



## Lego Engineers Camp Unit 2: Boats and Submarines

**Time:** 3 hours

**Ages:** 4-10

**Learning Objectives:**

1. What is buoyancy?
2. How do boats and ships float?
3. How do submarines sink AND float?

**Word of the Day:** BUOYANCY

### Activities, Materials & Prep Checklist

Introduction to Camp (15 mins) .....	1
Introduction to the Subject & Word of the Day (15 mins).....	1
Big Demo of the Day: The Cartesian Diver (10 mins).....	2
Materials: .....	2
<input type="checkbox"/> 1 pipette (approx. \$.05/ea on Amazon.com) .....	2
<input type="checkbox"/> One ¼” hexnut .....	2
<input type="checkbox"/> 1 pair scissors .....	2
<input type="checkbox"/> 1 clear 12-oz (or larger) clear plastic bottle with a screw cap, filled with water ..	2
<input type="checkbox"/> Ketchup packet (optional) .....	2
.....	2
<input type="checkbox"/> Cut the end of the pipette off, leaving approximately ½ inch of the end under the bulb. ....	2
<input type="checkbox"/> Cut a small triangular notch in the end of the pipette under the bulb. This will make the next step (screwing on the nut) easier.....	2
<input type="checkbox"/> Screw on the nut until it touches the bulb and cannot go up any further. ....	2

<input type="checkbox"/> Put the end of the Cartesian Diver into water, squeeze the bulb and allow the bulb to fill up approximately halfway.....	2
<input type="checkbox"/> Drop the diver into the bottle and top the bottle off with more water as necessary. In order for the diver to work it needs to <i>just</i> be able to float. When you give it a tap, it should sink down into the water, but then float back up. Test this a couple times.....	3
<input type="checkbox"/> Screw the cap on the bottle and secure tightly.....	3
<input type="checkbox"/> Test the diver by squeezing the bottle to make sure that when you squeeze the bottle, the diver goes to the bottom and when you release the bottle, the diver goes to the top. ....	3
<input type="checkbox"/> If you have other teachers helping you with the camp, make some demonstration bottles for them to show the campers as well.....	3
<input type="checkbox"/> Consider making a second bottle as described above, except use a sealed ketchup packet instead of the pipette and hexnut. The packet should just barely float in the bottle; you may have to try several different packets as they can have varying amounts of air in them. It works the same way as the pipette, and should dive when the bottle is squeezed. ....	3
Make a Cartesian Diver (25 mins).....	3
Materials: .....	3
<input type="checkbox"/> pipettes - 1 per camper .....	3
<input type="checkbox"/> ¼” hexnuts - 1 per camper .....	3
<input type="checkbox"/> class set - colorful Sharpies .....	3
<input type="checkbox"/> class set - scissors .....	3
<input type="checkbox"/> 12-oz. clear plastic water bottles, with lid, filled with water – 1 per camper.....	3
<input type="checkbox"/> Class set - pitchers with water.....	3
Prep:.....	4
<input type="checkbox"/> Cut the end off of each pipette, leaving approximately ½ inch of the end under the bulb. ....	4
<input type="checkbox"/> Cut a triangular notch in the end of the pipette under the bulb. This will make the next step easier.....	4
<input type="checkbox"/> Screw on the nut until it touches the bulb and cannot go up any further. ....	4
Feel the Pressure (10 mins).....	4
Materials: .....	5

<input type="checkbox"/> class set - plastic tubs filled with water (large enough for campers to put their entire forearm into water) .....	5
<input type="checkbox"/> class set - recycled plastic newspaper bags (you can also buy these on Amazon.com) .....	5
Prep: .....	5
<input type="checkbox"/> Fill up the plastic bins with water. The bins need to be deep enough for a child to be able to put their entire forearm inside. ....	5
Experiment with Sink & Float (25 mins).....	5
Materials: .....	5
<input type="checkbox"/> Buoyant objects (boats, inflated balloons, ping pong balls, corks, empty test tubes filled with air and capped, plastic lids, plastic cups, foam balls, craft sticks, plastic utensils, aluminum foil, certain Lego pieces, etc).....	5
<input type="checkbox"/> Non-buoyant objects (it's great to use a solid boat that doesn't float if you can find one; test tubes filled with water and capped; other dense objects that sink, such as washers, metal utensils, rocks, blocks, certain Lego pieces, etc. ) .....	5
<input type="checkbox"/> Objects that are buoyant until they get wet (e.g., sponges) .....	5
<input type="checkbox"/> At least 2 baby pools or plastic bins .....	5
Prep: .....	5
<input type="checkbox"/> Decorate a "demo" balloon boat using Sharpies. ....	5
<input type="checkbox"/> Stack up some Legos to look like packages.....	5
<input type="checkbox"/> Fill up the baby pool or other bins with enough water for the boats to be able to float around. ....	6
Snack Break (10 mins) .....	6
Make the Ultimate Floating Contraption (20 mins) .....	6
Materials: .....	6
<input type="checkbox"/> styrofoam plates, bowls, cups, corks, sheets of craft foam, aluminum foil, large and small craft sticks, balloons, etc. ....	6
<input type="checkbox"/> hot glue guns.....	6
<input type="checkbox"/> Lego people and/or standard Lego bricks .....	6
<input type="checkbox"/> baby pool or large plastic tubs partially filled with water .....	6
Prep: .....	6
<input type="checkbox"/> None .....	6

