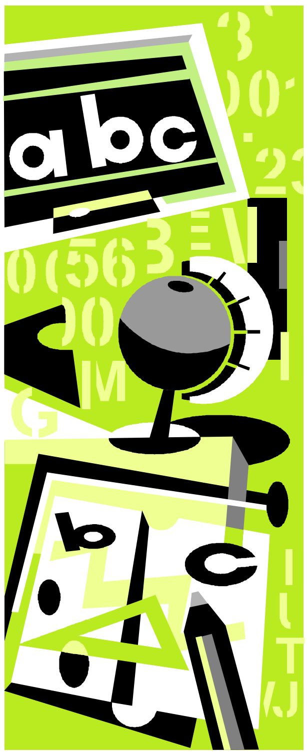
   ____

   ____

Date___________________________

7. List five healthy foods. List five unhealthy foods.

Healthy	Unhealthy



Discussion Questions:

1. Discuss why it is important for astronauts to receive the recommended daily servings.

____

____

2. Discuss types of problems you might face while trying to eat in space.

____

____

*Have students share their menus in class and state their favorite space meal for the trip.

Date______________________________

Food List and 3-Day Menu

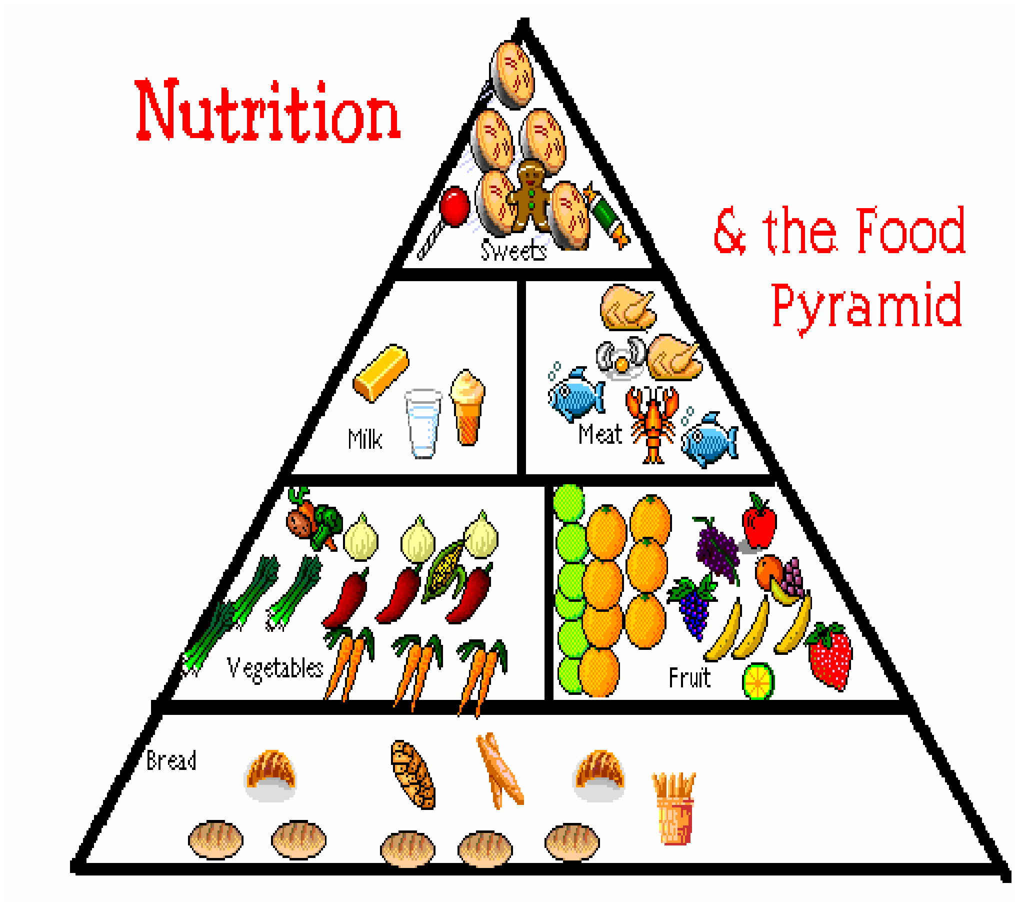
Breakfast	Lunch	Dinner
• Bacon • Cinnamon Toast Bread • Strawberry Cubes • Grapefruit Drink • Orange Drink • Sausage Patties • Sugar-Coated Cornflakes • Peaches • Water • Fruit Cocktail • Banana Pudding	• Cheese Crackers • Cream of Chicken Soup • Grape Punch • Tuna Salad • Apple Sauce • Sugar Cookies • Turkey Bites • Pea Soup • Ham and Potatoes • Chocolate Pudding • Water • Grapes	• Chicken and Rice • Beef Stew • Grape Drink • Chicken and Vegetables • Chocolate Cubes • Spaghetti and Meat Sauce • Turkey and Gravy • Pork and Scalloped Potatoes • Dry Fruitcake • Water

