If the buoyant force on an object is smaller in a liquid than its weight force, then the object sinks. If the buoyant force is greater than the weight force, the object swims.
If the buoyant force and weight force are equal, then the object floats in the liquid.

Material

(1)	Balloons, rubber, 10 pcs, 1 of	02620.03
(1)	Cartesian divers, pack of 3, 1 of	03820.03
(1)	Copper wire, d = 0.2 mm, l = 100 m, 0.4 m	06106.00
(1)	Steel pellets, d = 3 mm, 120 g	03990.00
1	Microspoon, steel	33393.00
1	Ungrad. Cylinder 360 ml, d = 40 mm, h = 40 cm	34217.00
1	Glass beaker DURAN®, tall, 100 ml	36002.00
1	Glass beaker DURAN®, short, 250 ml	36013.00
(1)	Test tube, d = 16 mm, l = 160 mm, 10 pcs, 1 of	37656.03
1	Rubber stopper 34/41, without hole	39261.00
	Absorbent towels	
	Scissors	

Setup and implementation

Experiment 1

- Place absorbent towels on the table in order to collect any overflowing water
- Fill the ungraduated cylinder completely with water and place in the diver
- Place the stopper on top and forcefully press until air comes out of the diver and it fills up a bit with water (Fig. 1)
- Take off the stopper and fill the ungraduated cylinder again up to the rim with water
- Press down on the stopper with your hand and allow the diver to sink
- Allow the diver to float, sink or rise by applying different pressure
- Observe the water level in the diver

Fig. 1

Fig. 2

Remarks

The more water there is in the diver, the easier it is to move it through the pressure applied. In order to fill the diver with more water, turn the ungraduated cylinder with the stopper placed on top; allow the diver to rise up towards the surface and turn the cylinder so that additional air bubbles can escape from the tail of the diver.

If too much water is in the diver, it sinks. Excess water can then be removed by carefully sucking the water out of the diver with the mouth.

Experiment 2

- Place absorbent towels on the table in order to collect any overflowing water
- Fill the ungraduated cylinder completely with water
- Pour steel balls into the 100 ml glass beaker
- Place the test tube in the water and fill in with one microspoon of pellets until the test tube immerses approximately one millimeter below its rim (Fig. 2)
- Pull out the test tube and seal water-tight with a piece of balloon cut to fit, to do so wrap a piece of copper wire several times below the opening around the test tube and twist the ends so that the wire is tense
- Place a stopper on the cylinder and apply different amounts of pressure, observe the test tube

Observation

Both objects swim without the cylinder being plugged.

If great pressure is exerted on the stopper and the liquid, then the diver and the test tube move downward (sinking).

With somewhat less pressure both objects can be kept afloat (floating).

If no pressure is exerted the objects rise again to the surface of the water (swimming).

If the pressure is quickly dropped, the diver spins around its own axis.

Water is located in the diver. When pressed the water level increases in the diver. Afterwards the diver sinks.

The test tube is sealed with a rubber membrane. This bulges inward due to the pressure.

Evaluation

Experiment 1

The pressure on the stopper increases the pressure in the water. As a result water flows into the diver. It has a small opening at the end of its tail through which the water can enter into. The trapped air is compressed as a result. The greater the pressure, the more water flows in. This causes the diver to become heavier.

If its weight force is larger than its buoyant force, then the diver sinks (Fig. 3):

$$F_W > F_B$$

If its weight force is less than its buoyant force, then the diver rises to the top until it swims (Fig. 4):

$$F_W < F_B$$

If its weight force is equal to its buoyant force, then the diver floats (Fig. 5):

$$F_W = F_B$$

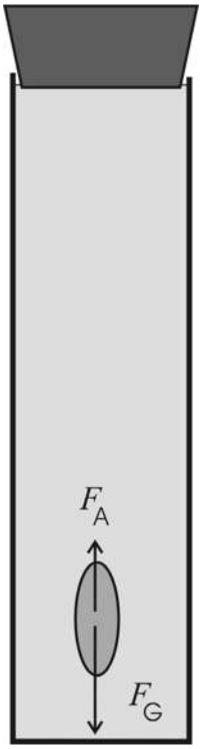

Fig. 3

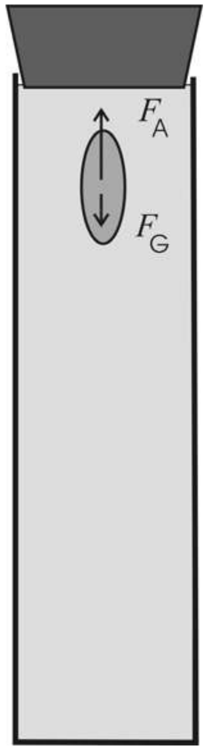

Fig. 4

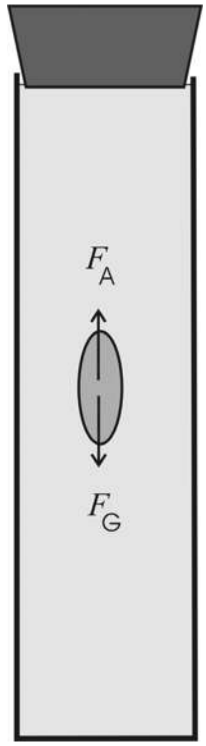

Fig. 5

If the pressure is quickly dropped, the compressed air quickly expands again in the diver. The water is pressed out of the side opening. The recoil force of the expelled water makes the diver turn.

Experiment 2
The test tube behaves similarly to the diver. The increased water pressure causes the rubber membrane covering the test tube to bulge inward. The greater the pressure, the more the membrane bulges inward. The trapped air is compressed as a result.
The change of volume also causes a change in the buoyant force of the test tube. The buoyant force is proportional to the volume of the immersion object. The greater the pressure in the water, the smaller the volume, the smaller the buoyant force. The test tube sinks.
The considerations of the ratio of buoyant and weight force are analog to the experiment with the diver (see above). Whereas the weight force changes in the diver, here the buoyant force can vary.

Whether an object swims, floats or sinks in a liquid depends on the ratio of its buoyant and weight force. Normally both forces have a fixed value so that the object either swims, sinks or floats in the water.

Whereas the weight force of the Cartesian diver can be changed, in a test tube the volume and therefore also the buoyant force is changeable. As a result, it is possible to allow the object to swim, sink or float.

Remarks
The experiment can also be carried out with a plastic bottle. The diver also sinks if it is pressed on the sides. This shows that the pressure does not necessarily have to be exerted from above. The pressure has the same effect in trapped liquids irrespective of the direction.

Room for notes