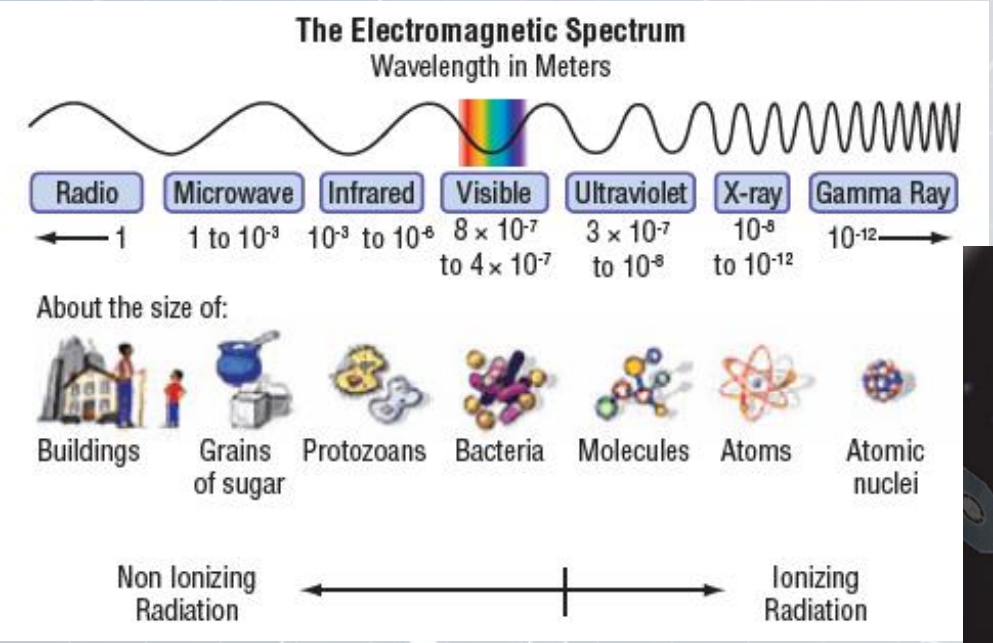
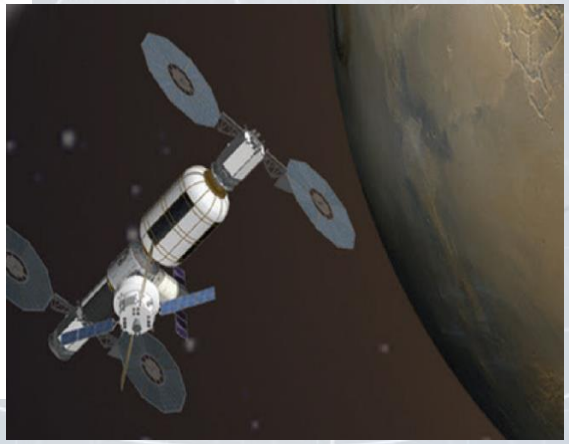
NASA Engineering Design Challenges