___________________ 3-Day Space Menu

Monday	Tuesday	Wednesday
Breakfast		
Lunch		
Dinner		

Date___________________________

Nutrition & Food Pyramid



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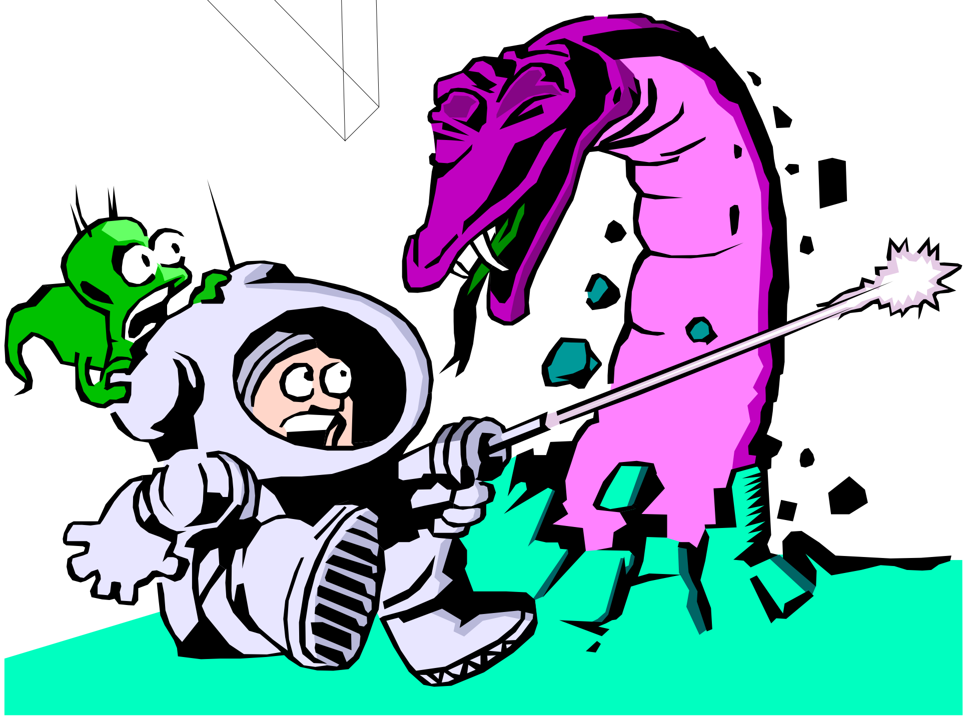
AHHHH... SOMETHING IS MAKING CRATERS



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about craters

Definitions

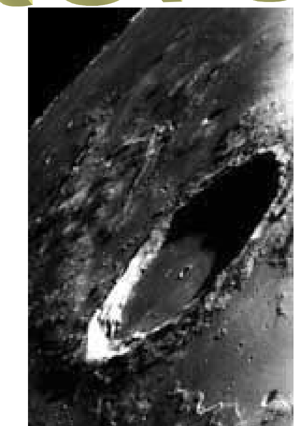


Image of unnamed crater on the far side of the moon courtesy of NASA.

Crater: A hole or depression. Most are circular or oval in shape.

Meteoroid: A small, rocky object in orbit around the Sun.

Meteor: This term describes the bright streak of light caused by a meteoroid as it burns up in Earth's atmosphere.

Meteorite: A part of a meteoroid that survives through the Earth's atmosphere.

Asteroid: A medium-sized rocky object orbiting the Sun.

