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# Balloon boat and Amphicar for AutoSTEM

## Construction instructions and pedagogical guidelines

This guide includes:

-  How the Amphicar can be used to learn STEM subjects
-  How to construct a balloon-powered Amphicar

## How the Amphicar can be used to learn STEM subjects

### What is the balloon-powered boat and Amphicar?

The Amphicar is a toy that is a boat and a car at the same time. When building it, the children can stop when it is a boat or continue to make a car that can still be used as a boat like the classical Amphicar. The **AutoSTEM** Amphicar is made from a standard milk or juice carton, straws, wooden skewers, bottle tops and a balloon. It will move on its own on land or water when the balloon is inflated.

It results in a toy that can be used by the children in many ways and opens up a number of subject areas for further learning. Moving cars and boats are very motivating and exciting toys for children. It is fun for the children to be allowed to play with their Amphicars, once they have made them.

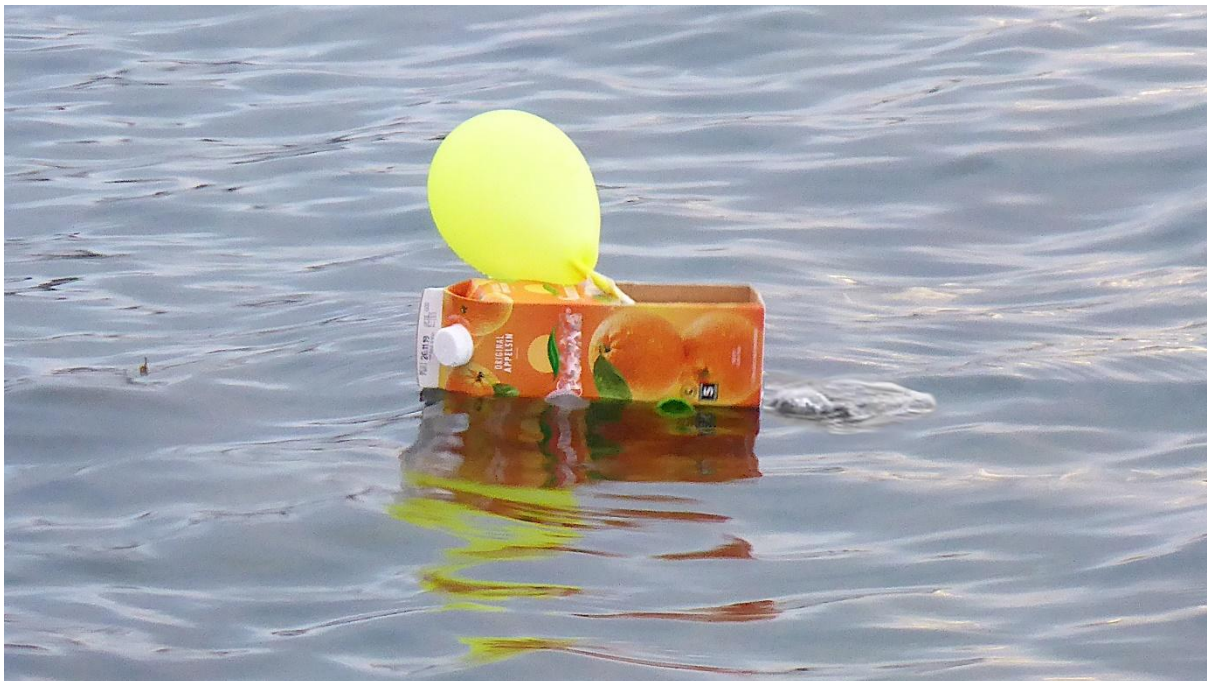


Figure 1. An example of the Amphicar









## Target group

The Balloon car example described here is designed for children from 4 to 7 years old. Teachers can adapt the proposal to other ages.

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

## Learning goals

When constructing the Amphicar several learning goals can be achieved:

-  To practice measuring
-  To use a ruler to draw a straight line (or for measuring)
-  To learn about physics and mechanisms
-  To develop engineering competencies of analysis and construction.
-  To learn mathematical concepts within the construction and assembly process, including shapes and numbers.
-  Other soft-learning goals can be included; problem solving and creativity.