EDC Radiation Shield





Radiation Exploration Challenge

Develop a radiation shielding system to protect astronauts aboard a spacecraft

Matter and Energy

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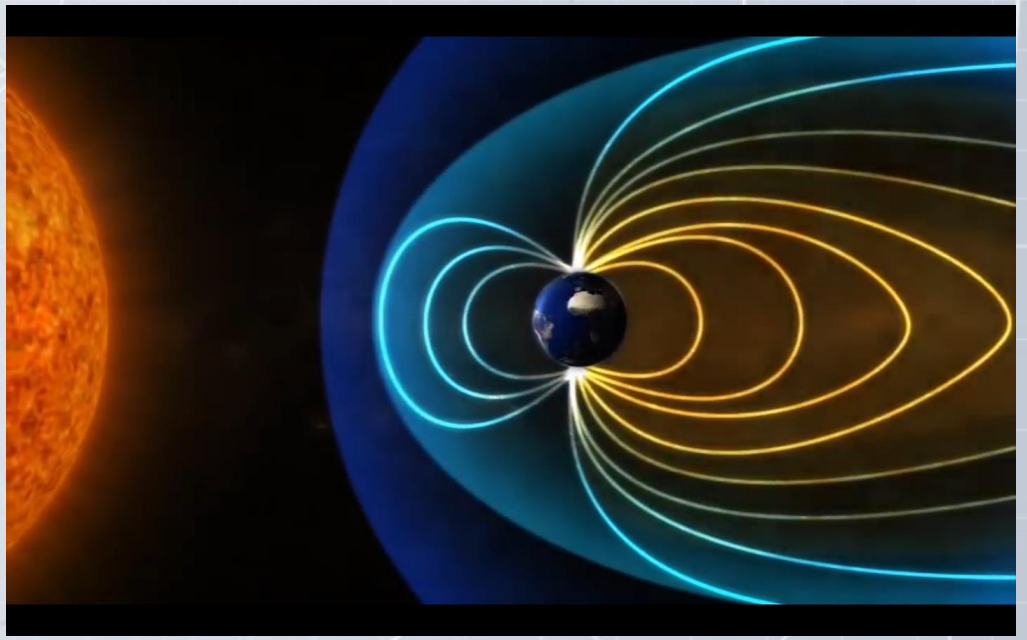
EDC Radiation Shield

Introduction Video



Watch the introduction video to the challenge.

Select the link below

https://www.youtube.com/watch?v=z0pPnIgkkgw&feature=youtu.be

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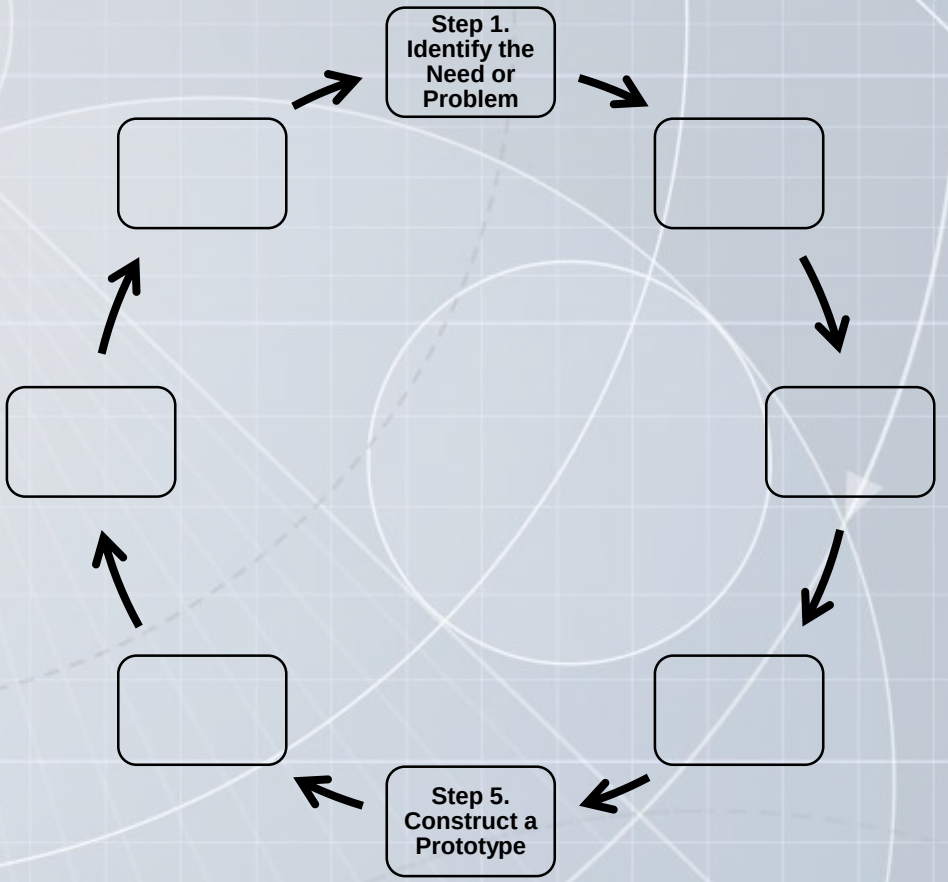
Engineering Design Process (EDP)

<u>Directions for the Students:</u> Can you determine the sequence that engineers take to make a completed design? On your own, try to label the steps of the Engineering Design Process. Put the rest of the steps below in order based on the two that have already been filled in for you.