Comet: a medium-sized icy object orbiting the Sun

Facts:

- On the Moon most are made by the impacts of meteorites.
- Meteoroids are smaller than asteroids.
- Asteroids are smaller than the planets, but larger than the meteoroids.
- Comets are smaller than the planets.

Date__________________________

MAKING CRATERS

Materials:

- 4 balls of different sizes
- Flour (as necessary)
- Cocoa (as necessary)
- A shallow container
- 1 ruler
- 1 pencil
- Data Sheet

Procedure:

1. To begin the activity, your teacher or instructor will fill one of the containers with flour and will sprinkle a little cocoa on the surface. This will make the changes caused by the balls more visible.
2. Gather the various balls; they will be the "meteoroids."
3. Write in your data sheet the description of each ball.
4. Pick out one of the balls and drop (***not throw***) the ball from about a height of 30 cm.
5. Describe what you observe, measure the crater diameter and crater depth. Record there results on your data sheet.
6. Repeat Steps 4 and 5, but using the other three balls (one at the time).
7. Repeat Steps 4, 5 and 6, but this time dropping the balls at height = 90 cm and height= 120 cm.

Conclusions:

____

____

Date____________________________

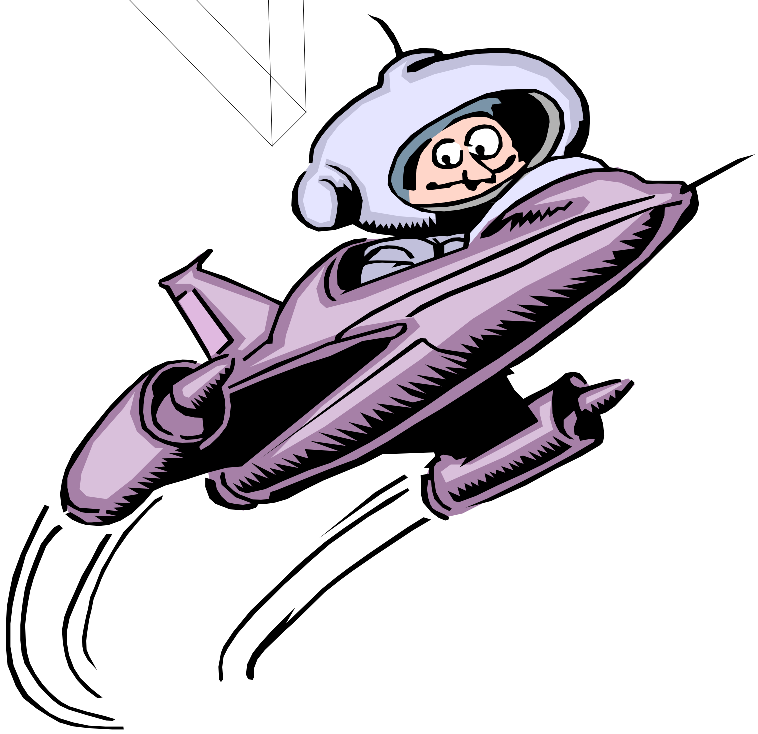
IMPACT CRATERS

Data Sheet

	Description such as weight, size, texture, etc	Drop Height = 30 cm		Drop Height = 120 cm	
		Crater Diameter	Crater Depth	Crater Diameter	Crater Depth
Ball #1					
Ball #2					
Ball #3					
Ball #4					

Date____________________________

LET'S GO FOR A TRIP ON A BOTTLE ROCKET!



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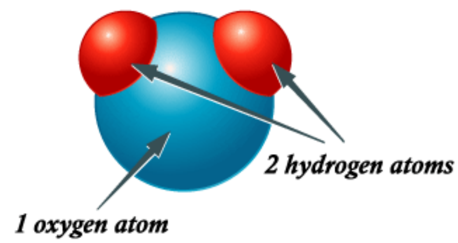
Water Matters

Water Molecule



Students will recognize and/or understand:

5. The three states of matter (solid, liquid, gas)
6. Solubility as a function of temperature
7. Ice renucleation
8. Polymer solubility
9. Surface tension

