

# AIRCRAFT CARRIER

GUARDIANS OF THE SEA



EDUCATION GUIDE



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## Welcome to the *AIRCRAFT CARRIER* Guide for Educators!

We cannot think of a better way to inspire students to explore science and engineering concepts than by climbing onboard an aircraft carrier through this suspenseful film. On the following pages you will find three open-ended inquiry activities for grades 4-8, all directly related to the film and exploring concepts in greater depth that the film introduces. Here are a few important things to keep in mind as you read on:

1. Each activity begins with a Challenge Question. There are multiple ways to address these challenges -- not one right answer. We want to encourage students to think independently and solve problems like scientists and engineers.
2. All activities are addressed directly to the student so that you can easily photocopy and distribute the pages to your class. The amount of supplies you will need depends on the number of students in your classroom.
3. We know there's a big difference between a 4th grader and an 8th grader. You can add more specific instructions if you feel your students need that, or you can add extra challenges. We added a "Find out more" section to facilitate that.
4. All activities are linked to the Next Generation Science Standards. *Sea Power* has especially strong connections to the Engineering Design Standards, plus there's a lot of physics, materials science, and more.
5. We also have a selection of online resources to provide more background information for you and research opportunities for your students.

We hope you and your students enjoy these challenges. If you would like to share photos of any of their projects, please email [info@k2communications.com](mailto:info@k2communications.com).

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# Challenge Question #1: How does an aircraft carrier stay afloat?

## You will need:

- cardboard boxes and other recycled materials
- duct tape
- scissors
- popsicle sticks
- large tub filled with water
- measuring cups
- marking pen

1. Study the shape of the aircraft carrier in the photograph. What are the engineering design variables that need to be considered for a boat that carries heavy planes? (For example: What materials were used to build it? What shape is it? How heavy is it?)
2. Design an experiment to test one of the design variables on a model aircraft carrier made from cardboard boxes and duct tape. Choose one very specific question you will study and describe the plan for testing your hypothesis.
3. Build your aircraft carrier from the supplies listed above. Test it in the tub to make sure it floats and doesn't tip over easily. Then make alterations to the design to improve its buoyancy. What changes did you make and why?
4. Create a simulation for landing planes (made from popsicle sticks and duct tape) on your aircraft carrier. Study the size and weight of a real aircraft carrier and real airplane so that you can make your models to scale. How much weight does your aircraft carrier hold before it sinks?
5. Based on your experiments, write a report to the US Navy with your recommendations regarding aircraft carrier design. If you email your report to [info@k2communications.com](mailto:info@k2communications.com), we will forward it to the Navy and with your approval, post it on the film web site and share it with other students nationwide.



## Challenge Question #1:

# How does an aircraft carrier stay afloat?

### Find out more:

- Mark the water level in the tub before you add the aircraft carrier, and again after you add the aircraft carrier. How much water is displaced by your aircraft carrier before and after you add the planes?
- Take your aircraft carrier to a body of water outdoors and try to simulate conditions, such as wind and waves, in the middle of the ocean. What new factors does this add that weren't present when you were testing in the tub?

### What is buoyancy?

Buoyancy refers to how well an object floats. A heavier object does not float as well as a lightweight object, but it can be shaped in a way to improve its buoyancy. Because of its shape, an aircraft carrier has much better buoyancy than a ball of metal that weighs the same. A floating aircraft carrier is displacing the same volume of water as would fill the bottom half of the ship, the part that is underwater. When you add the weight of the heavy planes, the ship sinks further down, displacing more water.



An aircraft carrier weighs over 100,000 tons (or 220,462,280 pounds!).



The airplanes they land there typically weigh 32,080 pounds each.



The 6,000 people on an aircraft carrier weigh a total of about 900,000 pounds.

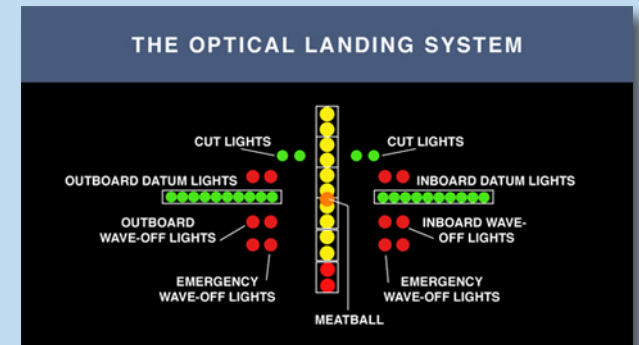
## Challenge Question #2:

# Why do aircraft carriers need both Landing Signal Officers and Optical Landing Systems?

### You will need:

1 page magnifier (aka a Fresnel lens), 3 small flashlights, red and green twinkle lights (1 string of each color), wire cutters/strippers, 4 batteries (D or stronger), duct tape, cardboard, scissors, a partner to work with you