- ~~Identify the Need or Problem~~
- Select the Best Possible Solution(s)
- ~~Construct a Prototype~~
- Communicate the Solution(s)
- Research the Need or Problem
- Develop Possible Solution(s)
- Test and Evaluate the Solution(s)
- Redesign



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KLEW Chart

- **KNOW**
- **LEARN**
- **EVIDENCE**
- **WONDER**

Know	Learn	Evidence	Wonder
What do I know about radiation and space travel?	What did I learn about radiation and traveling into space based on my research?	What evidence do I have that supports what I learned about radiation and space travel?	What am I still wondering about radiation and space travel?

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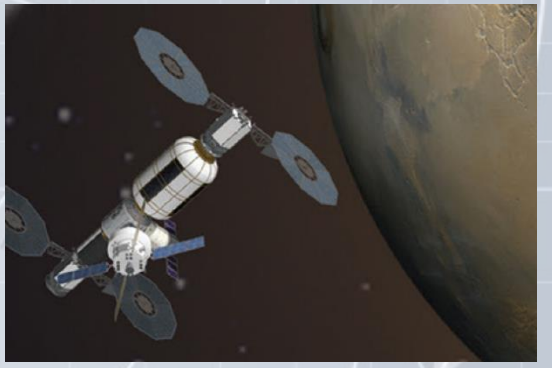
The Challenge:

NASA is working on a new vehicle to take astronauts beyond Low Earth Orbit and on long-term duration human space exploration such as to Mars and other destinations the solar system. However, many dangers to the human body, such as solar radiation, exist as humans travel away from Earth. To ensure the safety of the astronauts this new vehicle will need protective shielding that offers similar protection to Earth's atmosphere and magnetic fields. This shielding needs to be durable and safe, while having as little mass as possible for launch.



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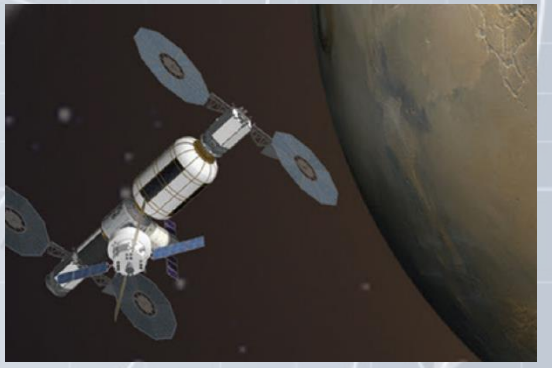
The Challenge: - Continued



In this Engineering Design Challenge, you must design and build a radiation shield to absorb or reflect as much visible and ultraviolet light as possible. The shield will also be subject to the following tests: flexibility test, ballistic impact test, and load bearing test. For testing, the shield must completely cover the entire opening of the “test chamber” (oatmeal canister). If the design survives all dry tests, immerse your design in water for ten seconds and repeat all tests. Ideal designs should survive all dry and wet tests; however, teams are free to identify tests that their designs will not pass. The mass of the shield may not exceed 300 g, but should be as light as possible. The thickness of the shielding may not exceed 2 cm, but should be as thin as possible. Total materials for the final shield design may not exceed $10.00.

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Materials

The following is a suggested list of materials needed to complete this challenge. The quantity will depend on the number of students participating. Alternatives can be used if necessary.

- Digital scale or balance (1)
- Measuring tape (1)
- Rulers (1 per team)
- Ream of paper
- Oatmeal canister (used as a test chamber)
- Flashlight
- Ultraviolet reactive (“solar”) beads
- General building supplies

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STEP 1: Identify the Need or Problem

Based on this information and the challenge introductory video, answer the following questions.

Using your own words, restate the problem in the form of “How can I design a _____ that will _____?” Be sure to include all expected criteria and constraints.