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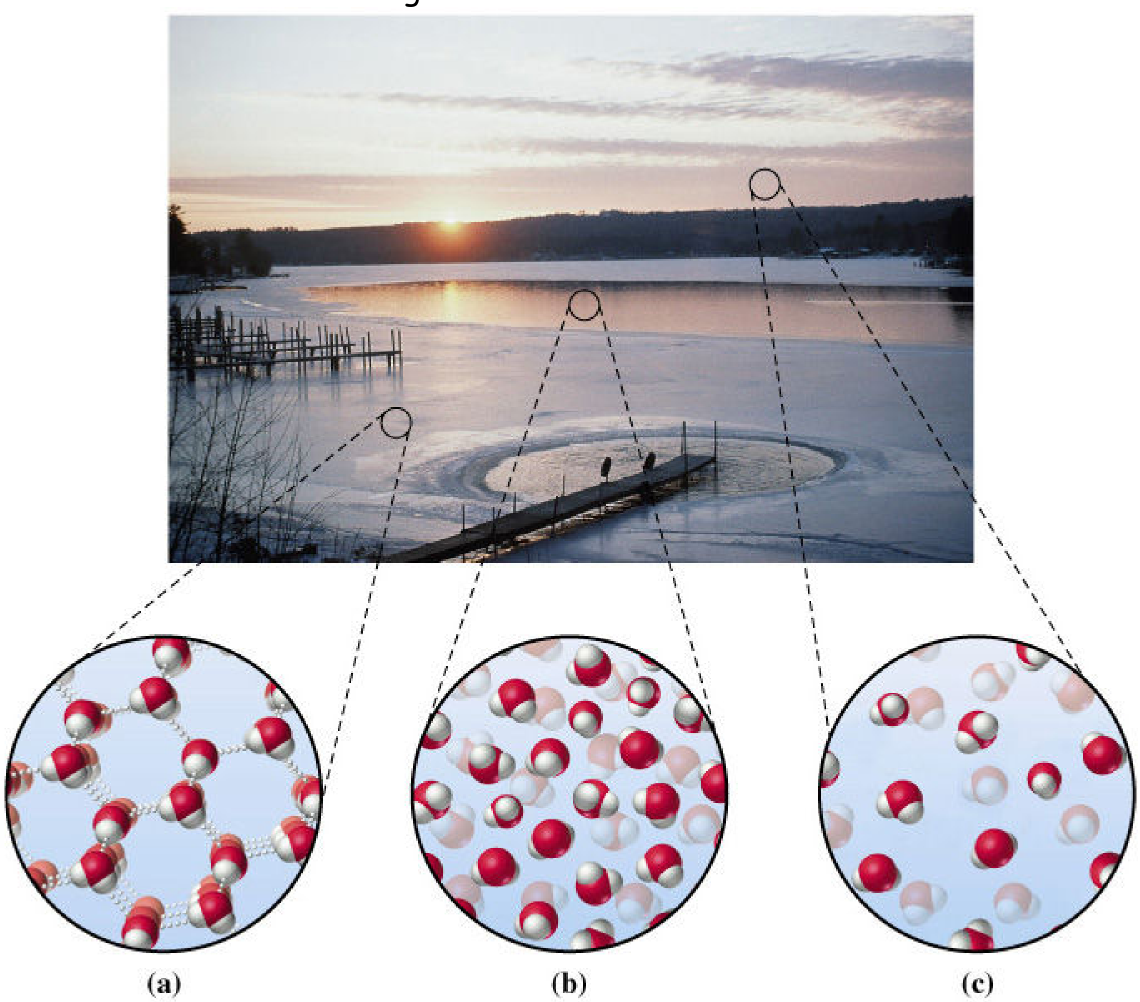
1. States of Matter

- Introduce term "solid"
- Introduce "liquid"
- Introduce "gas"



Date_________________________

2. **Water Stations**

- solubility as a function of temperature
- ice renucleation
- polymer solubility
- solubility

Set-up

- First 20 minutes will involve an introductory activity of the three states of matter
- The next 20 minutes will be a discussion of the theory pertaining to the specific stations
- The next 1 hour will involve experimental work performed by the students at each station.

