e::MISSION
SPACE STATION ALPHA

Lesson 9: Power Systems I

Preparatory Readings

LP #	Unit 1: Mission Bfg/ App Process
Mission Briefing	
1	The Mission
1	We Need You
1	Space Station Alpha
opt	Verizon
How to Apply	
2	Apply Today
2,3	Personal Essay
2,3	Class Activity: Station Systems
opt	Mission Patch

LP #	Unit 2: Space Weather
4	Specialist Orientation
Chapter 1	
4	Here Comes the Sun
4	Inside the Atom
5	Sheer Magnetism (Hands On)
5	Dr. Z: Inside the Sun

LP #	Unit 3: Radiation Health
Chapter 2	
7	New Frontiers & New Dangers
8	Electromag Rad: Taming the Wild Energies
7	Do You Want the Recipe?
7	In the Kitchen with Poly
7	Measuring Exposure to Radiation
Enrichment Activities	
7	Ready, Aim, Mutate! (Hands On)
7	Sweet Dreams are Made of These (Hands On)
7	Are You Too Hot? (Hands On)

LP #	Unit 4: Power Systems
Chapter 3	
9	The Energy Supply Problem
9	Rechargeable Batteries
10	All About Power
10	Emergency Procedures
10	Practice Ex: Power on the SS (Hands On)
Enrichment Activities	
10	Electrical Current Mag Field (Hands On)
10	Electrical Circuit: Quick Guide (Hands On)
10	Nailing Down Energy (Hands On)
10	A Shocking Discovery (Hands On)
10	Electrolysis (Hands On)
10	It's Electric (Hands On)

LP #	Unit 5: Life Support
Chapter 4	
12	How I Discovered Air
12	A Weighty Discovery
12	Living in a Bubble
12	Breathing on the Space Station

LP #	Unit 6: Pre-Mission Prep
13	Overview of Teams
13	Mission Directives
13	Classroom Setup
Team Preparation Introductions	
13	STORM Team Overview
13	Radiation Team Overview
13	Power Team Overview
13	Life Support Team Overview
13	Communications Team Overview

Other Homework Due: Entry in *Mission Specialist's Log*

Subject
Electrical power supply and electrical circuits.

Description of Student Activities:
Conduct the *Space Station Stumpers* quiz. Organize student groups for electricity explorations and explain the procedures. Discuss homework assignment with entire class.

Duration
20 min. *Space Station Stumpers* quiz
20 min Organize for explorations
5 min. Homework preparation

Materials
Articles
Quiz

Main Topics
- The space station's power (electrical) system functions in the same way as an earth-bound electrical system.
- Solar cells and rechargeable batteries provide the electrical power on the space station.
- The space station's orbit in the shadow (eclipse) and outside of the shadow (insolation) of the earth requires that two sources of energy be available.
- Electrical circuits on the space station are vulnerable to extreme solar weather.

Outcomes
1. The students will identify and describe two sources of electrical power on the space station: solar cells and rechargeable batteries.
2. The students will describe a basic circuit in terms of its three (or four) components.
3. The students will explain the terms "watts" and "electromotive force."
4. The students will explain some of the uses of electricity on the space station.

Special Comments:
For the quiz, keep the pace fast, lively, offer the answers if you "stump" the students, and at the end go back and cover the information that they missed. There are lots of facts. The important concepts are *watts, emf,* giving the students a firm mental image of a *circuit* and its *main components, and understanding the functional limitations of batteries and solar cells.*

For the explorations, some take less time than others. Assign these experiments to students appropriately. To stay on track for the next lesson, students should begin their explorations and get at least half way through. Be sure to leave enough time to explain the homework.

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Procedure:

(20 minutes) *Space Station Stumpers*

Students will take part in a quiz (attached) called *Space Station Stumpers* (Based on *Energy Supply Problem* and *Rechargeable Batteries).* You might model the quiz like a team-based Weakest Link™. The competition will make it fun. The quiz is meant as a review of the materials in the articles assigned as homework.

We suggest that the quiz be an "open book" quiz. Finding the correct answers to the questions is a way of repeating the materials and helping the students put the facts into context. The quiz should take no more than 20 minutes of class time. Maintain a rapid pace.

You may choose to conduct this activity in a variety of ways:

1. Divide class into two or more teams and hold a competition. (You might divide the class into teams and conduct a quiz show such as the Weakest Link). Incorrect answers can be challenged.
2. Divide class into groups and score the quiz as a function of time and correct answers
3. Have entire class compete with teacher. Students answer question in time allotted (5 seconds), 1 point for students. Incorrect answers, or no response in time allotted, 1 point for teacher.

(20 minutes) Preparation for electrical explorations
Organize students into groups, assign exploration, and have them read and discuss the printed materials for their exploration. Some of the explorations take less time than others. Assign these experiments to students appropriately. They should also be asked to begin to consider how their exploration applies to the space station and how they will present this to the rest of the class tomorrow. To stay on track for the next lesson, students should begin their explorations and get at least half way through.

Homework for Lesson 10

Complete: *The Practice Exercise: Power on the Space Station*

To give students a clearer idea of what kilowatt/hours (kWh) means, they will do a simple exercise building a fictitious space station. In this exercise, they consider the power consumption of various appliances in the space station, and compare this to where they live. Ideally, students would find out the cost of electricity in their home in terms of kWh. (Look at an electricity bill for a month.)

