Energiakeskus
Põhja pst 29
10415 Tallinn, Estonia
Phone: +372 715 2650
info@energiakeskus.ee
www.energiakeskus.ee

# HANDS-ON & BRAINS-ON
# Work package 8

# Experiments with liquids (for grades 1…4)

## 1. Fluency of liquids in a vessel / in connected vessels

These series of experiments help to explain fluid's behaviour in connected vessels and in vessels with different shape.

**Parallels with a human body:**

- One of the most important liquids in human body is blood.
- Blood circulation is affected by the fact that liquids always tend to flow downwards due to gravity.
- If one hand is kept down for a while and the other is lifted up, we can observe their colour of skin changing. One hand will become darker and the other one – paler. So, blood has flown downwards because of gravity.

**Equipment:**

- 1 to 1.5 m long transparent PVC hose (at least with diameter 20 mm)
- A cup for pouring water
- A bowl for storing used water
- Water
- A small amount of aluminium powder for visualizing fluid's motion

**Experiment 1.1:**

1) Add some aluminium powder into the water in a cup.
2) Lift up both open ends of PVC hose and pour the liquid (water with aluminium powder) into the hose. (**Figure 1**)
3) Notice that water level stays the same on both ends.

In this experiment both ends of the hose can be handled as connected vessels. In such vessels fluid's surfaces stay on one level even when we lift up or tilt one end of the hose.

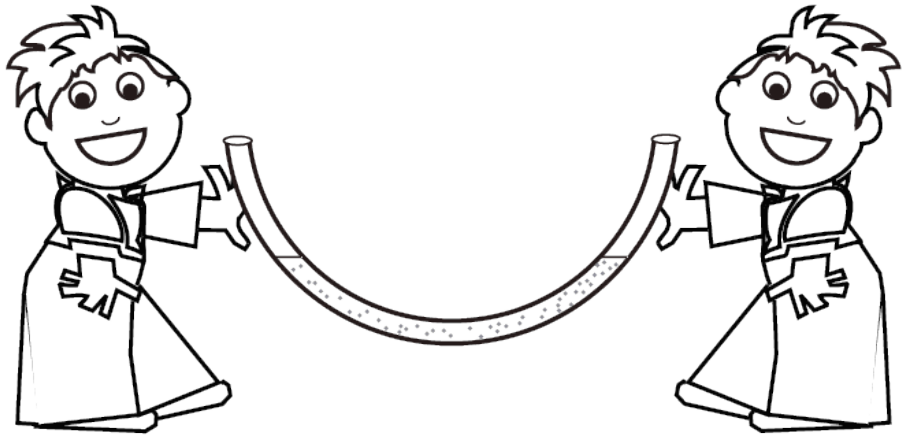

**Figure 1. Experiment 1.1**

**Experiment 1.2:**

1) Bend the filled PVC hose into a spiral, an eight or a ring. (**Figure 2**)
2) Notice that the fluid takes a shape of every vessel it's poured into.

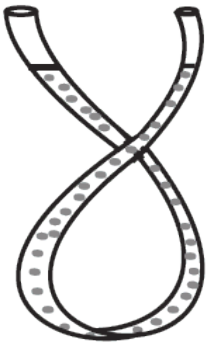

**Figure 2. Experiment 1.2**

**Experiment 1.3:**

1) Lower one end of a hose into a jar and lift the other end a bit higher. (**Figure 3**)
2) Notice that the fluid flows into the lower-standing vessel.