Build with Legos: Create a Boat (45+ mins) .....	7
Materials: .....	7
<input type="checkbox"/> Class set - pictures of Lego boats (see attached) .....	7
<input type="checkbox"/> Class set - miscellaneous Legos in bins. We do not recommend buying sets because (1) they are expensive and (2) this dramatically decreases the creativity of the exercise. Instead, buy pieces in bulk from eBay. As a rule of thumb, don't pay more than an average of \$.04-.06 per piece or \$5-7 per lb. Be sure to buy more basic bricks and wheels than unusual special parts. If you plan to let campers take their inventions home, plan for about 80 pieces per camper.....	7
<input type="checkbox"/> Small labels (optional) - 1 per camper.....	7
<input type="checkbox"/> Small index cards (optional) - 1 per camper.....	7
<input type="checkbox"/> Pools or bins partially filled with water.....	7
Prep:.....	7
<input type="checkbox"/> Print out pictures of Lego boats (see attached). Cutting them out and laminating them will help preserve them. ....	7
<input type="checkbox"/> Put Legos into bins or bowls. It is OK for them to be jumbled up. ....	7
<input type="checkbox"/> If campers will be taking home what they build, preprint their names on labels to attach to their inventions. ....	7
Extra Activity: Sub in the Water (Optional) .....	7
Materials: .....	7
<input type="checkbox"/> 2 large plastic rectangular bins partially filled with water .....	7
<input type="checkbox"/> 4 small submarines or boat toys that don't float .....	8
<input type="checkbox"/> at least 12 toy cars and other toys that don't float .....	8
<input type="checkbox"/> 2 bandanas .....	8
<input type="checkbox"/> timer .....	8
Prep:.....	8
<input type="checkbox"/> Put the pebbles in the bottom of the bin and fill the bin about 2/3 full of water... ..	8
<input type="checkbox"/> Drop in some different toy cars and other figures into the bottom of the bin. ....	8
Printable: Lego Boats .....	9

## Introduction to Camp (15 mins)

**<Skip this if you have done it on a previous day with the same group of kids and extend your other activity times by a few minutes.>**

Welcome to the Lego Engineers Camp! This week you will all be engineers-in-training as we learn and experiment with different things that move and then design and build them using Legos. (If this is a week-long camp, you can have a special closing event, where you can set-up stations to show what the children have learned during the week).

Each day we will have a theme and a “Word of the Day.”

Invite the campers to say their name and something they would like to share about themselves. This can be anything from what grade they are going into, what their hobbies are, what their favorite thing to build out of Legos is, etc. Make sure that all of the kids know each other and are familiar with the teacher and TA.

During camp there are some important camp rules that we must follow:

1. Listen when the teacher is talking so that no one misses any important instructions.
2. Raise your hand and wait for the teacher to call on you before speaking.
3. NEVER put anything in your mouth unless the teacher says it is ok.
4. NEVER leave the lab at the end of camp unless there is a parent present to pick you up!

## Introduction to the Subject & Word of the Day (15 mins)

Ask the kids some questions to get them excited about the camp: How do ships float? How do submarines sink AND float?

Today we will be experimenting with and building things that move in water: boats and submarines.

**Word of the Day:** BUOYANCY

**The Science:** What is buoyancy?

Buoyancy is the term for something that has the ability to float in a liquid. This is important to think about as we build boats and submarines using Legos.

Buoyancy was first explained almost 2000 years ago, when a famous mathematician, Archimedes, discovered that an object is buoyed up by a force equal to the weight of the liquid pushed out of the way by the object. If an object weighs **more** than the weight of the water it pushes out of the way, it will sink. If an object weighs **less** than the weight of the water it displaces, it will float.

Understanding buoyancy helps engineers design things like boats, submarines, seaplanes, pontoon bridges, rafts, life preservers and scuba gear.

**Show Videos.** Show videos about buoyancy and videos that show boats, ships and submarines in action. Suggested videos are available on the Curiosity Zone channel on YouTube: <https://www.youtube.com/user/CuriosityZone/featured>.

## Big Demo of the Day: The Cartesian Diver (10 mins)

### The Science:

Cartesian divers provide a great scientific demonstration of how submarines work. The “diver” is made with the bulb of a pipette with a small opening at one end. It is placed in a plastic bottle full of water and is weighted just enough to make it barely float.

Squeezing and releasing the bottle causes the diver to sink and float. How does this work? When the bottle is squeezed, the air inside the diver is compressed and takes up less space. This allows some water to enter the diver, making it heavier and causing it to sink to the bottom. When you release the pressure on the bottle, the air inside the diver expands making the diver float again.