You may wish to introduce the homework by discussing a light bulb in terms of wattage, for instance, and describe the kilowatts of power consumed in an hour by a light bulb. Don't forget that a kilowatt is 1000 watts. A 100-watt light bulb consumes $1/10^{th}$, or .1 kW of power in an hour, or .1kW/h of power.

Read

- *All About Power*
- *Emergency Procedures*

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Space Station Stumpers

A Quiz on Space Station Alpha's Power Systems

Time

15 minutes

Questions

1. What are two ways solar storms can affect the space station's electrical systems?
2. What is the critical percentage for total power reduction on the space station?
3. What is one thing the astronauts can do to conserve power during a solar storm?
4. Who created the TV series *Star Trek*?
5. What was the source of electrical power on the Enterprise?
6. Is this source fictional or real?
7. What is the word used to describe how earth-bound electrical power plants create electricity?
8. Who discovered the photoelectric effect?
9. What is the photoelectric effect?
10. Who explained what actually happens during the photoelectric effect?
11. What is the primary substance used in photovoltaic arrays?
12. What does "doping" mean?
13. What does "emf" mean?
14. How many volts of emf are needed to service a typical house in the US?
15. How large will the PV arrays on the space station be when complete?
16. Batteries employ what type of process to create free electrons?
17. What type of batteries are used on the space station?
18. What is the name for that period of time in which the space station is in the shadow of the Earth?
19. What is the name of that period of time in which the space station is in full sunlight?
20. What percentage of the space station batteries' electrical power is depleted during one orbital period of eclipse?
21. If they are not recharged by the solar arrays, how many orbits can the space station make before the batteries run down?
22. What is electricity?
23. What metals make good conductors?
24. What substances make good insulators?
25. Electrons flow from the positive pole of a battery through a conductor to the negative pole. True or false?
26. What three components are needed to make a circuit?
27. Does a washing machine contain a part of an electrical circuit when turned on? Yes or No?
28. The power required by an electrical device to do its "work" is measured in terms of what?

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Space Station Stumpers

A Quiz on Space Station Alpha's Power Systems

Time	Questions
15 minutes	1. What are two ways solar storms can affect the space station's electrical systems? **A: They can affect solar arrays (PV cells become less efficient at converting photons to electricity); and/or disrupt the computer systems ("flip their bits").**
	2. What is the critical percentage for total power reduction on the space station? **A: 50% reduction in total power.**
	3. What is one thing the astronauts can do to conserve power during a solar storm? **A: turn down power load of non-vital equipment.**
	4. Who created the TV series *Star Trek*? **A. Gene Roddenberry**
	5. What was the source of electrical power on the Enterprise? **A. Dilithium crystals.**
	6. Is this source fictional or real? **A: fictional**
	7. What is the word used to describe how earth-bound electrical power plants create electricity? A. Induction or induce: Spinning **electromagnets induce electricity in power lines.**
	8. Who discovered the photoelectric effect? A. Edmund Becquerel
	9. What is the photoelectric effect? **A. Light photons hitting a metal cause electrons to be released from the metal's atoms.**
	10. Who explained what actually happens during the photoelectric effect? **A. Albert Einstein**
	11. What is the primary substance used in photovoltaic arrays? **A. Silicon crystals.**
	12. What does "doping" mean? **A. Injecting impurities into pure crystals of silicon, either boron or phosphorous molecules.**
	13. What does "emf" mean? **A. electromotive force.**
	14. How many volts of emf are needed to service a typical house in the US? **A. 120 or 240 volts.**
	15. How large will the PV arrays on the space station be when complete? **A. 2/3 of a football field, or about 32,000 square feet.**
	16. Batteries employ what type of process to create free electrons? **A. A chemical process.**
	17. What type of batteries are used on the space station? **A. Nickel-Hydrogen batteries.**
	18. What is the name for that period of time in which the space station is in the shadow of the Earth? **A. Eclipse period**
	19. What is the name of that period of time in which the space station is in full sunlight? **A. Insolation period**
	20. What percentage of the space station batteries' electrical power is depleted during one orbital period of eclipse? **A. 35%**
	21. If they are not recharged by the solar arrays, how many orbits can the space station make before the batteries run down? **A. 35% depletion per 1/3 orbit (1/3 orbit = about 30 minutes) or just under one orbit (85.7 minutes)**
	22. What is electricity? **A. electrons flowing in a wire/conductor.**
	23. What metals make good conductors? **A. Gold, silver, copper, zinc, steel**
	24. What substances make good insulators? **A. rubber, glass, air, wood**
	25. Electrons flow from the positive pole of a battery through a conductor to the negative pole. True or false? **A. false – negative to positive. Electrons have a negative charge and thus gather at the negative pole and flow through a conductor towards the positive pole.**
	26. What three components are needed to make a circuit? **A. a conductor (which may include a switch), a load, a power source (emf)**
	27. Does a washing machine contain a part of an electrical circuit when turned on? Yes or No? **A. Yes.**
	28. The power required by an electrical device to do its "work" is measured in terms of what? **A. Watts.**