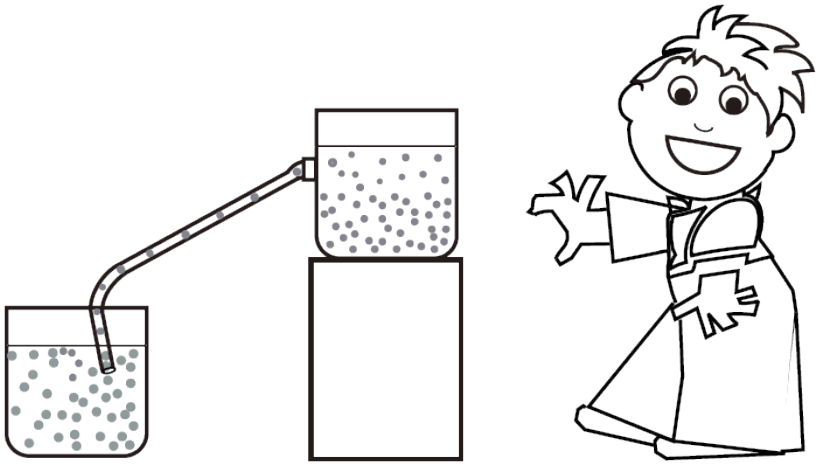

**Figure 3. Experiment 1.3**

***Conclusions*** 1) Fluid's level stays the same in connected vessels. In a living body this principle can not be manifested because heart constantly pumps blood into vessels in all directions.
2) Fluid fills up a vessel of any shape. Also blood takes a shape of every blood vessel in the body.
3) Fluid flows into lower-standing vessel under gravity's influence. Blood is also affected by gravity, so it tends to flow more easily into vessels (body parts) that are situated below.

## 2. Fluency of liquids in a system of vessels

This experiment helps us to explain fluid's behaviour in a more complex system of connected vessels.

**Parallels with a human body:**

Blood vessels can be found everywhere in the body.
Blood circulates in a closed system of vessels.
A middle-weighted man has about 5 litres of blood, a child with weight of 25 kg – about 1.8 l.

**Equipment:**

- 4 to 5 transparent PVC hoses (length 1…1.5 m, diameter 15 mm)
- PVC triplets (junctions) to interconnect hoses
- A funnel to fill the liquid circuit
- A cork to close the liquid circuit
- Water
- Some aluminium powder to observe fluid's motion.

**Preparations:**

Construct a liquid circuit from 4 to 5 pieces of hoses. For that, connect them as shown on **Figure 4**. Use junctions made of PVC. When the liquid circuit is complete, check it for possible leaking.

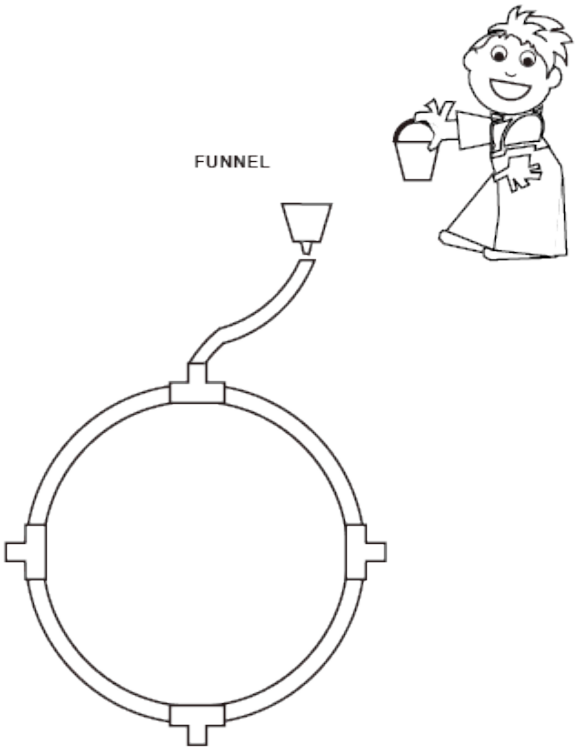


**Figure 4. Experiment 2.1**

**Experiment 2.1:**

1) Add some aluminium powder for fluid's motion to be seen.
2) Fill the circuit with liquid (water with aluminium powder) using the funnel (**Figure 4**).
3) Close the liquid circuit with a cork.
4) Notice that the circuit is filled upwards (due to Earth's gravity).

