Education Programs
Inspiring Tomorrow's Explorers
SPACE FOUNDATION

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Protecting Our Space

Objectives

Students will:

- Learn about physical and EMP (electromagnetic pulse) threats to the United States and important facilities within its borders
- Learn how engineers have developed ways to protect physical and air spaces from threats
- Use the engineering design process to construct and test a simulated physical space to protect from various threats

Suggested Grade Level

6th – 12th (for primary and upper elementary students, see *Extensions & Adaptations* section below)

Subject Areas

Engineering Design

Timeline

30 – 60 minutes

Standards (NGSS)

- **MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- **MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- **HS-ETS1-1** Analyze a major global challenge to specify qualitative and quantitative criteria and constrains for solutions that account for societal needs and wants.
- **HS-ETS1-2** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

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- **HS-ETS1-3** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

21st Century Essential Skills

- **Learning Skills**
  - Critical Thinking, Analysis, Creativity, Collaboration, Communication
- **Literacy Skills**
  - Information, Technology, Environmental
- **Life Skills**
  - Flexibility, Leadership, Initiative, Productivity, Global Awareness, Listening

Background

An electromagnetic pulse (EMP) is a massive burst of electromagnetic energy that can occur naturally or be generated deliberately using nuclear weapons. An EMP releases huge waves of electromagnetic energy, which can act like a giant moving magnet. Such a changing magnetic field can cause electrons in a nearby wire to move, thereby inducing a current. With such a huge burst of energy, an EMP can cause damaging power surges in any electronics within range.

These pulses can occur deliberately or naturally. Natural EMPs occur when the sun occasionally spits out massive streams of plasma, and if they come our way, Earth's natural magnetic field can deflect them. But when the sun spits out enough plasma at once, the impact can cause the magnetic field to wobble and generate a powerful EMP. The last time this happened was in 1859 in the so-called Carrington Event, and while electronics were still rare then, it knocked out much of the recently built telegraph network.

Then, there's the possibility of deliberate EMPs. If a nuclear weapon were to be detonated high in the atmosphere and the gamma radiation it would release could strip electrons from air molecules and accelerate them at close to the speed of light. These charge-carrying electrons would be corralled by Earth's magnetic field and as they zipped around, they would generate a powerful, fluctuating electric current, which, in turn, would generate a massive EMP. The explosion could also distort Earth's magnetic field, causing a slower pulse similar to a naturally occurring EMP.

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The high-altitude nuclear weapon-generated electromagnetic pulse (EMP) is one of a small number of threats that has the potential to hold our society seriously at risk and might result in defeat of our military forces.

EMP effects are both direct and indirect. The former are due to electromagnetic “shocking” of electronics and stressing of electrical systems, and the latter arise from the damage that “shocked” – upset, damaged, and destroyed – electronics controls then inflict on the systems in which they are embedded. The indirect effects can be even more severe than the direct effects.

The electromagnetic fields produced by weapons designed and deployed with the intent to produce EMP have a high likelihood of damaging electrical power systems, electronics, and information systems upon which American society depends. Their effects on dependent systems and infrastructures could be sufficient to qualify as catastrophic to the Nation.

Depending on the specific characteristics of the attacks, unprecedented cascading failures of our major infrastructures could result. In that event, a regional or national recovery would be long and difficult and would seriously degrade the safety and overall viability of our Nation. The primary avenues for catastrophic damage to the Nation are through our electric power infrastructure and thence into our telecommunications, energy, and other infrastructures. These, in turn, can seriously impact other important aspects of our Nation’s life, including the financial system; means of getting food, water, and medical care to the citizenry; trade; and production of goods and services.

Vocabulary
Engineer, Electromagnetic Pulse (EMP), High altitude electromagnetic pulse (HEMP), threat, protection

Materials

- Large squares of cardboard for base
- Miscellaneous junk materials such as:
    - Toilet paper tubes
    - Paper towel tubes
    - Small boxes
    - Craft sticks
    - Blocks

  - Egg cartons
  - Bottles
  - String
- Tape
- Different size objects to use as the “threats” like beads, marbles, tennis balls
- Clear, plastic wrap (optional)
- Magnets and paper clips (optional – see extension)

Lesson

1. Depending on age group of students, discuss electromagnetic pulses/high altitude electromagnetic pulses (EMP/HEMP) and how these threaten the country and power grids within it. Discuss how engineers develop ways to protect against physical threats and EMP threats. See background information in this lesson for details.
2. Students should work in groups of 2-4 for the project.
3. Provide students with various junk and craft materials (see materials list above for examples) which they will use to construct a physical space they will need to protect from threats, as well as a structure to protect that space.
4. Students may use a large square of cardboard as their base.
5. Allow students some time to discuss and plan their structure and protection (explain that this is part of the engineering design process).
6. Allow students enough time to construct their physical structure (explaining what it might represent), and a barrier.
7. The instructor can then gently toss various “threats” into their barrier to see if it holds.
8. If time allows, allow students the opportunity to reconstruct their barriers if they have failed, or see how their barriers could be improved under different scenarios (testing and retesting also part of the engineering design process).
9. See *Extensions & Adaptations* section for additional ideas including budgeting and adding magnets to the challenge.

Extensions & Adaptations

1. For primary level students, omit detailed information about EMPs, threats, etc. Explain the role of an engineer in terms of developing strong structures for protection. Provide

simple materials or blocks for their structure and develop a simple way to test its strength.

2. For upper elementary students, lessen the surface area in which they have to build upon, and use smaller junk/craft materials as their space. Another alternative would be to begin with blocks and building a protective fence around their structure. Increase difficulty by increasing the size of the threats. Optional – omit information about EMPs.
3. For middle and high school students, add in a budgeting element. Give them an allowable amount of money to spend on supplies (explain that this is a very common constraint when engineers are developing a product or idea); then give each supply a dollar amount. Students must construct their threat protection while staying under budget.
4. For middle and high school students, add the magnetic element of EMP threats by having students include metal objects within their space. For example, give each group 20 paper clips they must place within their space. Then, use a larger magnet as the threat by running it around the perimeter of their protected space. If the metal pieces within the structure remain undisturbed and intact, they have succeeded.
5. After testing threats against each group's structure, have students combine their structures to create a large compound which then must be protected. Will their current protection structures still work? Will they have to develop a whole new plan?

Resources

Foster, Dr. John S. Jr., et al. (2004). Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack [Executive Report]. Volume 1, 48.

Gent, E. (2021, March 11). US Air Force is guarding against electromagnetic pulse attacks. Should we worry? Retrieved from https://www.livescience.com/air-force-emp-attacks-protection.html