## Guide on how to introduce STEM concepts during construction

The starting point is the Balloon car, how it functions, and how to construct it.


### Observing

The first thing the teacher does is show a model of the Amphicar and make it run on the floor and on water (if available). The teacher can ask, 'Why did it move?'

### Exploring and learning about physics and mechanisms.

Children can observe the Amphicar, make comments, and ask questions about how it functions.

The following concepts can be introduced and explored

-  **Energy:** different types of energy:
  - Work (The child does work by inflating the balloon.)
  - Elastic energy: potential energy due to the deformation of the balloon
  - Rotational kinetic energy (the rotation of the wheels)
  - Translational kinetic energy (the forward motion of the Amphicar)
  - Thermal energy (Heat is created by friction.)



- **Force:** The child uses force to inflate the balloon. The balloon applies force on the air, pressing it out through the straw. According to Newton's third law (action equals reaction), the force of the backwards streaming air (called the thrust) creates an equal force in opposite direction on the Amphicar (called the propulsion) that pushes the Amphicar forwards.
  - Buoyancy (upthrust): an upward force exerted by a fluid that opposes the weight of an immersed object. The Amphicar's buoyancy is larger than the gravitational force that pulls it downwards. Therefore it floats on water. If the weight is too much, it will sink.
  - Friction: the force resisting the motion when the wheels roll on a surface (rolling friction) or the boat floats through the water (fluid drag)
- **Pressure:** the force applied perpendicular to the surface of an object per unit area over which that force is distributed
- **Conservation of energy:** Energy can be converted but not destroyed.
  - The child's work is converted into elastic energy (of the balloon and the pressurised air inside the balloon),
  - Elastic energy into translational energy (of the air jet and the car),
  - Translational energy into thermal energy (of the water)
  - Or on land into rotational energy (of the wheels) and rotational energy into thermal energy (the wheels and the ground become slightly warmer through friction)
- **Centre of mass:** In order to find the centre of a wheel, the children can balance the bottle top on the tip of a skewer.
- **Parts of a boat:** hull, deck, bow, stern, port, starboard, and jet engine
- **Parts of a car:** wheels, axles, and bearings for the axles

### ***Starting to construct the Amphicar and learning mathematics***

The teacher talks with the children asking what is needed to make the Amphicar. During the construction, many mathematical concepts can be used, introduced, or discovered.

- **Counting:** two straws (one will be divided into two parts), four bottle tops, one skewer that will be divided into two parts



- **Measuring length:** Straws and skewers have to be cut into pieces of a given length. Older children can use a ruler, younger children can use fingerbreadth and handbreadth as units.

Direct comparison

- to make a hole in the bottle top that is 'just' big enough for the wooden skewer to pass through,
- to find the right size for the hole in the deck, and
- to measure the length of the bearings.

- **Designing (shapes):** The boat's hull is a cuboid with a triangular prism at the bow. The stern is a square. The hole in the deck is a rectangle. The wheels are circles (cylinders).

- **Locating:** use spatial concepts like rear, front, under, top, bottom, centre (find the centre of a circle), around, rotation (the motion of the axles and the wheels), translation (the forward motion of the Amphicar), through (the axles go through the bearing), perpendicular

### **Expanding on the idea**

The initial car idea can quite easily lead to further ideas and explorations. The teacher can ask the children for their ideas, perhaps, looking at the way vehicles are used in the world outside, different shaped cars,

One idea is to add loads as lorries and vans do. This then asked the question what happens when a load is added and why? The children can investigate how much load can be added before the boat sinks.



## How to construct the balloon-powered boat and Amphicar

To make the balloon-powered Amphicar you will only need basic parts and tools that are found in every school or preschool. Below we list the parts needed and alternatives.

