Design A Space Probe: 5.I.1

Grade Level	5
Sessions	1 – approximately 60 minutes 2 – approximately 60 minutes
Seasonality	N/A
Instructional Mode(s)	Whole class
Team Size	Individual
WPS Benchmarks	05.SC.ES.08 05.SC.TE.01 05.SC.TE.04 05.SC.TE.06
MA Frameworks	3-5.ES.12 3-5.TE.1.1 3-5.TE.2.1 3-5.TE.2.3
Key Words	constraints, moon, planet, rocket, solar system, space probe

Summary

The students will design a space probe using basic constraints, such as mass, destination, and science objectives. They will give justification for their decisions on mass, destination, and science objectives along with drawing a picture of their probe.

Learning Objectives

2002 Worcester Public Schools (WPS) Benchmarks for Grade 3-5

Earth/Space Science

05.SC.ES.08 – Recognize that the earth is part of a system called the "solar system" that includes the sun (a star), planets and many moons. The earth is the third planet from the sun in our solar system.

Technology/Engineering

05.SC.TE.01 – Identify materials used to accomplish a design task based on specific property, i.e., weight, strength, hardness, and flexibility.

05.SC.TE.04 – Identify a problem that reflects the need for shelter, storage or convenience.

05.SC.TE.06 – Identify relevant design features (i.e., size, shape, weight) for building a prototype of a solution to a given problem.

Additional Learning Objectives

1. At the conclusion of this lesson, students will have a further understanding of the engineering design process and how it applies to real-world applications.
2. At the conclusion of this lesson, students will be able to identify how erosion works and where it is a problem.
3. At the conclusion of this lesson, students will be able to identify solutions to erosion problems and rate solutions based on a variety of variable.

Required Background Knowledge

1. Students should have a basic understanding of the engineering design process

Essential Questions

1. How can you overcome the challenges of space flight in order for your spacecraft to achieve its mission of exploration?

Introduction / Motivation

Show the students pictures of planets and space probes. Tell them that the probes are built here on earth by engineers and are then sent into outer space. The students will then have to design their very own space probe.

Procedure

Note: Feel free to alter the following lesson as you see fit based on your resources, student needs, and student capabilities.

Session 1 (50-60 minutes)

The instructor will:

1. Have the students pick a planet (or moon) and have them do some research on the planet. They should know where the planet is, how many moons it has, if it has an atmosphere, and whether or not it is a gas planet, or a rocky planet. They should also do research about space probes that were sent to the planet and think of what kind of space probe they would like to design. This research can be done at home or in class, whichever the teacher would find more appropriate. The research worksheet provided should give good guidance to what the students should do.

2. Instruct the students on the solar system. Inform them that space probes are sent all over the solar system and that they each have their own challenges to overcome. The following objects that are in Bold and Italics should be taught to the students. They are the basic things that need to be considered when building a space probe. They include radiation, temperature, electricity, propulsion, and science package.
3. **Radiation:** All probes need to be able to be protected against radiation. Probes closer to the sun will receive more radiation than those further away, and will need more shielding (In reality, large planets with strong magnetic fields, such as Jupiter, also have strong, and dangerous radiation belts. For this project, however, we will ignore these radiation belts and assume that only probes going close to the sun need extra radiation shielding).
4. **Temperature:** All probes need some kind of temperature control device. Probes going close to the sun need a cooling system, while probes going out past Jupiter need a heating system. (This is abstracted; in reality most probes need both.)
5. **Electricity:** All probes need to have electricity to function. For probes that are close to the sun (Mercury – Mars), Solar Cells can usually provide enough power. However, as the probe gets farther away from the sun, the amount of power that can be received through solar cells drops drastically. Probes that go far away from the sun (Jupiter – Pluto and beyond), need other power sources such as Nuclear Batteries (Radioisotope Thermal Generators, or RTGs, (this is a minor technical detail that the students do not need to know)).
6. **Propulsion:** All probes need some kind of propulsion device. For the most part, booster rockets are used to hurl the probe towards the planet with enough speed that an additional large propulsion unit is not needed. Mission planners will usually also make use of the gravity of other planets to slingshot the probe on a new path with a different speed. This enables the probe to reach farther places with a smaller amount of fuel, but it usually takes longer compared to a direct flight path. For this lesson plan the students will not need to worry about how their probe gets to their planet of interest, however, it should be noted that all

probes are equipped with a small propulsion unit which enables it to perform course correction maneuvers and orbit changes once it arrives at its target.