General List of Materials:

- Hot Plates
- Magnetic Stirrers
- Ice
- Water (DI)
- Beakers/glassware

Date____________________________

Water Bottle Rocket Design

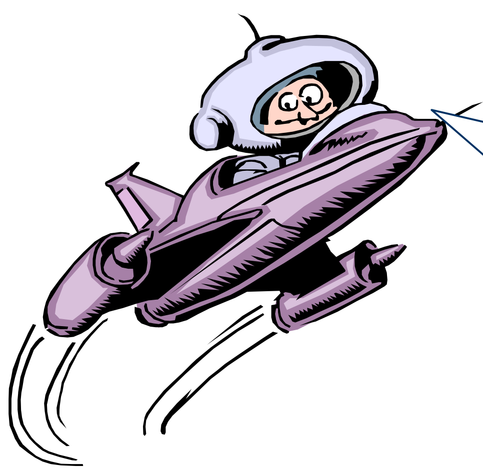
Rocket Design Activity

Follow your instructor to determine the best way to build your rocket. Using the website found in the materials section, optimize the parameters for building your ***rocket***.

ENJOY!

Experiment Objective

Today's experiments will explore the use of design parameters learned in the rocket design activity to build your own water bottle rocket.



So, get ready to build and lunch your own rocket into **deeeeeeeeeeeeeeeep** space!

Date___________________________

Materials

- The following website will guide you in designing your ultimate rocket:

  http://www.grc.nasa.gov/WWW/K-12/bottlerocket/br2d_b.swf

- The following material is needed to build your own water bottle rocket:

2 liter soda bottles

Construction or gift wrapping paper

Latex interior house paint

Heavy paper, cardboard, corrugated cardboard, balsa wood, or laminated foam board

White glue, wood glue, hot glue, or construction adhesive

Clear plastic packing tape or duct tape

Modeling clay

Garbage bags

String

Lesson Notes

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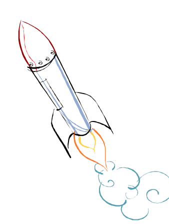

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More notes…

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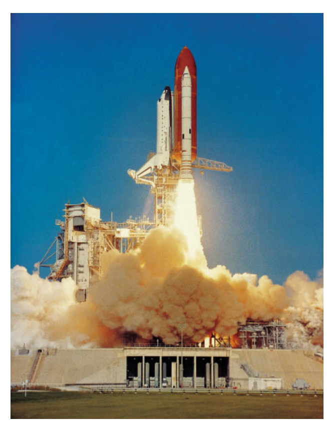
DATA:



Date____________________________

DATA:

Date___________________________

Research Modules

Date_________________________

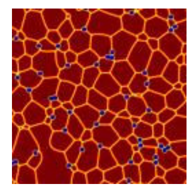
Microstructure

Lesson Background

Metallurgy is a domain of materials science that studies the physical and chemical behavior of metallic elements, and their mixtures, which are called **alloys**. An **alloy** is a homogeneous mixture of two or more elements, at least one of which is a metal, and where the resulting material has metallic properties. Examples of alloys are: steel (iron and carbon), brass (copper and zinc) and bronze (copper and tin or aluminum).

What do the microstructures of metals and alloys *look like?*

The fine detail of the structure of metals and alloys is defined as **microstructure**. The microstructures of the metals are formed by **grains.** The **grains** are small crystal structures that grow in all directions when molten metal and alloy are cooled. **Metallic bonds** held the crystal structure of the grains and are made from a 'cloud' of free electrons.



What instrument do scientists use to study the microstructure of metals and alloys?

Scientists most of the time use a microscope. A microscope (micro = small, scope = to view) is a tool used to enlarge, or magnify, objects that are too small to be seen with your eyes alone. The microscope is an important tool for students, scientists, and researchers who are studying very small objects. For example, microscopes are used to study different types of cells, mineral, metal, and plastic structure.

Do all the microscopes use light?

There are other types of microscopes that do not use light. Two examples are the Scanning Electron Microscope and the Transmission Electron Microscope. These use electrons to obtain images of the samples at a much higher magnification than light microscope.

Date___________________________

Objective:

- ✓ The student should get familiar with the microstructure of different materials.
- ✓ The student will learn the proper procedure for operating a microscope?
- ✓ Identify different instruments used to study the microstructure of metals or non-metals.
- ✓ Recognize new vocabulary words as part of the Material Science Curriculum.
- ✓ Why metals are good conductors of heat and electricity?

Activity Overview

This activity will allow students to study the structure of metals. Learn how to use the microscope. There will research certain facts about various metal materials use in class. Student will complete the data collection sheet as part of this investigation.