**Conclusions** (confirming the previous findings in a case of more complex system):

1) Fluid's level stays the same in connected vessels.
2) Fluid fills up a vessel of any shape.
3) Fluid first fills the lower parts of the circuit due to gravity.

## 3. Fluid's flowing under the impact of a force

By following experiments we explain that a liquid can flow only under the influence of some kind of force. Normally, this force is gravity. But we can apply additional forces.

**Parallels with a human body:**

- Contraction of a heart muscle makes blood to circulate through the body.
- Heart muscle is a tireless pump, which during the human life can rest only half a second at a time.
- Circulatory system is a closed system where a constant amount of blood is transported.
- Blood pressure is formed in the vessels, when vessel walls resist fluid's movement.
- In bigger vessels blood flows quickly, about 0.5 meters per second.
- In fine capillaries blood flow is slow, about 1 mm per second.

**Equipment:**

- 4 to 5 transparent PVC hoses (length 1…1.5 m, diameter 15 mm)
- PVC triplets (junctions) to interconnect hoses
- A hand-pump to pump liquid
- A funnel to fill the liquid circuit
- A cork to close the liquid circuit
- Water
- Some aluminium powder to observe fluid's motion.

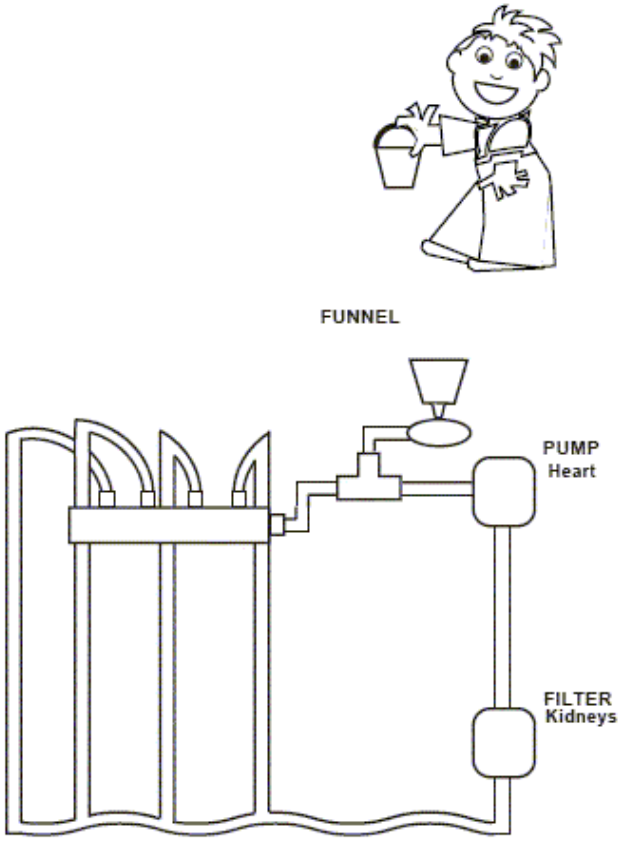


**Figure 5. Experiments 3.1–6.1**

**Experiment 3.1:**

1) Start to pump and observe fluid's motion through the hoses.

(**Figure 5**)
2) Notice that fluid starts to move due to a force applied by a pump.

**Experiment 3.2:**

1) Clench one of the hoses with a finger and watch how the water's flow slows down in that area.
2) Notice that an amount of a fluid flowing depends on hose's diameter.

**Conclusions:** 1) For fluid's motion an extra force is needed. So, heart also has to apply remarkable force to blood to make it circulate.
2) An amount of flowing fluid depends on hose's diameter. Also an amount of circulating blood and its speed depends on vessel's diameter.

# 4. Solvation of a matter in fluids (Figure 5)

These experiments explain how different matters can be dissolved in or mixed with fluids.

**Parallels with a human body:**

- Circulation carries substances into every part of a body through blood vessels.
- There are potassium, calcium, sodium and magnesium salts dissolved in blood – that is the reason why blood tastes salty.
- Blood also supplies cells with different nutrients – oxygen, glucose, vitamins, lipids etc.
- Also several residual substances are transported by blood: uric acid, carbon dioxide etc.
- Most of the substances present in the body can be found solved in blood. So the condition of an organism and contacts with lots of chemical substances can be defined by taking blood sample.
- Through circulation a medicament or some other substance taken will reach every part of a body in a minute.

**Equipment:**

- 4 to 5 transparent PVC hoses (length 1…1.5 m, diameter 15 mm)
- PVC triplets (junctions) to interconnect hoses
- A hand-pump to pump liquid
- A funnel to fill the liquid circuit
- A cork to close the liquid circuit
- Water
- Salt (0.5 kg).

**Experiment 4.1:**

1) Dissolve different matters in the fluid. For that open the circuit and add some salt into the fluid.
2) Salt's crystals sink at first and then "disappear" (dissolve in the fluid).
3) Now add liquid food colours using the funnel and watch their motion.
4) Notice that colour spreads slowly and heterogeneously.

**Experiment 4.2:**

1) Close the liquid circuit and start to pump.
2) Then add much more salt, about 100–200 g.
3) Notice that the salt does not dissolve anymore and sinks.

**Conclusions:** 1) Matters can dissolve in fluids. There are also a lot of different matters dissolved in the blood.
2) Matters can dissolve in fluids within a certain amount only. For instance, only a limited amount of oxygen can be dissolved in a certain amount of blood.
3) The extra matter can accumulate on the vessel's bottom. For a comparison, due to bad nutrition habits some residual substances like cholesterol begin to deposit onto the walls of blood vessels and may cause serious health problems.

## 5. Removal of matters from fluid (Figure 5)

By this experiment we explain removal of matters from fluid using filters

**Parallels with a human body:**

- Substances dissolved in blood are transported through circulatory system until they finally reach kidneys.
- By using blood pressure, redundant water and waste substances are removed from blood there. These matters are transported out of the body through urethral system.

**Equipment:**

- 4 to 5 transparent PVC hoses (length 1…1.5 m, diameter 15 mm)
- PVC triplets (junctions) to interconnect hoses
- A hand-pump to pump liquid
- A funnel to fill the liquid circuit
- A cork to close the liquid circuit
- Water

**Experiment 5.1:**

1) Direct the fluid (coloured water form the previous experiment 4.2) through the filter, by opening the tap as it is shown on **figure 5** and starting to pump.
2) Watch how the fluid becomes clear (transparent) again. The colorant is gathered into the filter.

**Conclusion:** It is possible to filter a dissolved matter from a fluid. In human body kidneys work as filters.

## 6. Pressure in a fluid (Figure 5)

We explain that by pumping pressure is formed in the fluid and is carried over into all parts of the vessel.

**Parallels with a human body:**

- If a blood vessel is damaged, some blood flows out, until a thrombus is built from blood platelets and proteins to close the wound.

**Equipment:**

- 4 to 5 transparent PVC hoses (length 1…1.5 m, diameter 15 mm)
- PVC triplets (junctions) to interconnect hoses
- A hand-pump to pump liquid
- A funnel to fill the liquid circuit
- A cork to close the liquid circuit
- A manometer to measure the pressure in the system
- Water
- Some aluminium powder to observe fluid's motion.

**Experiment 6.1:**

1) Open the system and add the manometer.
2) Close the system, start to pump and watch the reading of a manometer.
3) The pump causes the pressure in the fluid that carries over into all parts of the circuit.
4) The fluid moves because of that pressure.
5) Open the system carefully from whichever junction and start to pump weakly.
6) Observe the fluid erupting from the rupture.
7) Repeat the experiment with other junctions.

**Conclusion:** Fluid's pressure is carried over into all parts of the vessel, as well as blood pressure is present in all parts of circulatory system.