What general scientific concepts do you and your team need to consider to begin solving this need or problem?

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STEP 2: Research the Need or Problem

Conduct research to answer the following questions related to the challenge problem. Cite where you found your information on the line labeled “Source(s):”

Who is currently working on this or a similar problem today? What solutions have they created or are working on currently? Source(s):

What questions would you ask an expert who is currently trying to solve problems like this one?

Who in our society will benefit from this problem being solved? How could this relate to everyday uses in society? Source(s):

What are some innovative options for using the materials that are available to solve this challenge? Source(s):

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STEP 3: Develop Possible Solutions

Sketch your radiation shield in the space below. Label each part of your drawing. Consider the following questions when brainstorming your ideas.

What features would your design have?

What materials could you use to design your radiation shield?

How will you design your shield to survive wet and dry conditions?

Are all the criteria and constraints being met by these ideas?

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STEP 4: Select the Best Possible Solution(s)

Work with your team to analyze each person's final drawing using the table below. Based on the team's discussions, determine which design will be used to solve the problem, and what features will be included to create team's prototype.

Design # Designer Name	Does this design meet all criteria and constraints of the problem?	What are the strong elements of this design?	What elements need to be improved?
1.			
2			
3			
4			

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STEP 5: Construct a Prototype

Make a final drawing of your prototype. Have it approved by your facilitator.

Approved by: _____

What are the resources that will need to be gathered?

Who in the group is doing what?

Team Member				
Responsibilities in the building process?				

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STEP 6: Test and Evaluate the Solution(s)

Report the following information:

Property	Constraint	Measured/Calculated
Mass:	Less than 300 g	
Thickness:	Less than 2 cm	
Cost:	Less than $10.00	

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STEP 6: Test and Evaluate the Solution(s) - Continued

Determine the best way to attach your radiation shield to the open end of the test chamber. Be sure the shield completely covers the opening. Conduct the tests below in dry conditions. If the shield survives successfully, carefully remove the shield from the test chamber and immerse the shield in water for ten seconds. Reattach the wet shield to the test chamber and repeat all tests. Record general observation data, such as stress, damage, strengths, weaknesses, and maximum weight capacities in the table on the next page.

Radiation tests: students will conduct a visible light test by shining a flashlight through the shield into the chamber and observing the remaining light, if any, through a quarter-sized viewing hole cut into the opposite side of the canister. Students will also conduct a UV test by placing three UV-reactive “solar” beads into the bottom of the canister, exposing the shield and chamber to sunlight for two minutes, and observing to what extent the UV beads have changed color.

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STEP 6: Test and Evaluate the Solution(s) - Continued

Load-bearing test: students will place a small (5-gram) mass of paper clips on top of the shield and observe for signs of stress or damage for one minute. Students will repeat the test, gradually increasing mass up to at least 500 grams.

Ballistic impact test: students will drop a small (5-gram) mass of paper clips onto the shield from a height of one meter, observing for signs of stress or damage. Students will repeat the test, gradually increasing mass up to at least 100 grams.

Flexibility test: students will remove the shield from the canister and determine to what degree their shield can bend without breaking.

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STEP 6: Test and Evaluate the Solution(s) - Concluded

Complete the table below to record the performance of the assembled shield design. Rank the materials according to the scale shown below.

Rank the materials from 0 to 5

0	1	2	3	4	5
No sign of property		Medium Sign of property			Large sign of property

Property to Test	Description of the Test	Rank	Observations of Shield Design:
Radiation – Visible Light	Does it block the light from the flashlight?	Dry: Wet:	Dry: Wet:
Radiation – Ultraviolet Light	Does it prevent solar beads from changing color?	Dry: Wet:	Dry: Wet:
Flexibility	Does it stretch or bend?	Dry: Wet:	Dry: Wet:
Load-Bearing	Does it hold a mass on top?	Dry: Wet:	Dry: Wet:
Ballistic Impact	Does it stop a falling mass?	Dry: Wet:	Dry: Wet:

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STEP 7: Communicate the Solution(s)

It is not enough to simply produce raw data. Scientists and engineers need to interpret the data so that they can convince others that their results are meaningful. This step will help you summarize how your design changed through multiple iterations of the engineering design process. Start by filling out the table about your initial prototype.