Vocabulary words

Alloy	Metallurgy
Grain	Microscope
Metallic Bond	Microstructure

Materials:

Laptop	Light-Microscope
Software	Metal Sample

Now it's time to use the microscope

Procedure:

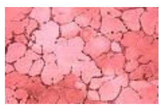
1. Allow the teacher or assistant to turn on the laptop and light microscope.
2. Set the microscope to the lowest magnification
3. Adjust the image with the coarse adjust knob first, and then use the fine adjust knob if necessary
4. Observe

Date____________________________

What do metals look like under a microscope?

- Aluminum – Al

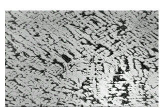
- Copper – Cu



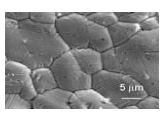
- Gold – Au

- Iron- Fe

- Lead – Pb



- Silver – Ag



- Titanium - Ti

Observe and describe.

____

____

____

Sketch a pattern of any of the surfaces that you like the most.

Give some examples of other well known alloys.

1. ____________________
2. ____________________
3. ____________________

Conclusions

____

____

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Date___________________________

Electrochemistry: *Salt water Tester*
Measuring Salt Never Sounded So Good

Design Activity:
How can you tell if water is salty? You could taste it – or you could build a salt water tester!

Objective:
Let's discuss the periodic table, electricity, and chemistry. We'll learn about electrolytes, too!

Materials:

- masking tape
- 9-volt battery
- buzzer
- 2 Popsicle sticks
- aluminum foil
- water
- saltwater

Date___________________________

New Vocabulary Words

Hypothesis

Date___________________________

Notes

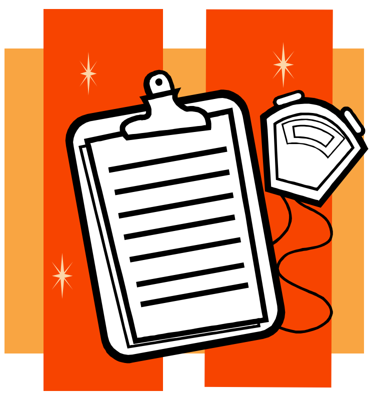
Lab Instructions

1. A saltwater tester uses electricity to tell you if water is salty or not. Here's how to make your own.
2. First, cover two Popsicle™ sticks with aluminum foil.
3. Then, get a buzzer - and tape the red wire of the buzzer to the positive end of the battery. The positive end will have a plus sign on it.
4. Next, tape one foil-covered Popsicle stick to the black wire of the buzzer. Tape the other one to the negative end of the battery. The negative end will have a minus sign on it.
5. You can see if your tester is working by touching the metal together. This will complete the circuit and make the buzzer buzz. If it doesn't buzz, check your connections to make sure everything is taped together in the right way.

Date___________________________

6. Now to use your saltwater tester, put just the tips of the metal in saltwater, about an inch apart. Make sure the two metal parts don't touch. The saltwater will act like a wire, connecting the metal sticks, completing the circuit, and making the buzzer buzz.

Data



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Melting in Layers: Surface Area to Volume Ratio

Objective

This lesson is intended to introduce the surface area to volume ratio. Students should understand how to calculate the parameter, but also need to understand that this parameter increases as the size becomes proportionally smaller. (An example of a proportionally smaller size would be a rectangle of sides 4 x 8 compared to a size of 16 x 32. The rectangle is "proportionally smaller" since 32/16 = 8/4.)

Terms

Conducts – this term refers to heat transfer through a solid

An example would be the heating of food. As we heat the bottom of the steak, heat will conduct through the steak, and the rest of the steak will be heated

PI – this is an irrational number which is equal to the circumference of a circle divided by its diameter (i.e pi*diameter = circumference)

Surface Area – this the sum of the areas of all exposed faces of an object

A cube has six different sides of equal area. Thus the surface area is six times the area of one face: namely length squared.

Volume – this term describes the amount of space occupied by an object

Materials

Ice, water, and three labeled identical cups

Experiment

1. Fill each cup with equal amounts of water.

   Water should be taken from the same source to ensure consistent temperatures.

2. Measure three equal masses of ice.

   Leave one sample of ice as is. Crush one sample leaving small, but clearly defined chips. Crush the last sample up as completely as possible.