### Parts and tools required



For the boat

- 1x standard one-litre milk or juice carton
- 1x paper straw
- 1x balloon
- Sellotape or other sticky tape
- Scissors
- a marker pen
- a ruler



For the Amphicar (in addition to the above)

- 1x paper straw
- 1x wooden skewer (about 4mm wide and at least 20cm long)
- 4x plastic bottle tops of the same size

Since the materials that can be used are very wide and easy to find, the teacher can ask the children to find objects that might otherwise be thrown away (milk carton, bottle tops, ...). In this way, we can add conservation and reusability into the teaching.

### Method

It is best to watch the video.

If you want to make only the boat, watch <https://youtu.be/jlE5rIU5gQo>.

If you want to make the Amphicar, watch <https://youtu.be/vdocyNN3osI>

### The boat

1. Take one straw and measure two fingerbreadths (about 3 cm or 1½ inch) from the end alongside the straw and mark this point. Do the same at the other end of the straw, too (see figure 2).



Figure 2. Measure two finger-widths on each end of the straw

2. Open the upper side of the boat

- a. Lay the milk or juice carton on its side so that the top is on the right and the opening points away from you. This will be the hull of the boat. The side facing upwards is the upper side, the deck of the boat. The side facing downwards is the bottom. The side with the opening is the port (larboard, left-hand side) and the other side is the starboard (right-hand side). The bottom of the carton is the stern (rear end) and the top of the carton is the bow.



Figure 3. The carton becomes the hull of the boat

- b. Lay the straw on the upper side of the boat so that one mark is on the rear starboard corner and the other mark meets the port edge (see figure 4).



Figure 4. Measure with the straw the size of the hole to cut in the deck

- c. Mark the point where the mark meets the port side.
  - d. Take the ruler and draw a line across the deck from the mark to starboard perpendicular to the port side.
  - e. Use the scissors to prick a hole in the deck (The teacher might help with this.) and cut away all of the deck that is between the line and the stern. Only the foredeck remains.
3. Use the scissors to prick a hole in the stern just above the middle of the bottom edge of the stern. The hole shall be 'just' big enough for the straw to pass through and still be tight.
  4. Attach the balloon to the straw.
    - a. Slip the balloon's open end over the one end of the straw and fold it as tightly as possible around the straw.
    - b. Wrap the sticky tape as tightly as possible around the folded neck of the balloon and the straw.
  5. Take the other end of the straw and push it from the inside of the hull through the hole in the stern until the mark sits in the hole.
  6. Attach the straw with sticky tape to the foredeck and to the stern. The sticky tape at the stern shall be at the outside and seal the hole around the straw.

The boat is now finished and can be used. If you like, you can colour it with paint. Continue with step 7 if you want to make an Amphicar.



### **The Amphicar**

7. Take the second straw and cut it into two pieces that are as long as the boat's width. These will be the bearings for the axles.
8. Making the holes in the wheels:
  - a. Take a bottle top, find the centre, and make a hole. Many bottle tops are so soft that you can use the pointy end of the skewer to make the hole. If the plastic is too hard, you have to use a hammer and a nail. Do the same for all the four wheels.
  - b. Check the holes in the wheels are big enough for the skewer to go through, but do not make them too big as the wheels might fall off.
9. Cut the wooden skewer into two pieces, each 10cm long (the length of the bearing plus two fingerbreadths). These will be the axles.
10. Final assembly:
  - a. Use sticky tape to attach the two bearing straws to the bottom of the boat. They should be about a handbreadth apart and be perpendicular to the length of the hull.
  - b. Put a wheel on one end of each axle.
  - c. Push the axles through the inside of the axle holder straws.
  - d. Put the remaining wheels on the other ends of the axles.
11. Place the completed car on to a flat surface (table or floor) check that no part of the car body is touching the table or floor. Otherwise, the car might not work. If the straw that sticks out at the stern is too long, you can shorten it by cutting a piece away.

The Amphicar is now finished and can be used.

### **Making the Balloon boat and Amphicar move**

Lift the boat or Amphicar and blow into the end of the balloon holder straw so that the balloon inflates. When the balloon is quite big, squeeze the straw, quickly put the boat in the water or the Amphicar on to a flat surface and let it go weeeeeeeee.

The Amphicar can also drive down a slope at the sea or lake shore, enter the water, and continue as a boat.