1. Cut a section of 5 green bulbs from the twinkle lights. Strip the wire at each end. Do the same with a section of red bulbs.
2. Using the supplies above, build 2 separate circuits so that you can make both strings of bulbs light. It will take some experimenting to do this, but keep trying!
3. Assemble a model of an Optical Landing System including “datum lights,” “wave-off lights” and “the meatball.” Hint: To create the meatball, you will need the flashlights and page magnifier/Fresnel lens. A Fresnel lens is used in a real Optical Landing System. How does the light change when directed through the lens?
4. Choose one person to be the Landing Signal Officer (LSO) and one person to be the Pilot. Create two simulations for landing the plane on the aircraft carrier – one in which the pilot is able to land successfully in spite of choppy waves and one in which the pilot has to be “waved-off.” The LSO operates the Optical Landing System. Talk to each other as if you were the LSO and pilot using radios and headsets.
5. Write up a report from the LSO to your commanding officer explaining why you made the decisions you made.
6. When the Optical Landing System was first created in the 1950s, it was expected to eliminate the need for LSOs because it is designed to communicate information quickly and efficiently. But accident rates were significantly reduced when LSOs were involved. LSOs are skilled in operating the System, but what else can they do that the Optical Landing System cannot?



## Challenge Question #2:

# Why do aircraft carriers need both Landing Signal Officers and Optical Landing Systems?

**Find out more:** Why is the nickname for the LSO “Paddles?” What is a “pickle” and how is it used?

**Who are the people who help planes land on an aircraft carrier, and how do they do it?**



The 7 categories of jobs on an aircraft carrier are categorized by the color shirts the people wear. The chart will help you understand who is who. Things happen very fast when a plane is landing on an aircraft carrier. With 6,000 people working together, the shirts are a big help to keep up with what's going on. It is the LSOs, in white shirts, who help the pilot land the plane.

The Optical Landing System is a group of lights – horizontal green lights that the pilot uses to see the plane's relationship to the horizon, vertical red lights that flash if it is unsafe to land, and, in the middle, a series of amber Fresnel lenses (like the light you'd find in a lighthouse). When the Fresnel lenses line up correctly and the plane is at the correct angle to land, the pilot sees one round amber light nicknamed the meatball. If the meatball turns red, that means that the pilot is too low to land; the LSOs will flash the red wave-off lights and the pilot will have to circle around again. The LSOs communicate with the pilot by radio and also use hand signals and, at night, flashlights. LSOs adjust the Optical Landing System and turn it on or off with a control device nicknamed the “pickle.”

**How do you build a circuit?** If you have tried and tried and can't get those bulbs to light, check out “Christmas Light Circuit” by More than a Worksheet at <https://www.youtube.com/watch?v=cBKzKZRpsVQ> (but don't cut all of your bulbs apart!). Once you can light 1 bulb, you can go on to lighting a string of 5.

**Rainbow Wardrobe**  
A Guide to the Color-coded Jerseys on an Aircraft Carrier

	<b>Purple</b> Aviation Fuels [nickname: "Grapes"]
	<b>Blue</b> Plane Handlers Aircraft elevator operators Messengers and Phone Talkers
	<b>Green</b> Catapult and arresting gear crews Air wing maintenance personnel Cargo-handling personnel Hook runners Helicopter landing signal enlisted personnel (LSE)
	<b>Yellow</b> Aircraft handling officers Catapult and Arresting Gear Officers Plane directors
	<b>Red</b> Ordnanceman Crash and Salvage Crews Explosive Ordnance Disposal (EOD)
	<b>Brown</b> Air wing plane captains Air wing line leading petty officers
	<b>White</b> Air wing quality control personnel Squadron plane inspectors Landing Signal Officer (LSO) Air Transfer Officers (ATO) Medical personnel

### Challenge Question #3:

# How do you design a cable strong enough to stop a speeding jet?

#### You will need:

- 2 large binder clips
  - string
  - 2 straight-back chairs
  - 10" long pieces of "cable" made from very thin materials, such as nylon fishing line, cotton string, wire, long rubber bands, and 2 sizes of spaghetti
  - 1 small paper cup
  - sharp scissors
  - 1 pipe cleaner
  - measuring tape
  - 20 pennies
1. Tie one clip to the back of each chair by wrapping string around one side of the clip as shown in the photograph. Position the chairs back to back, about 10-11" apart.
  2. Use the scissors to poke 2 small holes in the top part of the paper cup. Run the pipe cleaner through the holes so that it loops above the cup, like a basket. Twist the ends of the pipe cleaner so that it stays attached to the cup.
  3. Clip each end of the cable you are testing to one of the clips, so that it is parallel to the floor with the cup hanging in the center as shown in the photograph.
  4. Add pennies to the cup, one at a time. Watch what happens to the material. Measure the material when you start and at different intervals, graphing the number of pennies compared to number of inches for each material.
  5. Repeat this tensile strength test (steps 3 and 4) with the different cable materials.
  6. Select 2 materials that, based on your testing, you recommend for the cable that stops the planes on an aircraft carrier. What qualities of this material did you consider in making your recommendation?