7. **Communication:** Every space probe needs some kind of communication system, which allows the probe to communicate with its controllers here on Earth. Probes which remain close to the Earth can usually get away with having just large antennae, however, the farther the probe gets from the Earth, the weaker the radio signal gets. For probes, which explore the outer solar system, they need to have large radio dishes instead of antennae.
8. **Science Package:** Finally, all probes need some kind of science instruments to fulfill its mission. The kind of science instruments that a probe will have is dependant on its mission. Several types of instruments are given below.
    - *Cameras:* Cameras are always a good choice to put on a space probe, especially if it's the first time that a probe has visited a particular type of object. These could also include Infrared cameras which show the temperature of the object.
    - *Spectrometer:* Spectrometers are useful devices that can detect the individual elements that are present on an object at a distance. If a probes mission is to find water or oxygen on another planet, it will most defiantly have a spectrometer of sorts, or a similar device.
    - *Radar:* Radar is a useful tool for mapping the surface of a planet that is obstructed with clouds (like Venus). They are used primarily as a way to texture map large areas (i.e. hills and valleys etc…). They are also a useful tool for determining the distance to an object.

Session 2 (50-60 minutes)

The instructor will:

9. Quickly review the key terms and concepts that taught in the previous session.
10. The instructor will hand out the design worksheet to each student. He students will design their space probe individually. They will do this by filling out the worksheet provided.

11. The students should have a science objective for their probe such as looking for water, mapping the surface, or determining the chemical composition of the planet's atmosphere. They should recognize what kind of science instruments their probe will carry to achieve this mission.
12. The student should be able to understand why probes succeed, and why they fail. What kind of chances does their probe have on completing its mission?
13. The students should then draw a picture of their probe. What does it look like? (A probe with solar cells should show them on their drawing) What does it need on the outside to achieve its mission? (Can you see the cameras and other instruments? Can you see the propulsion device? Etc...)
14. Finally, the students should build a physical representation of their space probes using any craft materials available.

Materials List

Materials per class	Amount	Location
2-4 inch deep aluminum pans (or plastic or any waterproof container approximately 2-4"x 12-24"x 6-12)	Two	Hardware Store, Supermarket, Craft Store
Soil or dirt	Enough to fill the pan half way to the top	Outside, Hardware Store, Craft Store
2-liter bottle	One	Any Food or Convenient Store
Straws	Depends on Design	Supermarket, Craft Store, or Office Supply Store
String	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Popsicle stick	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Sticks	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Paper clips	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Pipe cleaners	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Tape	Depends on Design	Supermarket, Craft Store, or Office Supply Store

Materials per student	Amount	Location
Straws	Depends on Design	Supermarket, Craft Store, or Office Supply Store
String	Depends on Design	Supermarket, Craft Store, or Office Supply Store

Popsicle stick	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Sticks	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Paper clips	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Pipe cleaners	Depends on Design	Supermarket, Craft Store, or Office Supply Store
Tape	Depends on Design	Supermarket, Craft Store, or Office Supply Store

Vocabulary with Definitions

1. *Orbit* – The path a spacecraft takes around the sun or a planet.
2. *Rocket Motor* – A device that converts chemical energy into kinetic energy. Used to maneuver spacecrafts.
3. *Space probe* – A spacecraft that carries advanced equipment and tools to explore the bodies of the solar system.

Power Generation

4. *Nuclear Batteries* – A battery that generates electricity from the decomposition of nuclear materials such as uranium or plutonium.
5. *Solar Cells* – An array of light sensitive panels used to generate electricity.

Space Hazards

6. *Extreme temperatures* – Space has extreme temperatures that a spacecraft needs to be protected against. Temperatures range from -170 degrees Celsius in shadow, to 350 degrees Celsius in sunlight (-238 F – 662 F).
7. *Radiation* – Solar and cosmic radiation are high-speed particles that tend to damage computers and harm living creatures.

Science Instruments

8. *Infrared Sensors* – A tool that is used to determine the temperature of an object at a distance.
9. *Radar* – A device that uses radio waves to calculate a distance to an object.
10. *Spectrometer* – A scientific tool used to determine elements within materials.

Assessment / Evaluation of Students

The instructor may assess the students in any/all of the following manners:

1. Students will be graded on their creativity, knowledge of the design process, and ability to remain on task?

2. Evaluate both the **Research** and **Design** worksheets.
3. Use the grading rubric (attached) at instructor's discretion.

Lesson Extensions

None

Attachments

1. **Research Worksheet**
2. **Design Worksheet**
3. **Grading Rubric**

Troubleshooting Tips

None

Safety Issues

None

Additional Resources

http://www.worldspaceflight.com/probes/
http://www.firstscience.com/site/articles/power.asp
http://www.encyclopedia.com/index.asp
http://www.spacetoday.org/SolSys/Voyagers20years.html
http://www.space-odyssey.de/graphics/cassini.jpg
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=2001-014A
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1998-061A

Key Words

Moon, planet, rocket, solar system, space probe

Partnerships Implementing Engineering Education
Worcester Polytechnic Institute – Worcester Public Schools
Supported by: National Science Foundation

Designing Your Own Space Probe

Research Worksheet

Name_____ Date:_____

What planet will your probe explore?

