EDUCATOR'S GUIDE

Catapults

Preparation

Overview and Objectives
This lesson is geared toward students in grades 6-8.

Participants will learn about the catapults used to launch aircraft off of the flight deck on USS *Intrepid*. Pilots and the flight deck crew on Intrepid worked together to perfectly time and execute its steam catapults every time an airplane needed to take off. Participants will use a mathematical equation to understand the relationship between the catapults, external speed factors, and the success of an airplane's launch. They will then build their own catapults.

Standards

Common Core Math Standards

CCSS.MATH.CONTENT.7.EE.B.3

Next Generation Science Standards

MS-PS2-2.

This lesson includes a slideshow in which an instructor can lead participants through the catapult system and the two main activities.

Instructional Modalities

This activity was designed for both synchronous or asynchronous instruction.

For **synchronous instruction**, we recommend a platform that allows both for whole class discussion and for students to interact in small groups.

For **asynchronous adaptations**, we provide suggestions for teachers to provide additional support for the activities and for students to share their work with each other.

Materials

- **Catapults Slideshow**
- **Go/No Go Activity Sheet**
- **Catapult Visual Instructions**
- **Popsicle Sticks**
- **Rubber bands**

- **Glue**
- **Water/soda bottle cap**

Lesson

1. **Introductory Activity**
    - Discuss with students the differences between a runway on land and the flight deck on an aircraft carrier. Runways at most commercial airports are more than 10 times longer than Intrepid's flight deck.
        - **Why are runways needed for an airplane to take off?**
        - **Why is *Intrepid*'s runway so short?**
        - **How did airplanes on Intrepid take off with such little room?**

    - Participants will watch a two-minute video about the Cat Shot, or catapult launch, on an aircraft carrier. Discuss the following questions:
        - **What jobs are important for the launch of an airplane via catapult?**
        - **What creates the energy needed for the Cat Shot?**
        - **What other factors might impact how quickly or easily the airplane is launched off of the flight deck?**

2. **Core Activity**
    - Explain to students that the Cat Shot doesn't happen in a vacuum.
        - **What else is occurring around the airplane being launched?**
    - While the crew is launching an airplane via catapult, the ship is moving under it and the wind is moving around it. All airplanes have to deal with wind speed when they are taking off, but only Navy pilots take off from moving ships beneath them. The speed of both the ship and the wind must be taken into account when determining whether it is safe to launch an airplane.

    - During most of Intrepid's service, the Cat Shot launched an airplane off the ship at about 150 miles per hour. The ship could move at a speed of up to about 35 miles per hour. The wind speed will always vary.

    - Students will use the equation for airspeed to determine whether or not it is safe for an airplane to take off from Intrepid. Airspeed is the relative speed of the airplane and the air around it. The equation to calculate airspeed is given below:

    - Airspeed = Ship Speed (Vs) + Catapult Speed (Vc) - Wind Speed (Vw)
- At times, the wind speed will be negative. A positive wind velocity occurs when the wind is moving in the same direction as the ship. A negative wind velocity occurs when the wind is moving against the direction of the ship. Remind or instruct students on how to subtract negative numbers. If the wind speed is negative, students will instead add the positive value of the velocity.

- Students will use the Go/No Go worksheet to decide when it is safe for an Avenger to be launched. An Avenger may only take off from Intrepid when its airspeed is 170 mph. Students will be given the catapult speed (150mph), ship speed, and wind speed, and must solve for the airspeed. They must then make a decision about whether or not the Avenger should take off.
    - **How might the wind and ship speeds affect landing an airplane on an aircraft carrier?**

3. **Wrap Up**
    - Students will build their own catapults using popsicle sticks, rubber bands, and a bottle cap.
    - Follow the visual instructions to build a catapult. Students may see who can launch a small projectile (balled paper, pom-pom) the furthest or the closest to a target.

Asynchronous Adaptation

Have participants go through the slideshow and fill out the worksheet on their own. Ask them to record how far they can launch a projectile with their catapult and share online.

Extension Activities

To deepen student engagement with this content, you may choose to add the following activities :

Mass vs Distance

Use clay to measure out different size projectiles for students' catapults. Clay balls may be 0.5 g, 1 g, 1.5 g, etc. Working in pairs, students will launch different size balls and measure their distance traveled. Have students graph the relationship between weight and distance and discuss.

Additional Resources/ References

Strategies for teaching subtraction of negative numbers

Landing on an Aircraft Carrier

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ACTIVITY 1: GO/NO GO

You are the Captain of the Aircraft Carrier Intrepid. Assume that the required airspeed for takeoff of an Avenger is 170 mph. Using the airspeed equation and information provided, complete the following table and answer the questions that follow. Assume that a positive wind velocity is in the direction of travel of the ship.

Reminder: **Airspeed = Ship Speed (Vs) + Catapult Speed (Vc) - Wind Speed (Vw)**

Catapult Speed (Vc) mph	Ship Speed (Vs) mph	Wind Speed (Vw) mph	Airspeed (mph)	Go/No Go (Go if ≥170 mph)
150	20	-10		
150	20	10		
150	30	-30		
150	0	20		

1. With no wind, how fast should the ship be moving to launch the Avenger?

2. To maximize airspeed, would you turn the ship into or away from the wind?