Title: Package Drop
Program: Aviation Adventures - Extension Lesson
Grade: 1-2
Duration: 45 minutes

Objective: Students will use their STEM skills to design a method of dispersing a "seed" (lima bean) by the wind.

Materials per pair of students:

- 2 Empty water bottles
- 5 sheets of copy paper
- 1 rolls of Scotch tape
- 3 feet of string
- 10 Popsicle sticks
- 1 Trash bags
- 5 Pipe cleaners
- 1 6x6 inches sheet of Cardboard
- 10 Cotton balls
- 1 pair of scissors
- 2 Pencils
- 1 Sharpie
- 1 Ladder
- 10-15 Farfalle pasta (bow pasta)
- 1 Meter stick

Prep

1. Create a materials table or make one bag for each group with the materials available.
2. Reserve a testing area in the classroom. Label it with a sign or mark the area using tape.

Background:
Package engineering involves the design, development, and production of packages. Packages are all around us in the form of boxes, envelopes, food containers, and medicine bottles, just to name a few. Most people don't take a lot of time to think about all of the engineering that goes into the packages we see around us every day.

There are seven main functions (or jobs) of packages that packaging engineers need to think about. These functions include: contain, communicate, carry, display, dispense, protect, and preserve. We will focus on the protective, display, and communication functions of packages as they design an aid drop package. They will need to be sure that the supplies inside are not damaged (protect), the package is easy to see when it lands (display), and the package lets people know what is inside (communicate).

When people are cut off from essential supplies, sometimes the only way to quickly deliver food, water, medicine, and other necessities is through humanitarian airdrops. Aid drops are generally short-term projects, since dropping aid from the air can be more difficult to coordinate than delivering aid using trucks or person-to-person delivery. Aid drops can also be very expensive.

Aid drops have been used in Thailand to deliver aid to people living in areas isolated by flood waters during monsoon season. Aid drops have also been implemented in Afghanistan after the landslide in 2010, and in Haiti after the 2010 earthquake.

If package supplies are not properly protected, they can be damaged upon impact. If the people who need the supplies cannot easily find the aid drop packages, or are not certain that what is inside is safe and meant to help them, the supplies may go to waste.

ENGAGE (10 minutes)

FEMA engineers need your help. They are planning a humanitarian mission after Hurricane Maria and they need a package to protect the payload during its descent to the surface. Your goal today is to be engineers that will design and create a prototype package that will protect pasta inside from breaking when dropped from a 5 ft height.

Have a short discussion about engineering. Use the following questions:

- What is an engineer? *Engineers are people the use their knowledge in math and science to design, create and improve technology.*
- What is technology? *Anything human made that solve a problem or fulfill a desire.*
    - Mention something that you think its technology. *Students may say: computers, TVs, cars, planes, robots… Tables, chairs, markers, shoes, and others are also technology.*

- Have you used the Engineering Design Process before? What is the EDP? *(pause and take answers - Possible answers may include time to design and build, what materials do we have, why are we using an egg.)*
  - Define a **GOAL** for the design and **ASK** questions to establish design criteria.
    - What is the problem?
    - What have others done?
  - **IMAGINE** at least two possibilities for design.
    - What could be some solutions?
    - Brainstorm ideas.
  - **PLAN** the design before building.
    - Draw a diagram.
    - Make a list of the materials needed.
  - **CREATE** at least one design solution.
    - Follow the plan and create it.
    - Test it out!
  - **IMPROVE** the design based on evidence around the original design criteria.
    - Make the design better.
    - Test it out!

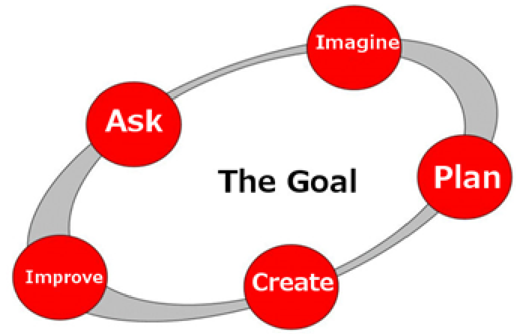

Figure 4: The Engineering Design Process

Before we start using the Engineering Design Process, let's start with the ASK step: What do you need to know in order to reach your goal? *(Pause and take answers)*

What is a delivery package for a humanitarian mission?

- After some natural disasters, transportation and communications systems stop working and people are uncommunicated. Helicopters, gliders and even drones can be used to send food and first aid in payloads. Because of the conditions, they won't be able to land, they drop the payload so people in need have access to their necessities.

What forces act on the payload that is going to be drop? *(Pause and take answers)* Gravitational Potential Energy!

  - *Gravitational potential energy* is the energy an object has because of its position in a gravitational field. Heavy objects hit the ground with more force than lighter ones as Newton's 2nd Law (force = mass x acceleration) describes.
  - That enormous amount of potential energy is converted to kinetic energy when the payload is in motion. In order to land and deliver the payload to the surface, this kinetic energy must be safely transformed (energy cannot be created or destroyed.) Part of the kinetic energy needs to be transfer from the payload to

the parachute. But in order to bring a payload to a safe touchdown, an additional landing system is necessary to transform the remaining kinetic energy.

Why are we using uncooked pasta?

- o The uncooked pasta represents the payload with all of its fragile and expensive kits, food and beverage, etc. We need to protect supplies from any harm that would prevent the payload to be damage.

How are we going to test?

- o When it is time to test, one member of each team will stand on the front of the classroom. The student will hold their team's package on one hand and stretch the arm above the head (around 5ft). When they are all ready, they will let go the package at the same time.