Where is this planet?

How many moons does this planet have?

Is your planet rocky or gaseous?

Does your planet have an atmosphere?

What is the atmosphere made of?

Have any space probes been sent to this planet before?

Why do you want to send a probe to this planet? What will the probe do?

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Designing Your Own Space Probe

Design Worksheet

Name_____ Date:_____

Using the information from your Research Worksheet, design your space probe on this sheet.

1) What kind of radiation protection does your probe need? Why?

2) What kind of temperature control device (heater/refrigerator) does your probe need? Why?

3) How does your probe generate electricity? Why can/can't your probe use solar cells?

4) What kind of scientific instruments does your probe have? How do they help the probe achieve its mission?

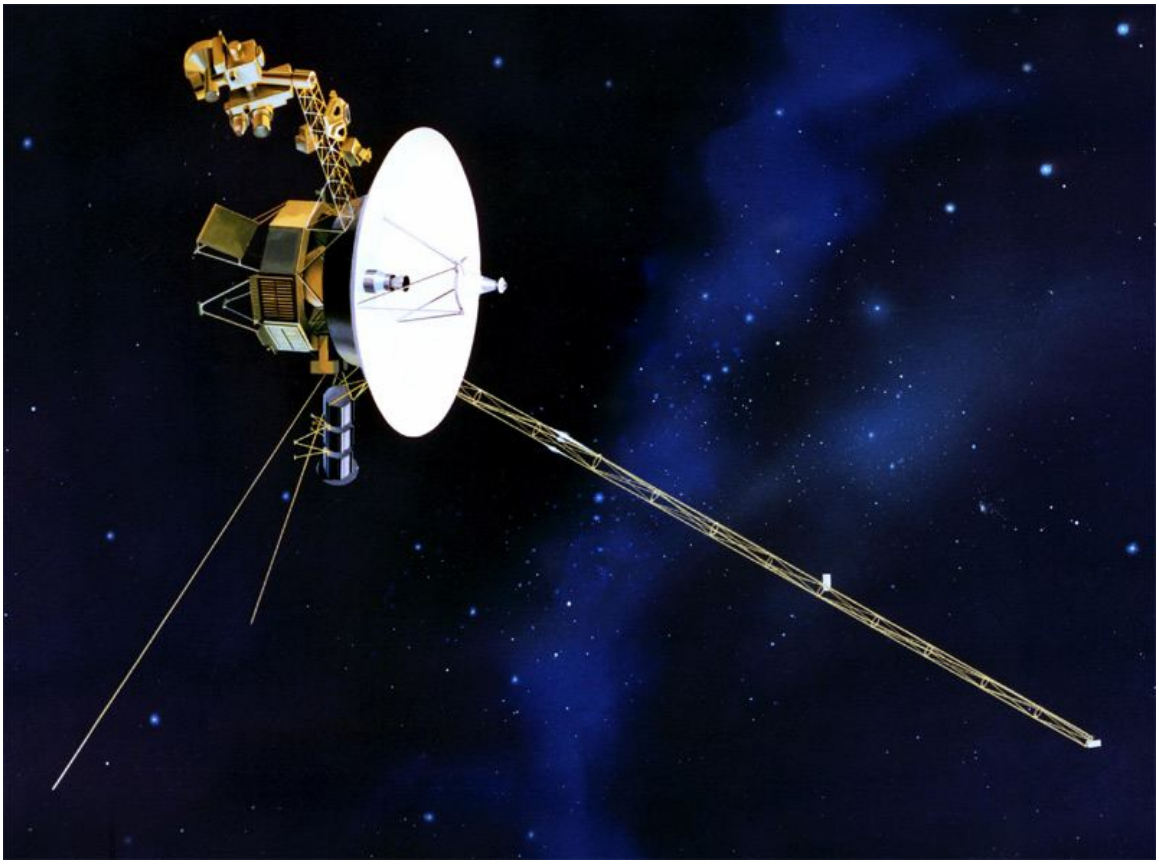
5) Draw a picture of your probe. Make sure to include power devices (solar cells), propulsion units, and scientific instruments.

Grading Rubric to evaluate student work

Students	Never (1)	Sometimes (2)	Often (3)	Always (4)	Points
Students performed preliminary research and gathered useful data about their planet of interest.					
Students used the information gathered to determine a useful science goal for their probe.					
Students showed that they understood the different components of a space probe in their design.					
The students drawings was representative of the probe that they had designed.					
Students remained on task with the assignment.					
				Total Max 20	

Voyager Space Probes:

The twin Voyager space probes (Voyager 1 and 2) are the farthest human made object in the universe. They were both launched in the summer of 1977 and were used to explore the outer solar system. Voyager 1 flew by both Jupiter and Saturn, while Voyager 2 flew past Jupiter, Saturn, Uranus, and Neptune. Both probes are currently hurtling out of the solar system into interstellar space.