How does a real submarine sink and resurface? Submarines have an inner and outer steel shell with a “ballast tank” in between. This ballast tank can be filled with either air or water. When the ballast tank is filled with air, the submarine floats and can come up to the surface of the water. To make the submarine dive, the submarine operator opens up valves on the main ballast tank, letting the air out and the seawater in. This changes the ship’s density, causing it to sink into the water. There are smaller ballast tanks that allow the crew to adjust the mixture of air and water inside them so the submarine will stay at a certain depth. To resurface, the operator lets compressed air into the ballast tank which forces the seawater out of the bottom of the tank.

### Materials:

- 1 pipette (approx. \$.05/ea on Amazon.com)
- One ¼” hexnut
- 1 pair scissors
- 1 clear 12-oz (or larger) clear plastic bottle with a screw cap, filled with water
- Ketchup packet (optional)



### Prep:

- Cut the end of the pipette off, leaving approximately ½ inch of the end under the bulb.
- Cut a small triangular notch in the end of the pipette under the bulb. This will make the next step (screwing on the nut) easier.
- Screw on the nut until it touches the bulb and cannot go up any further.
- Put the end of the Cartesian Diver into water, squeeze the bulb and allow the bulb to fill up approximately halfway.

- Drop the diver into the bottle and top the bottle off with more water as necessary. In order for the diver to work it needs to *just* be able to float. When you give it a tap, it should sink down into the water, but then float back up. Test this a couple times.
- Screw the cap on the bottle and secure tightly.
- Test the diver by squeezing the bottle to make sure that when you squeeze the bottle, the diver goes to the bottom and when you release the bottle, the diver goes to the top.
- If you have other teachers helping you with the camp, make some demonstration bottles for them to show the campers as well.
- Consider making a second bottle as described above, except use a sealed ketchup packet instead of the pipette and hexnut. The packet should just barely float in the bottle; you may have to try several different packets as they can have varying amounts of air in them. It works the same way as the pipette, and should dive when the bottle is squeezed.

**Procedure:**

- Hold up the prepped Cartesian diver in a bottle for all of the campers to see.
- Point out the diver at the top of the bottle.
- Squeeze the bottle a couple times to demonstrate.
- Ask the campers how they think this works.
- As you are demonstrating again, talk about how the Cartesian diver works and how this is similar to how a submarine works.
- Let the campers know they will be making these later in the day.

***<If you have two groups, split the groups up now.>***

**Make a Cartesian Diver (25 mins)**

**The Science:**

See the “Big Demo of the Day” section above.

**Materials:**

- pipettes - 1 per camper
- ¼” hexnuts - 1 per camper
- class set - colorful Sharpies
- class set - scissors
- 12-oz. clear plastic water bottles, with lid, filled with water – 1 per camper
- Class set - pitchers with water

**PAGES 4-6 INTENTIONALLY DELETED FOR PREVIEW**

- At the end of this activity, ask the kids some questions: Which design was best? What are the strengths of their design? How could you change your design if you were to do this again?

## **Build with Legos: Create a Boat (45+ mins)**

### **Materials:**

- Class set - pictures of Lego boats (see attached). Laminating the pictures will extend their useful lifespan.
- Class set - miscellaneous Legos in bins. We do not recommend buying sets because (1) they are expensive and (2) this dramatically decreases the creativity of the exercise. Instead, buy pieces in bulk from eBay. As a rule of thumb, don't pay more than an average of \$.04-.06 per piece or \$5-7 per lb. Be sure to buy more basic bricks and wheels than unusual special parts. If you plan to let campers take their inventions home, plan for about 80 pieces per camper.
- Small labels (optional) - 1 per camper
- Small index cards (optional) - 1 per camper
- Pools or bins partially filled with water

### **Prep:**

- Print out pictures of Lego boats (see attached). Cutting them out and laminating them will help preserve them.
- Put Legos into bins or bowls. It is OK for them to be jumbled up.
- If campers will be taking home what they build, preprint their names on labels to attach to their inventions.

### **Procedure:**

- Campers should use Legos to design and build a boat that floats and can carry cargo. Show the campers pictures of Lego boats for inspiration.
- If campers will be taking their invention home, consider giving them an index card to control the size of what they build. They must create something that fits on the index card.
- Allow the campers to test their creations in the bins of water and demonstrate for the class (time permitting).
- If the campers will be taking home their Lego creation, give them a label with their name on it to attach.

## **Extra Activity: Sub in the Water (optional)**

### **Materials:**

- 2 large plastic rectangular bins partially filled with water

- 4 small submarines or boat toys that don't float
- at least 12 toy cars and other toys that don't float
- 2 bandanas
- timer

**Prep:**

- Put the pebbles in the bottom of the bin and fill the bin about 2/3 full of water.
- Drop in some different toy cars and other figures into the bottom of the bin.

**Procedure:**

- Split the campers up into 2 teams.
- Explain that the object of this game is to dig through the water to find the 2 submarines or 2 sunken ships within one minute while blindfolded.
- Have one person at a time from each team come up to the bins, get blindfolded and race the clock!

**Printable: Lego Boats**