Now that you know the forces involved, you need to know the materials you have to complete the challenge and your budget. You will get a $500 budget to purchase materials. *(Give each team a copy of the price list and go over it with them.)*

Due to FEMA's recent budget cuts, they want to purchase the prototype design that would cost the least so keep that in mind when planning.

ACTIVITY (30 minutes)

Remind students of the goal: **Design and create a prototype package that will protect 4 Farfalle pasta inside of it from breaking when dropped from a 5 ft. height.**

For the purposes of this challenge: If the pasta breaks or cracks, you did not reach your goal.

- IMAGINE: You will now have 2 minutes to imagine individually a design for a package and draw 2 ideas. Your pasta needs to be place inside the package before being tested, remember to leave an opening for the pasta.
- PLAN: Now share your ideas with your group and decide on one plan. You can combine aspects of several different ideas into one Plan for the group. Make sure your plan meets the requirements of the goal.
    - o Give instructions on how to buy materials from instructor.
        - ONE person per team with list in hand may come to buy materials.
        - Return policy: only if materials have been UNUSED.
        - Remind students not to spend all their money in the first trial and to keep some in case they need to buy more materials later.
        - They may not use their tools as part of their package.

- CREATE: You will have 10 minutes to build your package device. *(Start time. Give regular time updates to teams so they can use their time appropriately.)*
- Test 1: After 10 minutes, call groups together for test.
  - When you call up all the teams to test, have them only send one team member up for the test.
  - Ask the team member to share their package with the class.
    - Describe your package design.
    - What materials did you choose? Why did you choose those materials?
    - How much money did you spend?
  - Ask the student to place 4 pieces of pasta inside the package and to hold in with one arm. Raise the arm above the head and let you know when ready. Drop the package to the ground.
  - After each test, ask the team the following questions:
    - Was it successful? Did it meet the goal? Open the package carefully and check the pasta.
    - What parts worked well? How do you know?
    - Which parts didn't work well? How do you know?
  - Make sure that all the teams shared.
  - After all tests, discuss with students which designs worked best and why. Discuss which designs were the least expensive. Which design would FEMA want to purchase? Why?
- IMPROVE: Give groups 8 minutes to improve their design. They must first draw their improved design on their worksheet and then make changes according to their new design. They can then go up to the Instructor table to make purchases.
- Test 2: After 8 minutes, tell groups to stop building and that it is time to test the packages.
  - Before testing, have groups share their improved package with the class.
    - How did you 'Improve' your package design?
  - Follow the same test procedures done previously. Have students answer the following questions after the test.
    - Were your improvements successful? How do you know?
    - What parts of your design worked well? How do you know?
    - What parts did of your design did not work well? How do you know?
    - What would you do to improve this design?
  - Make sure that all the teams shared.

NOTE: If short on time, let students create, test and improve for 15 minutes and have a group test at the end of the session.

Wrap-Up (5 minutes)

After all tests, discuss with the class the following questions:

- How can we use our knowledge of gravitational potential energy, the Engineering Design Process, and our creativity to design packages for different types of payload?
- Were you able to improve the package?
- What was the easiest part of the challenge?
- What was the hardest part of the challenge?

Standards:
Science

SC.6.N.1.1 Define a problem from the sixth-grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.6.N.1.2: Explain why scientific investigations should be replicable.

SC.6.N.1.3: Explain the difference between an experiment and other types of scientific investigation, and explain the relative benefits and limitations of each.

SC.6.N.1.4: Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation.

SC.6.N.1.5: Recognize that science involves creativity, not just in designing experiments, but also in creating explanations that fit evidence.

SC.6.P.11.1: Explore the Law of Conservation of Energy by differentiating between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vice versa.

SC.6.P.13.2: Explore the Law of Gravity by recognizing that every object exerts gravitational force on every other object and that the force depends on how much mass the objects have and how far apart they are.

SC.6.P.13.3: Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.

SC.7.N.1.1: Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.7.N.1.2: Differentiate replication (by others) from repetition (multiple trials).

SC.7.N.1.3: Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation.

SC.7.N.1.5: Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.

SC.7.N.3.2: Identify the benefits and limitations of the use of scientific models.

SC.7.P.11.2: Investigate and describe the transformation of energy from one form to another.

SC.8.N.1.1 Define a problem from the eighth-grade curriculum using appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.8.N.1.2: Design and conduct a study using repeated trials and replication.

SC.8.N.1.5: Analyze the methods used to develop a scientific explanation as seen in different fields of science.

SC.8.N.1.6: Understand that scientific investigations involve the collection of relevant empirical evidence, the use of logical reasoning, and the application of imagination in devising hypotheses, predictions, explanations and models to make sense of the collected evidence.

SC.8.N.3.1: Select models useful in relating the results of their own investigations.

Team name: ____

Goal: Design and create a prototype package that will protect payload inside from breaking when dropped from a 5 ft height.

Imagine: Take 1 minute to think individually about possible solutions.

Plan: Share your ideas with your team and combine them. Draw a design and list the materials you'll use.

Test 1:

Height: _________ Was your design successful? YES / NO, Why?

____

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Height: _________ Was your design successful? YES / NO, Why?

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____

Improve: How can you improve your design? ____

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____

Test 2:

Height: _________ Was your design successful? YES / NO, Why?

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Height: _________ Was your design successful? YES / NO, Why?

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Review: List the things that were successful and the things that can be improved in your design.

It was successful:	Can be improved: