Learning about: **Fluid Dynamics**

Hydrostatic Tower

There is a specific depth limit that a diver can reach underwater. If this limit is exceeded, divers may suffer from eardrum injuries. Experiment with this model to find out how pressure changes by depth.

Discover:

- What is hydrostatic pressure?
- Which factors affect hydrostatic pressure?

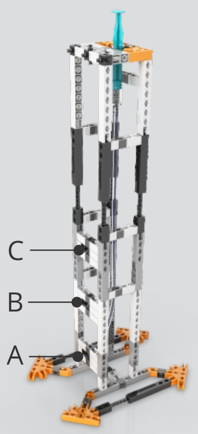
Level of Difficulty ★★☆☆☆

Materials Needed:
- Engino® Fluid Dynamics (STEM45).
- A plastic cup (see page 23).
- Water.

Procedure:

1. Find the instructions online and build the **Hydrostatic Tower** model.

2. Push the piston all the way inwards in the **syringe** and join the syringe with one nozzle of the rubber tubing. Take a plastic cup and fill it with water. Place the other side of the rubber tubing into the cup. Then, pull the piston outwards to fill the syringe with water. Attach the syringe on top of the model, as shown in below image. Place the nozzle of the rubber tubing on **position A** and do **exercise 1**.



3. Place your model in front of a sink, with the nozzle **facing the sink**. Now, remove the piston, observe what happens and do **exercise 2**.

4. For **case 1** place the rubber tubing on **position A**. For each case **the nozzle of the rubber tubing should be on the edge of the hole**. Fill the plastic cup with water and pour it into the syringe. Observe the intensity of the flowing water. For **cases 2** and **3** place the nozzle at **positions B** and **C**, respectively. Repeat the same procedure and write your observations in the table of **exercise 3.** Then do **exercise 4**.

1. Does the water pour out from the rubber tubing? Why is this happening?

The water does not pour out from the rubber tubing.........

There is no atmospheric pressure to push it downwards....

2. Fill the gaps of the following paragraph by using the words from the box.

atmospheric pressure, pour, air, not poured,

When the syringe is sealed by the piston, the water is ...*not*... ..*poured*...... But, by the time the piston is removed, .*atmospheric*....*pressure*..... pushes the water and makes it ......*pour*....... outwards. Water is forced to eject due to existence of ...*air*.........

3. Complete the table according to your measurements. Use the words: **weak**, **moderate** or **strong** to describe the intensity of water.

Case	Position	Water intensity
1	A	*strong*
2	B	*moderate*
3	C	*weak*

4. Which factor affects the intensity of ejecting water? Use hydrostatic pressure formula to explain your answer.

$P = \rho \times g \times h$

The factor that affects the intensity of ejecting water is the height (h). With increasing depth the hydrostatic pressure increases. Thus intensity of ejected water increases too...

Learning about: **Fluid Dynamics**

Communicating Vessels

It is interesting that kettles use simple physics to indicate the amount of liquid which is left into the pod. Build your communicating vessels model to find out how kettles use this principle.

Discover:

- What are communicating vessels?
- How do communicating vessels work?

Level of Difficulty ★★★☆☆

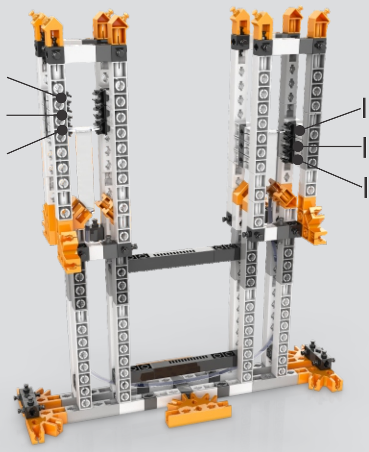
Materials Needed:
- Engino® Fluid Dynamics (STEM45).
- 15 ml of water.

Procedure:

1. Find the instructions online and build the **Communicating Vessels** model.

2. Remove the pistons from the syringes and complete **exercise 1**.

3. For **case 1** place one **syringe** on the **4th level** and the other one on the **3rd level** as it is shown below. Add half teaspoon (2.5 ml) of water into one **syringe**. Let the water settle and observe the water level into the two syringes.

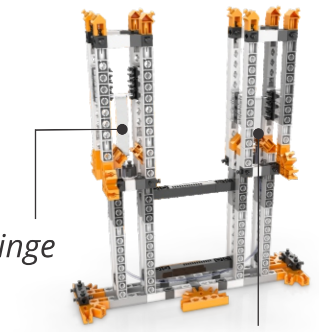


4. For **case 2** change the positions of the **first syringe** to **level 5** and of the **other** one to **level 2**. Levels are shown on the picture above. Observe the water level for this case.

5. Then, for **case 3** switch the position of the **first syringe** on **level 6** and of the **other** one on **level 1.** Recall your observations for all three cases and answer **exercises 2** and **3**.

6. Add another half teaspoon (2.5ml) of water into the **first syringe**. Observe again the level of water and answer **exercises 4** and **5.**

1. Join the two syringes with the rubber tubing and place them to the appropriate positions as shown on the image beside.



2. Do you observe something interesting about the level of water for all three cases? What is this?

The level of the water is the same for all three cases.........

....

3. Fill in the gaps below using the words from the box to write your conclusion.

always, atmospheric pressure, communicating vessels, level

The two syringes work as ...*communicating*....... ....*vessels*........ . The height of the water in the two syringes is ....*always*........ at the same ....*level*................ . This is because the ..*atmospheric*........ ..*pressure*.......... is equal in both sides.

4. What changes do you see when adding more water?

The height of the water is increased in both sides until it gets at the same level.....................

5. Will the level of water change if you use vessels of different shapes or sizes?

No, using vessels of different shapes or sizes will not affect the level of water.....................

Learning about: **Fluid Dynamics**

Siphon device

Siphons are used to empty liquids from tanks, that would otherwise be impossible or difficult to do. A fish tank is a great example of how siphon devices are used to refresh water.

Discover:
- What is a siphon device?
- How does the siphon device work?

Level of Difficulty ★★★★☆

Materials Needed:
- Engino® Fluid Dynamics (STEM45).
- 2 Plastic cups (see page 23).
- Water.

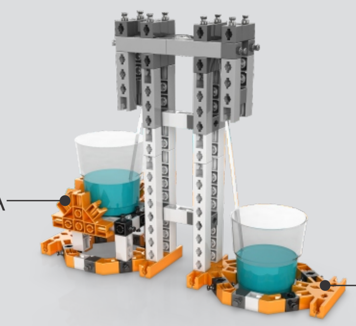
Procedure:

1. Find the instructions in **pages 23-28** and build the **Siphon Device** model.

2. Fill a plastic cup with water, until half full. You may use food colouring to observe better the water flow.

3. Place the plastic cup with water on **base A** and the empty one on **base B**. Place the nozzles of the rubber tubing into the plastic cups and do **exercise 1**.

4. Take the **syringe** and push its piston all the way inwards. Take the nozzle of the rubber tubing from the empty cup and join it with the syringe. Pull the piston outwards until the rubber tubing is fully filled with water. Make sure that **no air bubbles** are left into the tubing!



5. Carefully detach the syringe from the rubber tubing and **quickly** place the nozzle into the cup. Observe what is happening and notice the flowing direction of water. Then, answer **exercises 2** and **3**.

6. Empty both cups and fully fill cup A. Place the empty cup at base B. Repeat the experiment, as described in steps 4 and 5. Answer the questions of **exercises 4** and **5**

1. Is the water poured into the empty cup? Can you think of why is this happening?

The water is not poured into the empty cup. This is prevented due to the air inside the rubber tubing.

2. Fill the gaps of the following paragraph by using the words from the box.

flow, atmospheric pressure, air

While we fill the rubber tubing with water we also remove ......*air*......... . Thus, there is no .*atmospheric* .*pressure*... into the tubing. When the syringe is detached and the nozzle is placed into the cup the water starts to ..*flow*............

3. When does water flow stop? How much water is left in cup A?

Water flow stops as soon as no water is left in cup A.

4. How much water is left in cup A in this particular case?

Yes, some water is left in cup A. (Nearly a quarter or less)

5. When does water flow stop? Look at the water level on both cups. Do you notice any interesting facts?

Water flow stops as soon as the level of the water is the same in both cupr. The siphon device works as communicating vessels.

Learning about: **Fluid Dynamics**

Hydraulic Platform

How is it possible to lift up a car to change a flat tire? A hydraulic system is used to make this possible! Build this fascinating model to understand how you can lift heavy objects with little effort.

Discover:
- What does Pascal's law state?
- How can you easily lift up heavy objects?

Level of Difficulty ★★★★½

Materials Needed:
- Engino® Fluid Dynamics (STEM45).
- A plastic cup (see page 23).
- Pebbles.

Procedure:

1. Find the instructions online and build the **Hydraulic Platform** model.

2. Push the pistons of both syringes all the way inwards. Set the piston of the **first syringe** so that it indicates 5 ml on the readings of the syringe. Join one nozzle of the rubber tubing with the syringe.

3. Join the **other syringe** with the other nozzle of the rubber tubing. Push the piston of the **first syringe** inwards and do **exercise 1**.

4. Remove the tubing from the **first syringe**. Detatch the **other syringe** from your model and remove the tubing completely. Join one nozzle of the tubing to the **first syringe** and place it on the top of the model. It may need some push to fit properly.

5. Set the piston of the **other syringe** so that it indicates 2.5 ml. Join the other nozzle of the rubber tubing with the **syringe**. Now, press the piston of it and do **exercise 2**.

6. Fill the cup with small pebbles and place it onto the platform. Then **repeat the comparison** between pushing the two pistons by switching the two syringes as explained above. Answer the questions of **exercises 3, 4 and 5.**

1. What happens to the platform when you push the piston of the large syringe?

The platform is elevated when the piston is pushed.

2. Did you notice any difference in this case? Was it easier or more difficult to lift the platform?

Yes, there is a difference. It was easier to lift the platform in this case.

3. When having a cup full of pebbles on top of the platform, was it easier to lift the weight when pushing the large piston or the small one?

It was easier to lift the platform when pushing the small piston.

4. Think about the Pascal' s law and look at the formula shown below. How can you explain your answers in previous exercises?

$$F_2 = F_1 \times (A_2/A_1)$$

F_1 : the total weight
F_2 : the acting force
A_1 : area that weight acts onto
A_2 : area of exerted force

When, the area of exerted force is big, the force needed to lift the platform is more. Whereas, the area of exerted force is small, the applied force is less.

5. Fill the gaps of the following paragraph by using the words from the box.

hydraulic, area, amplify, smaller

A ...*hydraulic*..... machine is used to transmit pressure among its two sides. If the ....*area*...... of the acting force is ..*smaller*....... than the other, then it can ....*amplify*....... a force.

Learning about: **Fluid Dynamics**

Submarine

The first submarine was built in 1860 and could dive only 4 metres deep. Today, the advancements in technology enable submarines to dive up to 500 metres. Learn how they can dive into deep waters!

Discover:
- Why does buoyancy make a ship float?
- How do submarines change their buoyant force and immerse?

Level of Difficulty ★★★★☆

Materials Needed:
- Engino® Fluid Dynamics (STEM45).
- 2 Plastic bottles (see page 23) & some pebbles.
- Large sink filled with water

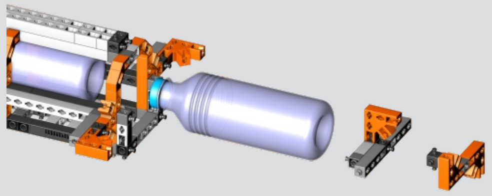
Procedure:

1. Find the instructions online and build the **Submarine** model.

2. To perform this activity it is essential to have a large sink filled with water. Make sure that the sink is large enough so that the model fits into it. Also, it is important that it has a depth larger than 50 cm.

3. Remember that **bottles have to be closed for all cases**. For the first experiment leave the model on the water surface and let it free. Observe whether it floats or not and answer the question of **exercise 1.**

4. Take your model out of the sink and remove the two bottles. The image below shows an easy way to achieve this.



5. Fill the two bottles with pebbles **up to a quarter**. It is important that you **do not add more pebbles** than suggested. Check the image on the right which shows the suggested amount.

6. Place the bottles back into the model and let it on water again. Answer the questions of **exercises 2** and **3**.

7. For the last experiment, keep the pebbles which are inside the two bottles and fill the rest with water. Place them back to the model and check whether it sinks or floats. Answer the question of **exercise 4.**

1. Does the submarine float or sink? Is the buoyant force larger or weaker than the model's weight?

The submarine floats. Thus, the buoyant force is larger than the model's weight.

2. When pebbles are added into the two bottles, does the submarine float?

When pebbles are added into the bottles the submarine still floats.

3. There are 4 different materials which are involved into this experiment. Can you name them? Can you also place them in order according to their density?

	Name of Material	High Density
1	*rocks/pebbles*	
2	*water*	
3	*plastic*	
4	*air*	Low Density

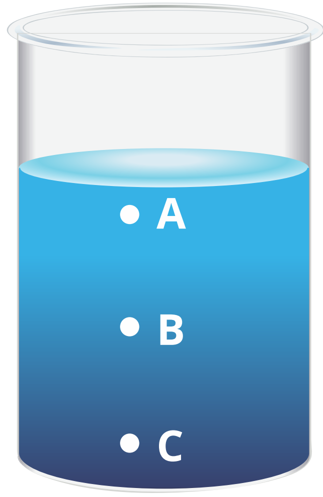
4. Does the model float or sink? Can you think of how submarines manage to dive into water when they are in mission and how they can raise back and float on the surface?

The model sinks. Submarines' vessels are fully fill with water in order to submerge. In order to raise back and float on the surface, these tanks are emptied from water and filled with air instead!

Quiz

Exercise 1

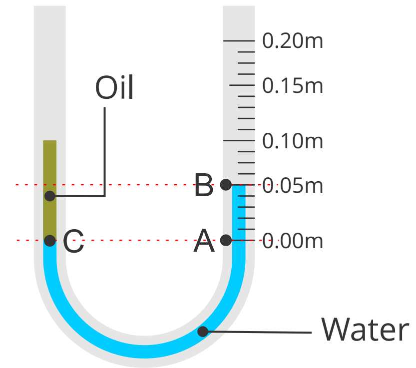
Which one of the 3 points has the more hydrostatic pressure? Explain your answer. **(points 2)**



Point C has more hydrostatic pressure since it is deeper than the other points. According to the the formula P = ρ x g x h the hydrostatic pressure and the height (depth) are interrelated. The deeper the point is, the more hydrostatic pressure is exerted on it.

Exercise 2

a) Measure the difference of water height among points A and B.
b) Calculate the hydrostatic pressure of the oil exerted at position C. It is given that the gravitational acceleration is $g=10m/s^2$ and the oil density is $\rho=900kg/m^3$. **(points 3)**



a) h (difference of water height) = 0.05m

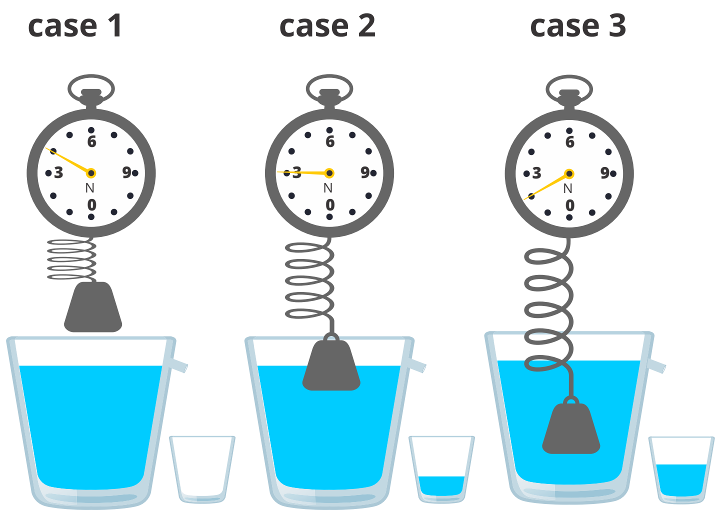
b) $P = \rho \times g \times h$

$= 900\ kg/m^3 \times 10\ m/s^2 \times 0.05\ m$

$= 450\ kg/m/s^2 = 450\ Pa$

Exercise 3 (points 5)

An object is weighed on a scale for three different cases. 1) Outside of water, 2) half immersed and 3) fully immersed.



a) For all 3 cases, fill the following table with the weight of the object (as indicated on the scale) and the weight of displaced water.

	Weight of object (Scale indication)	Weight of displaced water
CASE 1	*4N*	*0N*
CASE 2	*3N*	*1N*
CASE 3	*2N*	*2N*

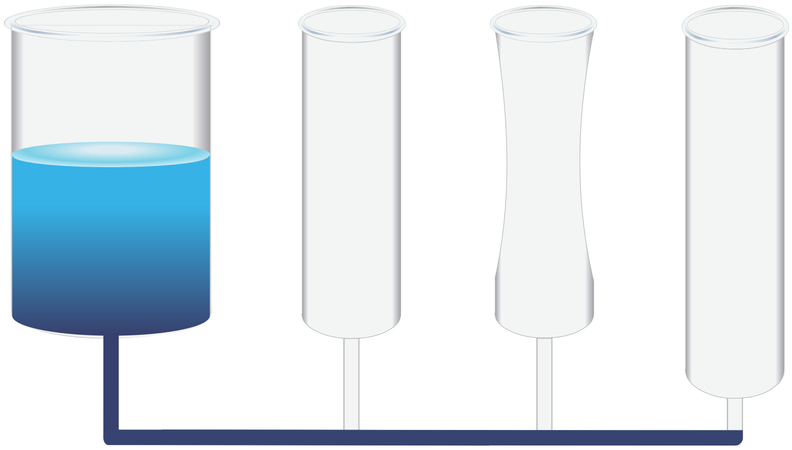
c) How much is the buoyant force for cases 2 and 3?

Case 2= *1N* N

Case 3= *2N* N

Exercise 4

a) Use your pencil to colour the level of the water in each of the three vessels. **(points 2)**



b) How are these vessels called? How do they work? **(points 2)**

These vessels are called "communicating vessels". The height of the water in the four vessels is at the same level. This is happening because the atmospheric pressure is equal in all four sides.

Exercise 5

a) A force of 500N is applied on the small piston (left one) which has an area of $0.2m^2$**.** Calculate the upwards force which is acted from the big piston, if it has an area of $5m^2$**. (points 4)**

$F_2 = ?$

$F_1 = 500N$

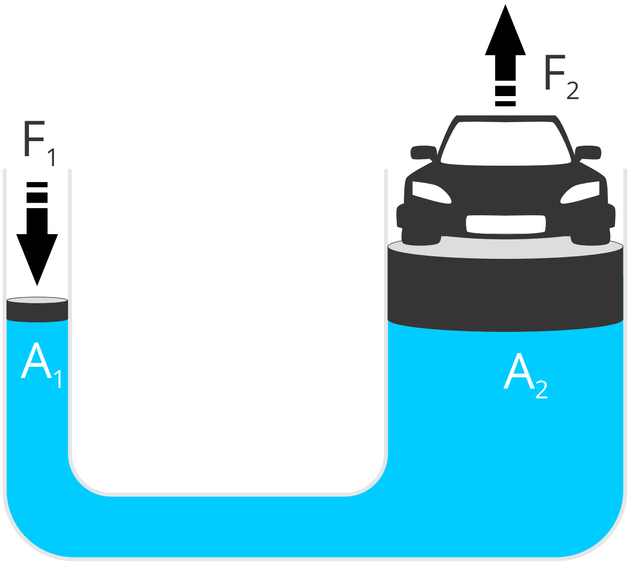
$A_2 = 5m^2$

$A_1 = 0.2m^2$

$F_2 = F_1 \times (A_2 / A_1)$

$= 500\ N \times (5\ m^2 / 0,2\ m^2)$

$= 12,500N$



a) Would such a configuration be able to lift up a car that weighs 10,000N and is placed on the big piston? Explain the reasons of your answer **(points 2)**

Yes, the above configuration will be able to lift up a car that weighs 10,000N, since from the above calculation we know that it can elevate objects weigh up to 12,500N.