

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

## 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.**