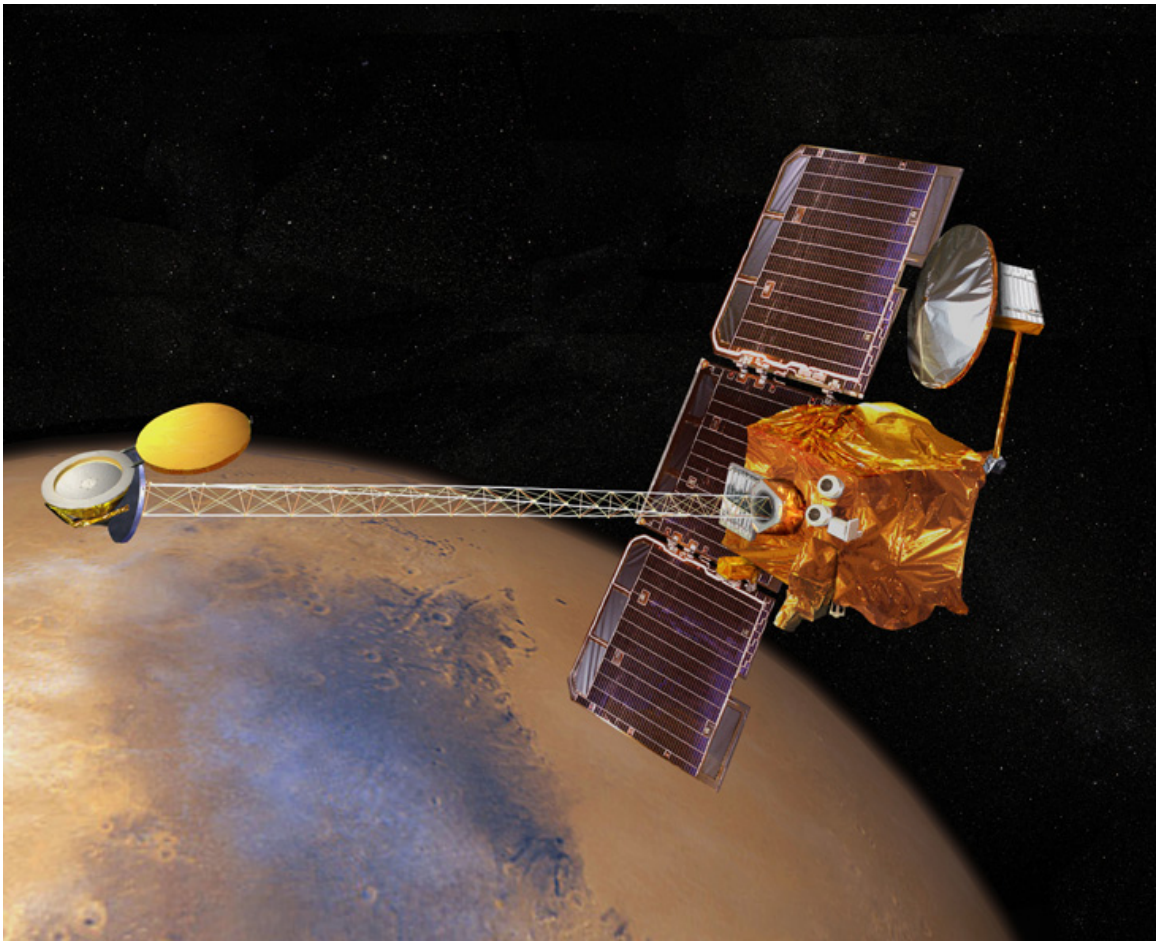


Cassini Space Probe:

The Cassini space probe is the latest success in the string of NASA space probes. Currently, the vehicle is orbiting the planet Saturn. It carried a small lander built by the ESA (European Space Agency) called Huygens. The lander detached from Cassini and entered the atmosphere of Titan, Saturn's largest moon, to conduct experiments on the atmosphere.

Mars Odyssey:

Launched in 2001, the Mars Odyssey space probe is currently orbiting the planet Mars. Its mission is to conduct a survey of the radiation environment along with mineral analysis of the planets surface. It's primary mission is to determine if the mineralogical data allow the possibility of life on mars at some point in its past. Currently, it is acting as a communications relay to the two Mars Exploration rovers that are currently roaming the planets surface conducting geological measurements.



Deep Space 1 Probe:

The Deep Space Probe 1 was an experimental probe which was used to test new space probe hardware. It tested a new mode of propulsion (the ion engine), along with other science tools and computer software. It flew by both a comet and an asteroid, which were close to earth at the time.