All modifications to your design, both major overhauls and minor tweaks, should be recorded below to track the changes made. After every phase of tests, complete the chart below by describing changes and summarizing what results the testing showed.

Iteration #	What are the key components to your initial prototype?	What do you think caused the design to succeed or fail during testing and why do you think that?
1		

Iteration #	What was added, removed, or changed in this iteration of your design?	What do you think caused the design to succeed or fail during testing and why do you think that?
2		
3		
4		
5		

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STEP 8: Redesign

Did this iteration of your design meet all of the constraints of the original problem? _____

What problem(s) did you discover while testing this iteration?

What will you do to try to improve your design based on this data?

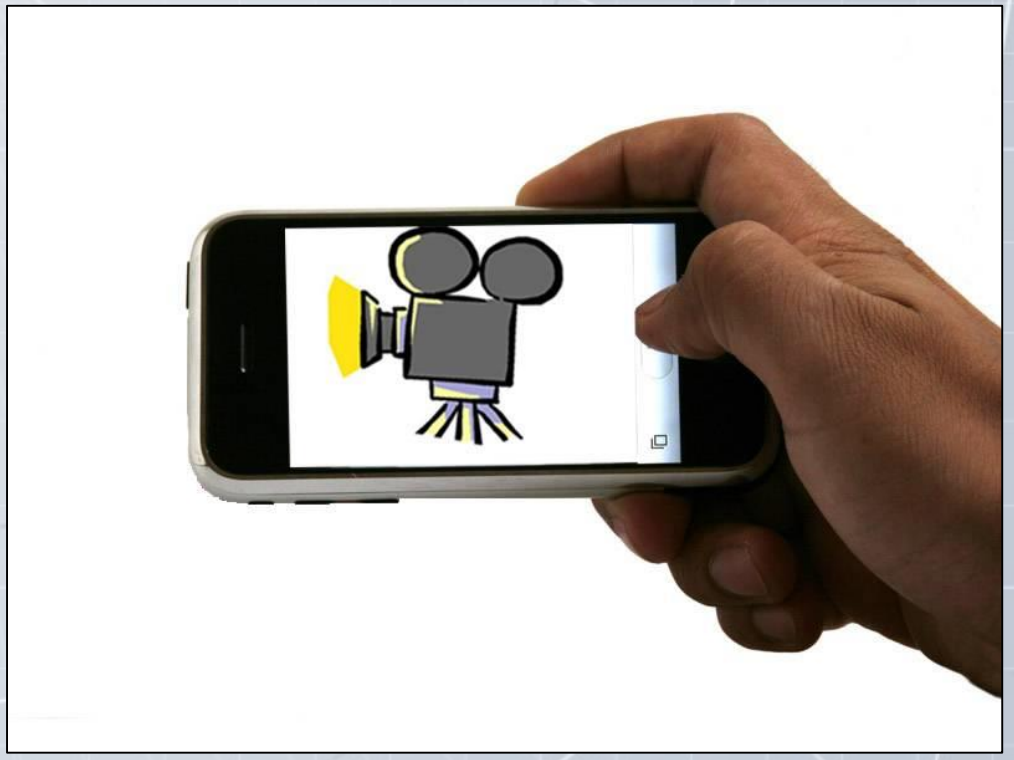
How do you predict that these changes will improve over the iteration you just tested?

EDC Radiation Shield

Conclusion

Students, you will have completed

- Creating a video documenting what the team has done during the Engineering Design Process and Challenge.
- Determine the video meets the criteria for submission
- Submit the video for review
- Add to the LEARN section of the KLEW chart
- Revisit the Engineering Design Process and fill in the steps of the EDP comparing it to the chart they did at the beginning of the challenge



EDC Radiation Shield

Submitting your final video…

Visit the website at
http://y4y.ed.gov/stemchallenge/nasa
for instructions on submitting your final video

Advance to the next page for tips on video production

Telling Your Story with Video