3. Add each sample to its own cup and wait.

4. Make hypotheses about which sample will turn to water first.

Note: This can be done as a demonstration, and the instructor may elicit hypothesis from the class or the kids can actually perform the experiment.

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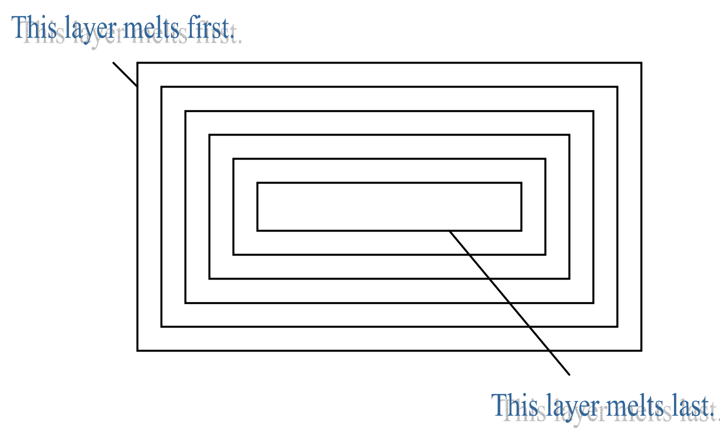
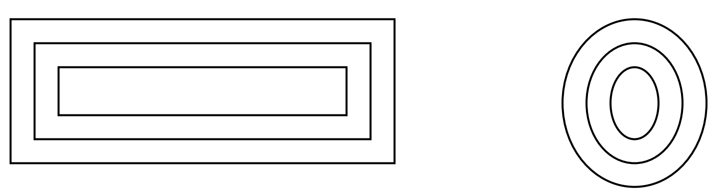
Lecture

The sample of ice which was crushed the most melts fastest. A melting sample of ice turns into liquid in stages. Essentially, as we place the ice in the water, the molecules closest to the liquid water (the outer layers) melts first. This can be demonstrated by heating one side of an object. It takes time for the heat to transfer from one side to the middle and then finally to the other side of the object. In the case of the ice cube, the heat source, is the water. Since the water completely surrounds the ice cube, the heat "**conducts**" from all sides inward. Thus, in our experiment, the center of the cube, is the coldest part.

Obviously, the warmest parts melt first, thus when ice melts, the outermost layers always melt before the inner most (unless circumstances have been established to maintain certain sides of the ice cube at different temperatures).



This suggests two important parameters besides mass (since we used equally massed samples) to determine the time it takes for the ice to melt. Clearly, if its melts layer by layer, the more layers the object has, the longer it will take to melt. (It simply has more layers to melt.) The mathematical term used to describe the number of layers is **volume**. If object A has a larger volume than object B, then object A has more layers. However, this does not mean that ice cubes with less volume always melt faster than those with more volume. Take a look at the following objects which have both equal mass and volume. The only difference is shape.



Each has three layers, since they have the same volume. But the layers of the rectangle are larger that those of the circle. After a certain time, the first layer of each have melted away; however this does not correspond to equal masses. The rectangular layer is composed of more molecules than the circular layer, thus, at each moment, more molecules are being melted in the rectangular shaped ice cube versus the circular one. The magnitude (largeness) of a layer is characterized by the term surface area. The larger the surface area, the larger layers the object has, and thus, the more molecules melting at a given moment. (Please note that the above pictures are idealized such that the layers only measure volume. This does not necessarily refer to thickness because one can see that larger surface areas, holding volume and mass constant, leads to thinner objects. This can be easily demonstrated forming various shapes with equal amounts of silly putty.)

Parameter	Analogy	Relationship to Melting
Volume	Number of Layers	Larger volumes melt slower
Surface Area	Size of Layers	Larger surface areas melt faster

Science has combined these parameters into one: the surface area to volume ratio. This is very logical. If the ice melts quickly, either due to small volume or large surface area, this will be indicated by a large surface area to volume ratio. Contrastingly, ice that melts slowly due to small surface area or large volume will have low surface area to volume ratios. Below is a table of formulas for the important parameters for basic shapes.