### Challenge Question #3:

## How do you design a cable strong enough to stop a speeding jet?

**Find out more:** How are the results of your testing changed if you braid three strands of material together?

### What are the steps for safely landing a plane on an aircraft carrier?

After the Landing Signal Officers clear the pilot to land, the pilot releases the “tailhook” from the back of the plane, which grabs on to one of four arresting wires, or “cables,” across the runway on the ship. The cable pulls on the plane and, with the help of a system of pulleys below, slows it down. The cables are steel ropes designed for tensile strength, as a cluster of wires (see illustration) woven together similarly to the way a spider builds its web.

### What is tensile strength?

Tensile strength is the amount of force required to stretch a material to the point where it breaks. Steel cables and spider webs both have excellent tensile strength. If the cable on an aircraft carrier broke, the plane would fly into the ocean. If the spider web broke, the spider wouldn't be able to catch her food. While tensile strength is about pulling something apart, compressive strength is about pressing it together. Concrete has excellent compressive strength and, when used to build roads, can withstand the traffic of heavy vehicles without breaking.



## Selection of Next Generation Science Standards for Grades 3-8 related to the Activities and Film

### Forces and Interaction

MS-PS-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.

### Structure, Function and Information Processing

MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain and respond to the information in different ways.

### Structure and Properties of Matter

MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

5-PS1-3. Make observations and measurements to identify materials based on their properties.

### Engineering Design

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.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

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

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.



For further information, please visit [nextgenscience.org](http://nextgenscience.org)

To find out more about the giant screen film  
*Aircraft Carrier*, please visit:

[www.k2communications.com](http://www.k2communications.com)

*Aircraft Carrier* is produced & distributed by  
K2 Communications and Giant Screen Films

## RESOURCES

### General:

America's Navy: STEM for the Classroom, Aircraft Carriers, Life on a Sub, Women in the Navy  
<http://www.navystemfortheclassroom.com/>  
<http://www.navy.com/about/equipment/vessels/carriers.html>  
<http://www.navy.com/navy-life/life-on-a-sub.html#why-live-on-a-sub>  
<http://www.navy.com/navy-life/winr.html>

"Rise of Machines" by Discovery Channel, a breathtaking CGI experience of technology inside aircraft carriers (Season 1, Episode 8). Watch the show online: <http://www.history.com/shows/rise-of-the-machines>

### Activity #1:

How Stuff Works: "Life Jackets and Buoyancy"  
<http://adventure.howstuffworks.com/outdoor-activities/water-sports/life-jacket1.htm>

NOVA: Buoyancy Brainteasers "Voyage of Doom"  
<http://www.pbs.org/wgbh/nova/lasalle/buoyancy.html>

Bill Nye, the Science Guy: "Buoyancy"  
<https://www.schooltube.com/video/7100de854a0a40fead91/Bill%20Nye%20-%20Buoyancy>

### Activity #2:

Air & Space, Smithsonian: "The Meatball"  
<http://www.airspacemag.com/how-things-work/the-meatball-8421491/?no-ist>

Illumin, USC: Taking Off and Landing on an Aircraft Carrier  
<http://illumin.usc.edu/142/taking-off-and-landing-on-an-aircraft-carrier/>

America's Navy: Rainbow Wardrobe  
<http://www.navy.mil/navydata/ships/carriers/rainbow.asp>

Carrier Landing Consultants  
<http://carrierlandingconsultants.com/>

Wikipedia: Modern United States Navy Carrier Operations  
[https://en.wikipedia.org/wiki/Modern\\_United\\_States\\_Navy\\_carrier\\_air\\_operations](https://en.wikipedia.org/wiki/Modern_United_States_Navy_carrier_air_operations)

US Naval Reserve Intelligence Program: Ready for Sea Handbook <http://fas.org/irp/doddir/navy/rfs/part04.htm>

### Activity #3:

Michigan Tech, Dept of Materials Science & Engineering: Tensile Test Experiment  
<http://www.mtu.edu/materials/k12/experiments/tensile/>

AZO: Mechanical Properties of Materials  
<http://www.azom.com/article.aspx?ArticleID=3426>

How Stuff Works: How Aircraft Carriers Work  
<http://science.howstuffworks.com/aircraft-carrier4.htm>

