GRADE LEVEL: 5-8 | TIME REQUIREMENT: 4 HOURS

PHYSICS: FORCES

2 READINGS | 2 ACTIVITIES

INTRODUCTION

You could use all four resources in sequence because they all focus on balancing forces and on using the engineering design process. They focus on two situations where engineering for use of forces were important in World War II. In the first case they look at the creation of the Higgins landing craft and what makes things buoyant. In the second they examine different aircraft and how their shapes determine their function.

OBJECTIVES

These resources give students the chance to investigate forces in flight, as they try to optimize a paper airplane design after reading about the use of a glider to make a rescue from the New Guinea highlands. They can also read about the development of the Higgins boat while investigating buoyancy and density. Both the flight and buoyancy investigations use a design project. The buoyancy investigation uses non-arithmetic means to investigate the relationship between density and buoyancy.

STANDARDS

NGSS DCI ETS1.A
Defining and Delimiting Engineering Problems

NGSS DCI ETS1.B
Developing Possible Solutions

NGSS DCI ETS1.C
Optimizing the Design Solution

NGSS DCI ETS2.B
Influence of Engineering, Technology, and Science on Society and the Natural World

NGSS SEP
Asking Questions and Defining Problems, Analyzing and Interpreting Data, and Engaging in Argument from Evidence

NGSS CCC
Structure and Function, Patterns, Scale, Proportion, and Quantity

PERFORMANCE EXPECTATIONS

3-5-ETS1-1
Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-3
Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

5-PS2-1
Support an argument that the gravitational force exerted by Earth on objects is directed down.

MS-ETS1-2
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

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.

MS-PS2-2
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

READINGS (2)

1. BUILDING THE HIGGINS BOAT

Description
A reading to introduce the activity Sink or Float, in which students learn about the creation of the Higgins landing craft. After the reading, ask students why they think boats float. Point out that tankers and aircraft carriers weigh many tons, and yet they float. Try a think-pair-share or a Kagan protocol to get students to think and productively discuss their ideas. To supplement this reading, you can use the videos on the Real World Science site.

2. CATCH A GLIDER

Description
A reading to pair with Earn Your Wings. You can assign the reading and then ask students to discuss how different shaped aircraft create a different balance of forces leading to different functions. Have them share their ideas in groups. To supplement, watch a video of students making and testing paper airplanes on the Real World Science site.

ACTIVITIES (2)

1.SINK OR FLOAT

Description
This resource takes students through a simple activity to show how density is critical to floating. Then another investigation quantitatively looks at the relationship between mass, volume, and floating. The first activity involves engineering, as the students change the shape of the material to make it float through a few design cycles.

Supplies (per group)
1 Ball of Sculpey clay (or similar polymer clay)
1 Plastic bin filled 1/3 with water
Blocks of different kinds of wood
Squares of tile, glass, metal
Metric rulers
Cooking (or other) mass scale

Instructions
Have the students test the ball of clay in the bin of water to see if it floats. When it doesn't, have them reshape the ball to get it to float. When students get it to float, have them add toy soldiers or pennies to see how much the boat can hold. After they put the clay away, have students measure the mass and calculate the volume of each block of wood or other material and then see if they sink or float.

2. EARN YOUR WINGS

Description
An engineering design activity that has students test different paper airplane designs, optimizing them through the design process. At the end, diagrams of the plane are drawn showing the forces acting on it when it is in flight.

Supplies (per group)
Sheets of plain paper
Measuring tape
Timer

Instructions
Have students make two paper airplanes: "hotdog (lengthwise)" and "hamburger (widthwise)." Once the airplanes are folded, have students test them and decide what variable to optimize (e.g., speed, distance, time in air). Students should then iteratively modify the airplanes until they are satisfied with the design.

ADDITIONAL RESOURCES

To learn more about these subjects in World War II, try these books:

+ *Andrew Jackson Higgins and the Boats That Won WWII* by Jerry Strahan, LSU Press 1998
+ *Lost in Shangri-La* by Mitchell Zuckoff, Harper Perennial 2012

READING

BUILDING THE HIGGINS BOAT

In 1938 Andrew Jackson Higgins was a flamboyant and ambitious owner of a small boat company in New Orleans, Louisiana. His 75 employees at one boatyard made fishing boats for Louisiana fishermen. As war approached, the military was looking for a company to design and build craft that could transport men and troops from large ships onto the shore.

At first, the Navy looked to large shipbuilders on the East Coast. These companies had been making boats for the military and industry for years. The landing craft that these companies made didn't perform well when tested by the military. They fell apart when traveling fast on waves, or they were stopped by submerged logs and sand bars.

Then the military came to New Orleans to see Higgins who quickly assembled a landing craft for them, **adapting** the design of his fishing boats which performed well in the shallow waters of swamps and marshes of Louisiana. Higgins then took the boats to Lake Pontchartrain and showed how well they worked by landing them up the Lake's seawalls and pulling them off again.

Later Higgins created a different version of his landing craft (more **adaptation**), this time with a combination door/ramp on the front. This door/ramp could be lowered to let soldiers off more easily and also allowed jeeps and small tanks to be moved on shore. All these landing craft were made of plywood and were built quickly and cheaply.

During World War II, the Higgins company made more than 20,000 boats for the military. Over 12,000 of these mostly wooden boats became the landing craft used on the beaches of Normandy for D-Day. General Dwight D. Eisenhower, the Supreme Allied Commander and future President of the United States, would later say that these were the boats that "won the war for us." The vessels came to be called "Higgins Boats" by soldiers and the Marines who rode to battle in them.

Today we face many big problems, and we can solve them in the same way Higgins did—with knowledge, persistence, creativity, and collaboration.

A full LCVP in training maneuvers at Morro Bay, California, January 1944.
(Image: The National WWII Museum, 2011.065.068.)

LCPL, LCVP, and barrage balloon on Lake Pontchartrain, July 1944.
(Image: The National WWII Museum, 2008.379.019.)

NAME: **DATE:**

LCVPs loading before going ashore in Guadalcanal, March 1944.
(Image: The National WWII Museum, 2008.354.070.)

1. Describe a problem facing the world today that you think could be solved using the same sort of approach Higgins used.