LESSON PLANS, READINGS & ACTIVITIES

PHYSICS: FORCES

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.

READING

CATCH A GLIDER

By the spring of 1945, the end of World War II was within sight for the Allies. Germany had surrendered on May 8th, and after many tough battles in the Pacific, the Allies were getting closer and closer to the mainland of Japan.

In 1944, New Guinea had been taken back from Japan. An American base at Hollandia (now called Jayapura) had a good port and landing strip. Hollandia had been a Japanese base, and now the Americans used it as part of the supply route for the continuing battle in the Philippines. To the south of Hollandia were mountains that reached over 5,000 feet in altitude. In those mountains, one high valley, called Baliem, had been given a more fanciful name—Shangri-La.

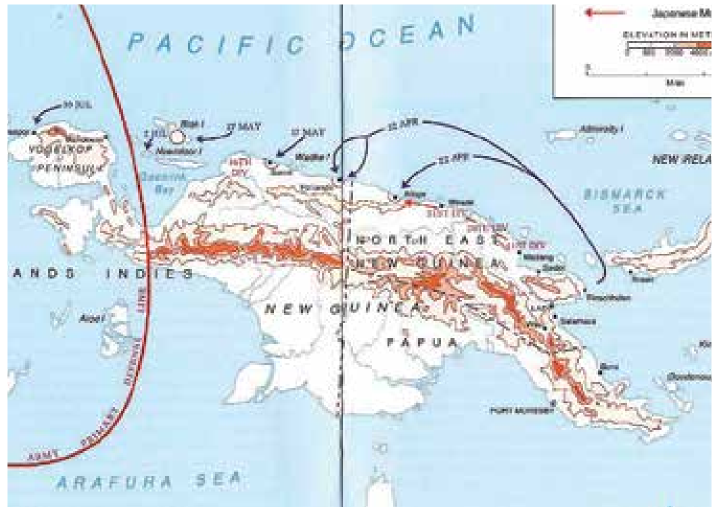
Westerners had discovered the valley in 1938 when an explorer named Richard Archbold was looking for new animals in New Guinea. The approximately 200,000 native people who lived in small villages in this 20km-by-80km valley kept animals and large gardens. After the American forces took New Guinea from the Japanese and started flying over the island to Australia, they began mapping the island. When the valley was rediscovered, news reporters called the valley Shangri-La after a fictional place in a novel called *Lost Horizon*. By that time, the war had been going on for almost four years, and military personnel had been working six or seven days a week even if they were just office workers or supply clerks far from the battlefield. Officers tried to keep up the morale of their workers and soldiers by planning relaxing events.

On May 13, 1945, Lieutenant John McCollum took a group of 19 of his staff on what he hoped would be an enjoyable sight-seeing flight over the valley so that they could see this strange place and bring back more stories about it. With four other crewmen he loaded his passengers, who included some WACs (Women's Army Corps), into a large C-47 cargo plane and headed for the valley.

On the way, something went wrong, and the plane crashed into the side of a mountain at the edge of the valley. The crash was bad, and only five people survived, with two of those five dying of their injuries soon after the crash. Corporal Margaret Hastings, Sergeant Kenneth Decker, and Lieutenant McCollum were injured, but left the crash site for the valley floor.

When the plane did not return to its base, search planes were sent to look for it. The valley was so large that it took some time to find the survivors. The three survivors were finally spotted on May 17. Shortly after, two medical paratroopers and 10 other paratroopers were dropped nearby to help. Other planes dropped food and tents and other supplies.

The southern part of the island was still unexplored and possibly held Japanese troops. The spot in the valley where the survivors were stranded was hundreds of miles from the US base in Hollandia. High mountains and dense jungles separated them



1940s map of New Guinea.
(Image: Courtesy of the United States Army.)

from safety, and the rough ground and dense forest prevented the construction of a landing strip for a plane. It took six weeks to make a rescue plan to attempt to rescue the survivors from the valley.

The final plan involved another C-47 and a glider. The glider, which was built of aluminum and balsa plywood frames covered with canvas, had a simple steering system. Such gliders were normally used to drop a few people and heavy supplies. For this mission, the Americans would **adopt** the glider for a new use.

The C-47 carried the glider to the valley, and then a glider pilot landed the light craft near the camp site of the survivors. The survivors and paratroopers were then loaded into the glider. If that was not risky enough, the next part certainly was. The same C-47 that had carried the glider returned, dangling a loop of cable that rescuers hoped would latch onto a hook on top of the glider. The C-47 eventually made its target. The glider would be pulled across the rugged valley floor before being lifted into the air. But it took a few passes to successfully hook the glider, and it took several more trips to get all of the survivors, medics, and paratroopers out to safety. By the last trip the canvas floor was torn, and the passengers could see through the floor to the valley below as they rose up, towed by the C-47.

1. Why was the glider made of flimsy material like balsa plywood and canvas?

NAME: **DATE:**

Glider troops about to board in Italy, August 1944.
(Image: The National WWII Museum, 2002.337.825.)

2. What was daring about the rescue attempt? What could have gone wrong?

3. The description says this plan was an innovation by adoption. Do you agree or disagree? Explain your reasoning.

ACTIVITY

SINK OR FLOAT?

INTRODUCTION

How do boats float? Considering the extreme weight of battleships, barges, and aircraft carriers, how and why do they not sink?

Take a ball of clay and place it gently in the bin of water. What happens?

If you change the shape of the clay, can you make it float? Try and then describe your results.

Draw a diagram of your best-designed floating clay-boat clay. Draw and label the forces acting on it when it is floating.

Pool your data as a class and make a scatter plot. Each point should represent the mass and volume of one of the objects you measured. The axes should be mass (y axis) and volume (x axis).

Make the dots for the objects a different color if they sank or floated.

NAME: **DATE:**

Your teacher has given you some objects to investigate.
Fill the table with the data you collect from these objects.

The computation of length x width x height gives the volume of a polygonal or squarish object. You can get the mass from a weighing scale.

OBJECT	MASS (g)	VOLUME (cm^3)	SINK OR FLOAT?

1. What is the pattern in the graph? Describe in words the relationships between mass and volume and floating.

2. Can you tell in advance if something will sink or float? How?

ACTIVITY
EARN YOUR WINGS

INTRODUCTION

You are going to make two paper airplanes, and then test them.

One design will begin with a lengthwise fold of the paper—this is the "Hotdog" plane. The other design will begin with a widthwise fold—the "Hamburger" plane.

After your tests, you are going to decide if you want to optimize your plane design for speed, distance, or time in the air, and you will choose one of the two designs.

If you record the distance and the time in air, you can also calculate the speed. Record data for 3 trials of both planes.

Record the details from your investigations and design changes below:

PLANE	SPEED	DISTANCE	TIME IN AIR
Hamburger Trial 1			
Hamburger Trial 2			
Hamburger Trial 3			
Hotdog Trial 1			
Hotdog Trial 2			
Hotdog Trial 3			

1. Which plane will you adapt to make your final design? Which factor will be optimized?

NAME: **DATE:**

DESIGN 1	
Draw Diagram:	**Data:**
How will you modify your design based on the evidence?	**Expected outcome:**

DESIGN 2	
Draw Diagram:	**Data:**
How will you modify your design based on the evidence?	**Expected outcome:**

2. Summarize your results. How did you improve your plane through cycles of the design and testing process?

3. Draw below a diagram of your best plane. Indicate the forces acting on the plane when it is flying.