Shape	Volume	Surface Area	Surface Area/Volume
Sphere	$4/3*pi*r^3$	$4*pi*r^2$	3/r
Square	a^3	$6*a^2$	6/a
Cylinder	$L*pi*r^2$	L*2*pi*r	2/r

Using anyone of these formulas, it can be demonstrated that a reduction in size leads to an increase in surface area to volume ratio.

Scale	Radius of Cylinder (m)	Surface Area to Volume Ratio (m^{-1})
Miliscale	$1*10^{-3}$	2000
Microscale	$1*10^{-6}$	2,000,000
Nanoscale	$1*10^{-9}$	2,000,000,000

What we see is that as we decreased size, the ratio becomes increasingly large. This is one reason why research is always trying to get smaller. By increasing surface area to volume ratios, we are able to increase reaction rates. And this does not only correspond to ice melting, but many reaction rates are governed by the surface area to volume ratio including catalysis, sensing, and many more. By approaching the nanoscale, reaction rates can be increased to very rapid speeds due to the corresponding large surface area to volume ratios at this scale.

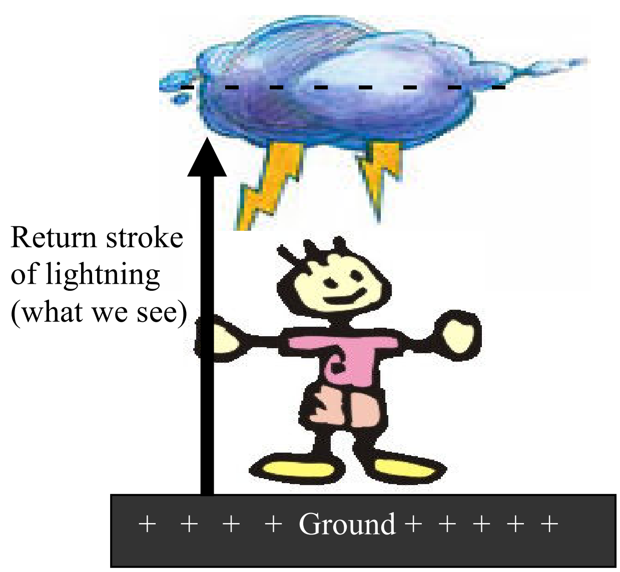
Date___________________________

Objective of this activity: For the student to become introduced to the concept of bioelectricity.

Hypothesis: Can the human body behave as a conductor?

Introduction:

Have you ever wondered why you are not supposed to stand outside during a lightning storm? Lightning is electricity formed in the clouds due to a separation of charge. Electricity likes to flow, or travel, through the path of least resistance. You may think of it this way- imagine that you are riding your bicycle. What happens when you have to ride your bike on a flat surface? Is there a difference when you ride your bike up a steep hill? Which surface would you rather ride your bike- on a flat surface, or up a steep hill? Well, electrons also like to travel the path that is easiest for them, which is the path of least resistance. Because your body behaves somewhat like a conductor (that is, electricity can flow through it), the lightning would rather travel through your body. This is also why tall metal structures, trees, and other objects can get hit by lightning.



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Materials:

- Battery (one per group)
- Voltmeter (one per group)
- Alligator clips (2 per group)

Procedure:

1. Turn on your voltmeter. Measure the voltage of your battery by placing the red lead of the voltmeter on the positive terminal of the battery, and the black lead on the negative terminal. What is the voltage of your battery?

2. Now connect the alligator clips to the battery and measure again the voltage of the battery (but this time connect the voltmeter leads to the alligator clips). Is there a difference in voltage?

3. Disconnect the alligator clip/cable from the (-) negative terminal of the battery (leaving the other side connected to the voltmeter). Touch the clip with one hand, and with your other hand touch the negative terminal of the battery. Has the voltage changed?

Questions:

1. Was the voltage reading higher with or without using your body to connect to the other terminal of the battery?

2. Why do you think using your body caused a change in the voltage reading?

3. Do you think electricity can travel through the body?

4. Now that you have learned that electricity controls your heart beats, do you think that being shocked by lightning might affect your heart?

Date___________________________

Vocabulary Words:

1. *Bioelectricity* is the study of ____________ and electricity.

2. A *closed circuit* has a complete path for ___________ flow, while an *open circuit* does not.

3. Electrons create _____________ when moving from atom to atom.

4. A *battery* is a voltage _____________.

5. Resistance limits the ____________ flow in a circuit.

Notes: