Static fluids

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Videos and experimental support Gorazd Planinsic

Please rename yourself

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Link to all workshop files

February 2025/April 2024 Static Fluids

List of equipment

A plastic bottle with holes along a perimeter

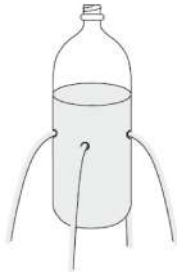
The same bottle with holes along the side and at the bottom (see the video)

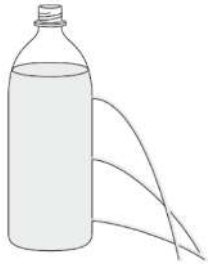
https://youtu.be/_-rqbLpfSho

An empty glass (wine glass is best, it needs to be transparent)

A bottle with vegetable oil (we need a little bit)

A pitcher with water





What should students know before Chapter 13 - Static Fluids?

Particle nature of matter

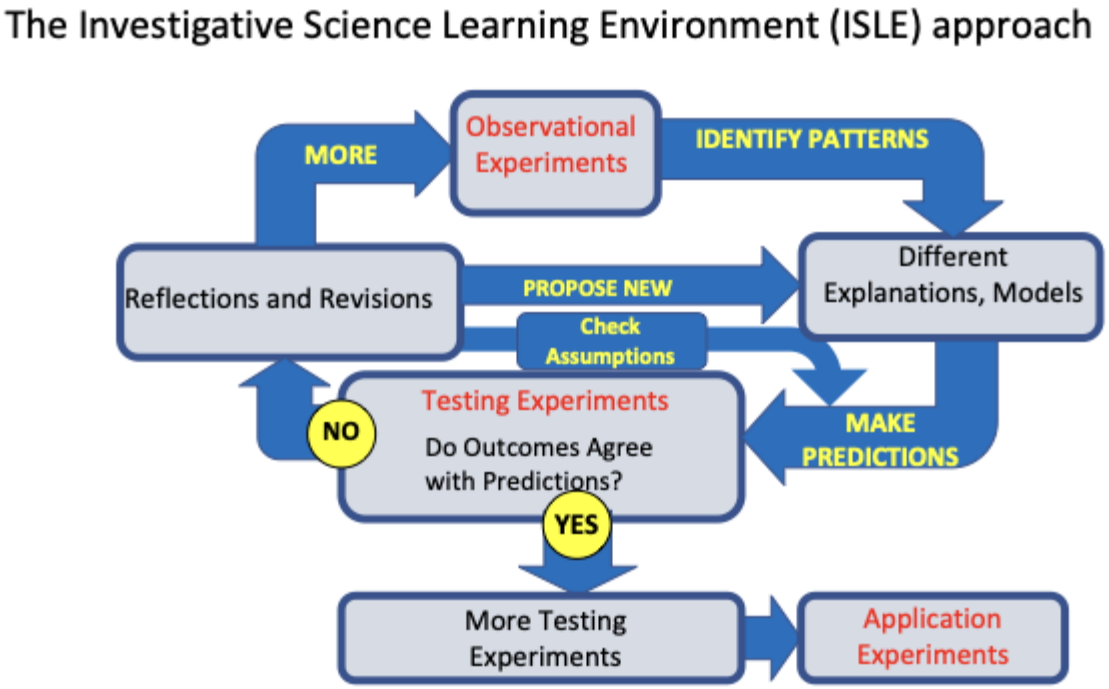
Pressure - operational definition (P=F/A) and cause-effect relationship (what affects the pressure)

Gas laws

All this is in Chapter 12 in the textbook and ALG/OALG

Operational definition of density as m/V - first section of Chapter 13

For those who are new to the ISLE approach



Etkina and Van Heuvelen, 2001, 2007; Etkina, 2015

Links to the folder and the documents with materials for today

February 2025/April 2024 Static Fluids

OALGChapter 13 Final.docx

Please open ALG/OALG for Chapter 13

Need to know 1

Use your closed plastic bottle with holes (filled with water) to open one hole at the bottom. Hold it by the top trying not to squeeze it. What do you observe?

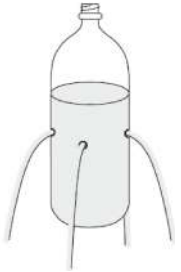
Now, open the other hole at the bottom. What do you observe?

Close both holes.

Now, open one of the holes on the side. What do you observe?

We will be able to explain this wild phenomenon soon.

All together



OALG 13.2.1 Observe and explain

Equipment: plastic bottle with small holes made around the circumference, a tray to collect water.

Use an opened 32-oz plastic bottle full of water that has been punctured in four places along the perimeter with thumbtacks (to make small holes, put pieces of Scotch tape first and then use the tacks to puncture the bottle). Hold the bottle about 1 m above the tray. Remove the thumbtacks from the bottle and observe the streams of water leaving the bottle.

Explain your observation using the concept of pressure.

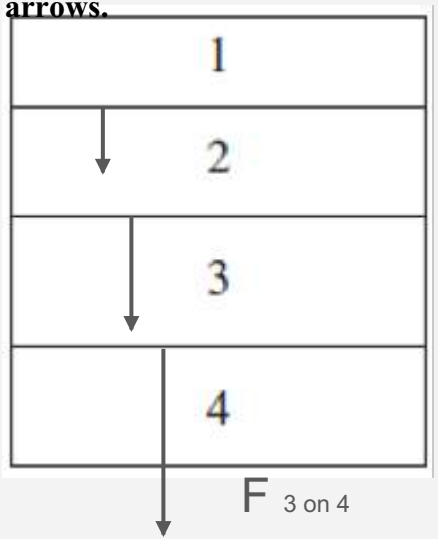
Pascal’s first law

What happens to the additional pressure exerted on the fluid?

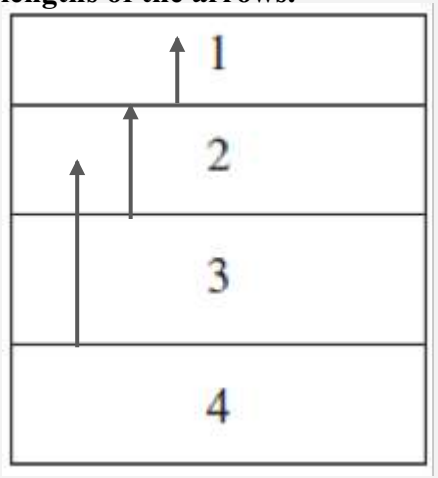
https://youtu.be/JUOWO5eH_iQ

Team 1 OALG 13.3.1 Read the text in the document OALGChapter 13 Final.docx

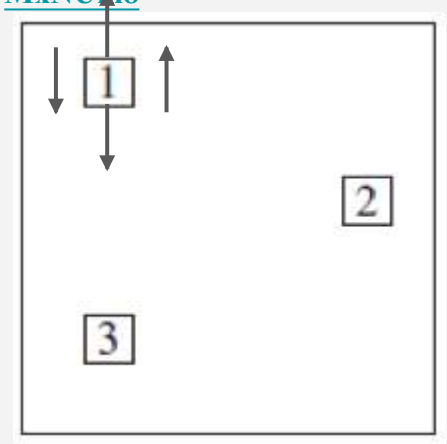
Draw force arrows to indicate the force that layer 1 exerts on layer 2, layer 2 exerts on layer 3, and layer 3 exerts on layer 4. Indicate the relative magnitudes of the forces by the lengths of the arrows.



Draw force arrows to indicate the force that layer 4 exerts on layer 3, layer 3 on layer 2, and layer 2 on layer 1. Indicate the relative magnitudes of the forces by the lengths of the arrows.



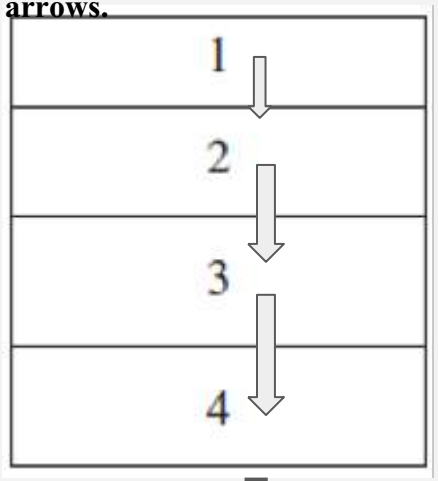
Draw arrows representing the pressure that the liquid exerts on very small surfaces inside the liquid shown below. Remember that liquids exert pressure in all directions. Check with https://www.youtube.com/watch?v=Y5ORCMxNUm8



Use the drawings in this table to help explain the observations of the experiment with the three thumbtacks.

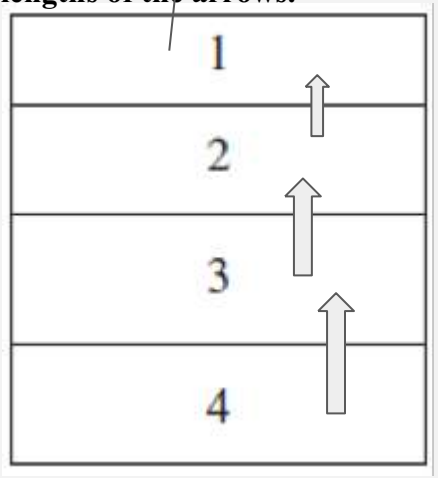
Team 2 OALG 13.3.1 Read the text in the document OALGChapter 13 Final.docx

Draw force arrows to indicate the force that layer 1 exerts on layer 2, layer 2 exerts on layer 3, and layer 3 exerts on layer 4. Indicate the relative magnitudes of the forces by the lengths of the arrows.



F 3 on 4

Draw force arrows to indicate the force that layer 4 exerts on layer 3, layer 3 on layer 2, and layer 2 on layer 1. Indicate the relative magnitudes of the forces by the lengths of the arrows.



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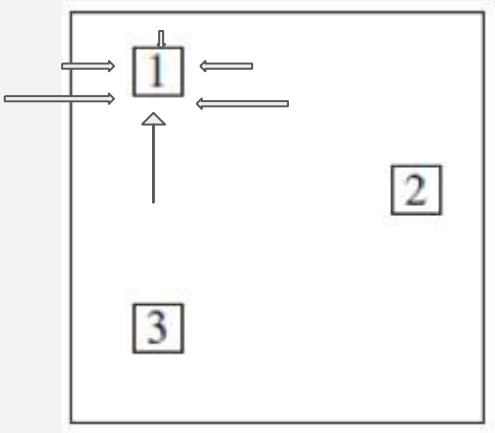

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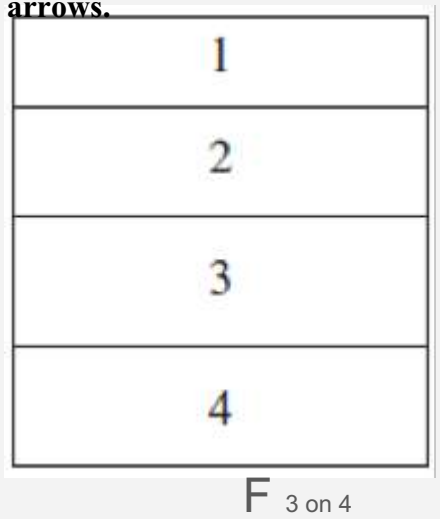
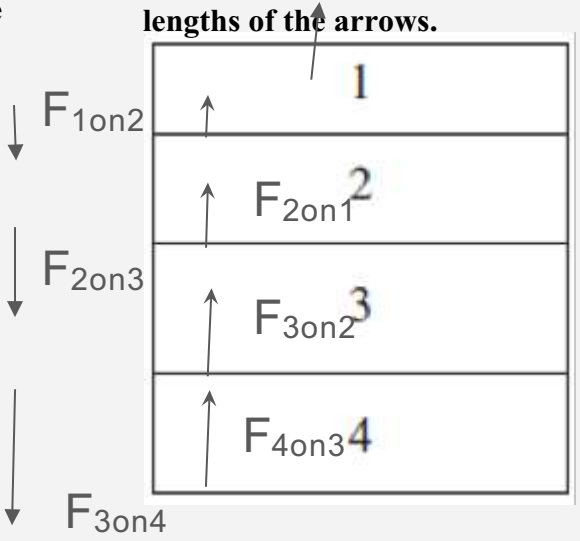
Team 3 OALG 13.3.1 Read the text in the document OALGChapter 13 Final.docx

Draw force arrows to indicate the force that layer 1 exerts on layer 2, layer 2 exerts on layer 3, and layer 3 exerts on layer 4. Indicate the relative magnitudes of the forces by the lengths of the arrows.



Draw force arrows to indicate the force that layer 4 exerts on layer 3, layer 3 on layer 2, and layer 2 on layer 1. Indicate the relative magnitudes of the forces by the lengths of the arrows.



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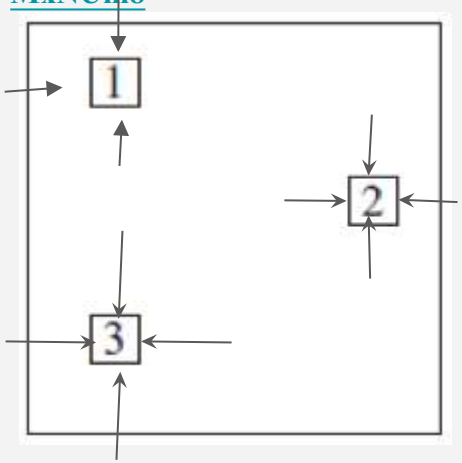


Use the drawings in this table to help explain the observations of the experiment with the three thumbtacks.

All together OALG 13.3.2

If the explanation you devised in the previous activity is correct, predict what will happen when you take the same bottle, **close** the lid, and then remove only the top and the bottom tack at the same time.

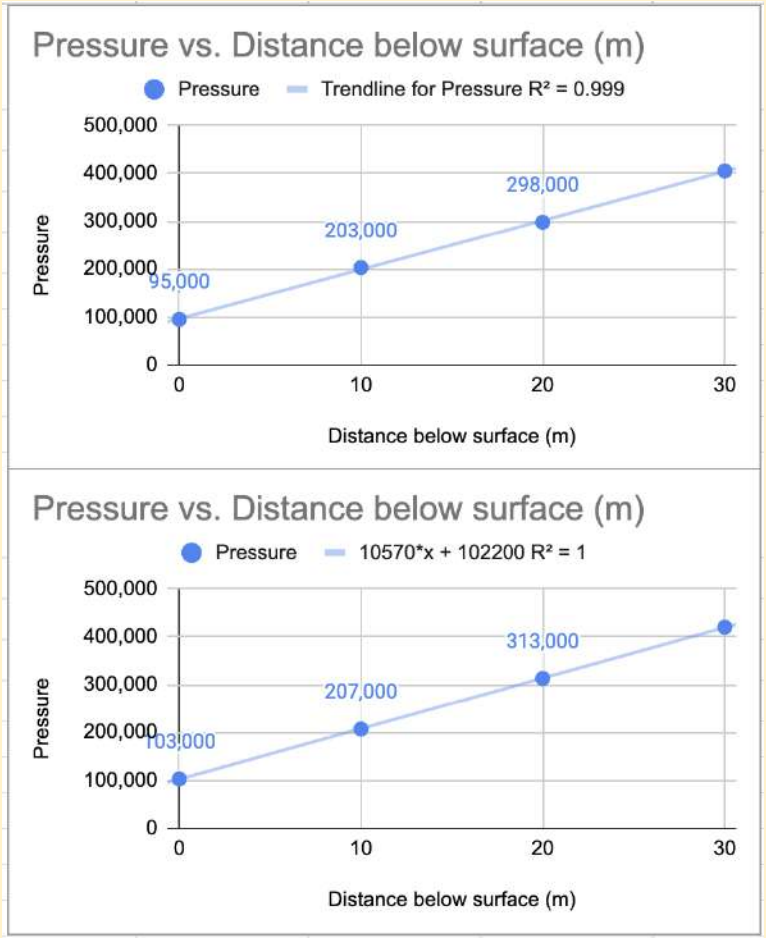
a. Predict the outcome.

b. Explain how you made your prediction.

c. Perform the experiment; record the outcome. Sketch what you observed.

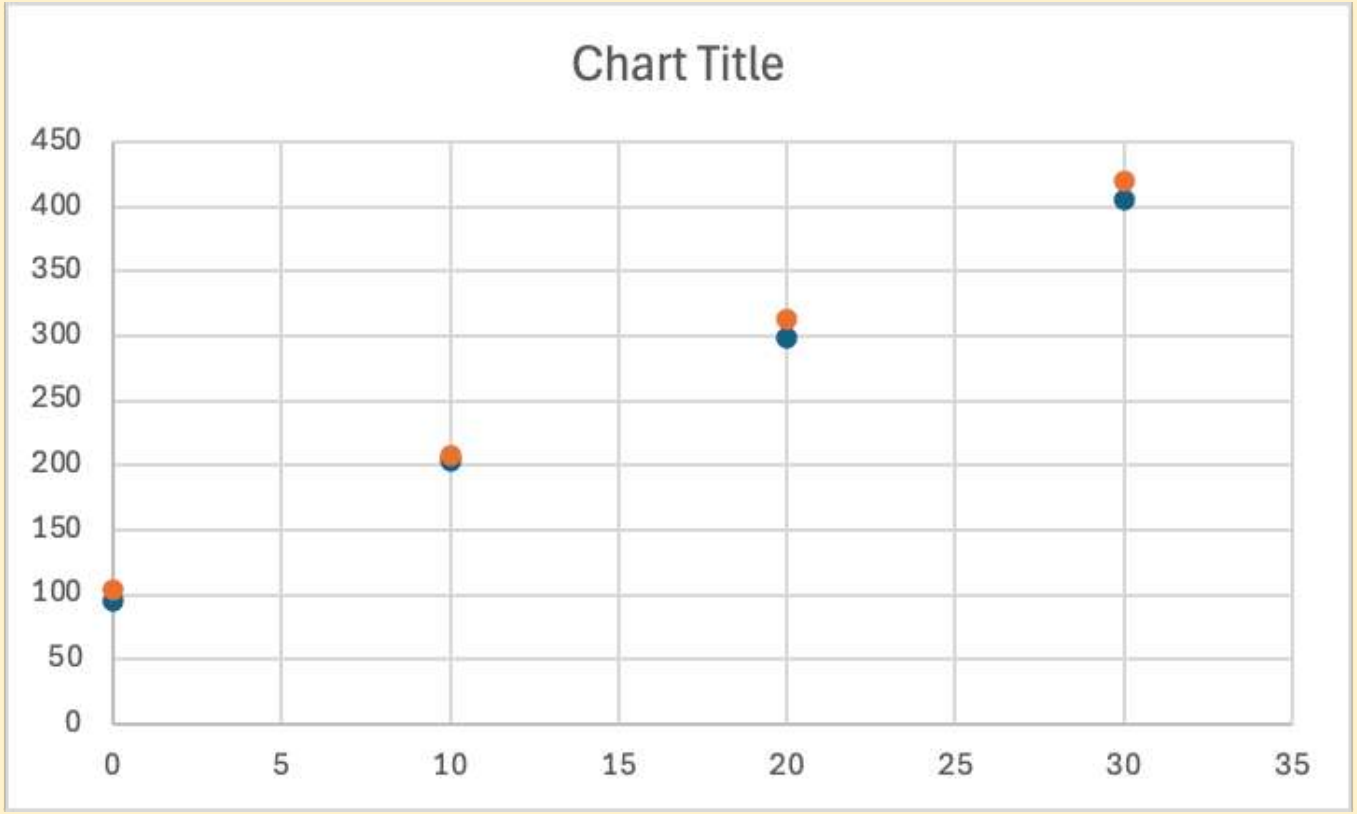
d. Do the results of your experiment allow you to reject or gain confidence in your explanation? Explain your reasoning.

Team 1 OALG 13.3.4 OALGChapter 13 Final.docx

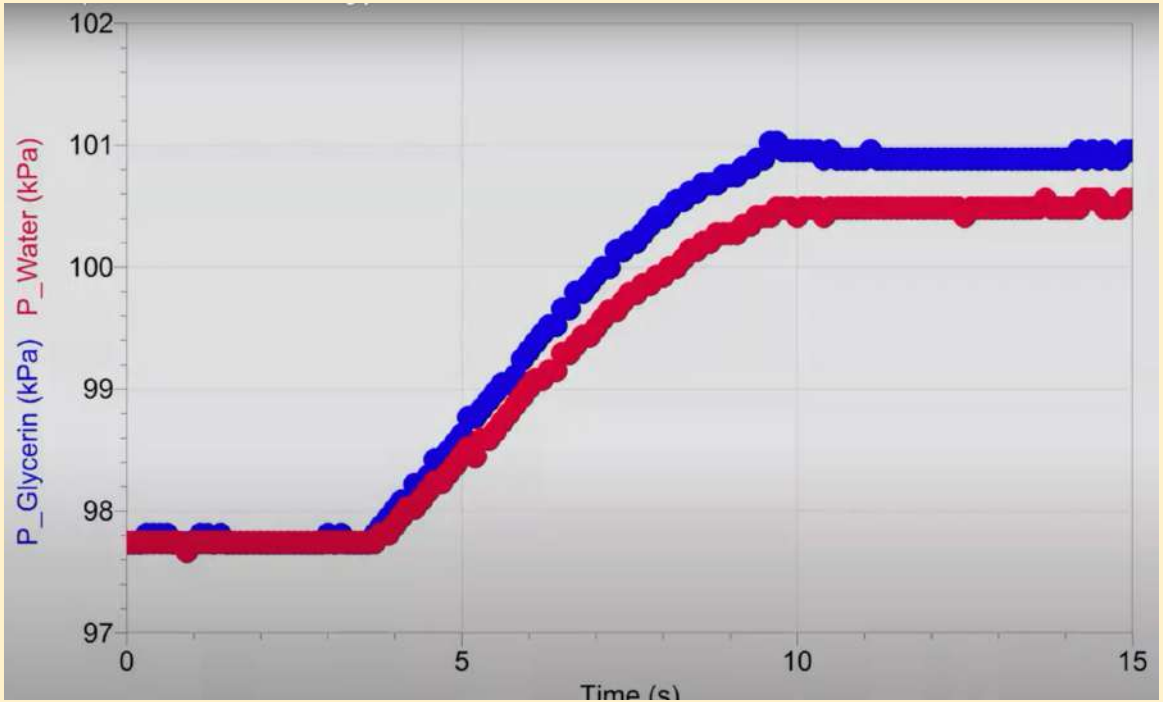


Team 2 OALG 13.3.4 OALGChapter 13 Final.docx

Team 3 OALG 13.3.4 OALGChapter 13 Final.docx



How is this experiment consistent with the data in the previous activity? https://youtu.be/Udp1ZyIMWok



All together - discuss but do not collect the data, see the graph on the next slide

OALG 13.3.6 Observe and explain (ALG 13.3.5)

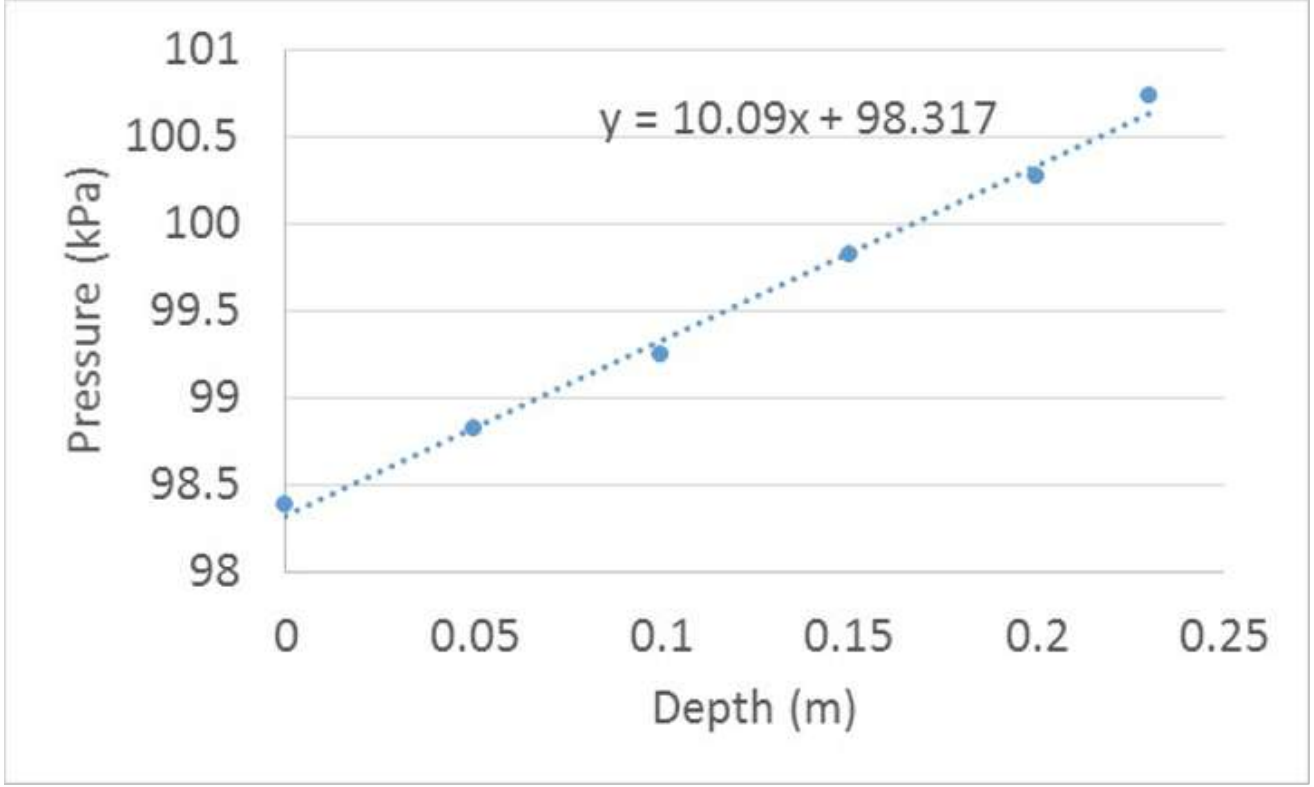
Watch the video of the experiment [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-13-3-5] and then proceed to the following questions.

a. Construct a graph of pressure versus depth. Describe which point on the set-up you used to determine the depth.

b. Based on the line of best fit for your graph, write a relation between pressure and the distance of the measuring point below the surface of the water.

c. Explain the relation.

d. *Explain why the height of the water column inside the plastic tube increases as the tube is lowered into the water. Suggest the physical law that you can use to predict the height of the water column inside the tube for a particular position of the tube. Indicate any assumptions that you made. Here you need gas laws*



How can we write the relation?

Team 1 OALG 13.3.7 here think of experiments that the students might do in class

YOU HAVE THE NEXT SLIDE TO PUT YOUR WORK ON

OALG 13.3.7 Test an idea

Equipment: to be determined in the activity.

Two of your friends disagree on how the pressure in a liquid depends on different physical quantities. Ari thinks that the pressure depends only on the depth—the deeper you go in the same liquid, the greater the pressure. Maria thinks that the mass of the liquid above the level at which one measures the pressure matters.

a. Discuss supporting arguments for Ari's and Maria's hypotheses.

b. In words and with a sketch describe an experiment that you can perform to find out whose idea can be ruled out. (Hint: you can perform an experiment similar to that in Activity 13.2.4 using different width water bottles)

c. Predict the outcome of the experiment based on each hypothesis.

d. Perform the experiment; record the outcome and decide whose hypothesis can be rejected.

Team 1

Team 2 OALG 13.3.7 here think of experiments that the students might do in class

YOU HAVE THE NEXT SLIDE TO PUT YOUR WORK ON

OALG 13.3.7 Test an idea

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Team 2

Team 3 OALG 13.3.7 here think of experiments that the students might do in class

YOU HAVE THE NEXT SLIDE TO PUT YOUR WORK ON

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Equipment: to be determined in the activity.

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c. Predict the outcome of the experiment based on each hypothesis.

d. Perform the experiment; record the outcome and decide whose hypothesis can be rejected.

Team 3

Testing a hypothesis means:

Accepting it temporarily as true

Design an experiment whose outcome I can predict using the hypothesis

Write down the prediction BEFORE doing experiment

Run the experiment and compare the outcome to the prediction

If they do not match it does not mean that the prediction was wrong, it means that the hypothesis could be wrong.

Great activity for the students but we will not do it here

OALG 13.3.9 Test an idea

In the video https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-13-3-9a the experimenter uses a 0.5 liter water bottle with the bottom cut off. In the bottle, there is a 5-mm diameter hole, about ¼ way down from the top. The hole is taped over with masking tape.

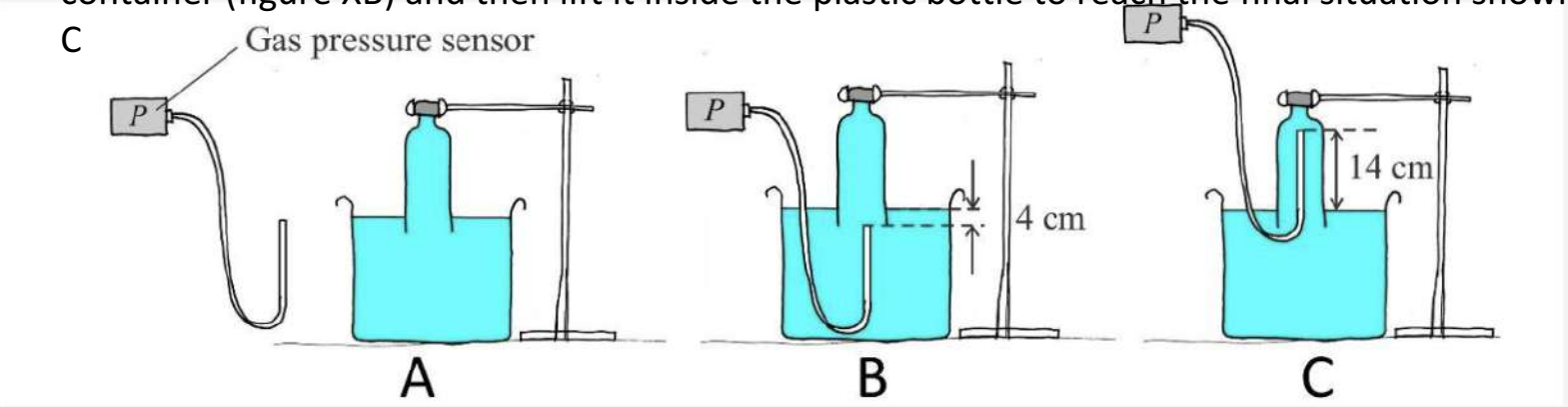
a. The bottle (without the cap) is placed into a container with water. The water level is above the taped hole). Watch the water level in the container and inside the bottle. Are they the same?

b. Now the experimenter will tightly close the bottle with the cap and lift the bottle up by holding it from the cap. The bottle does not completely leave the water. Observe what happens to the water level inside the bottle https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-13-3-9b. Explain. Use a pressure-vs-depth graph to justify your explanation.

c. Now, observe what happens when the experimenter removes the tape https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-13-3-9c. Explain. Justify your explanation by using the pressure-vs-depth graph.

Team 1

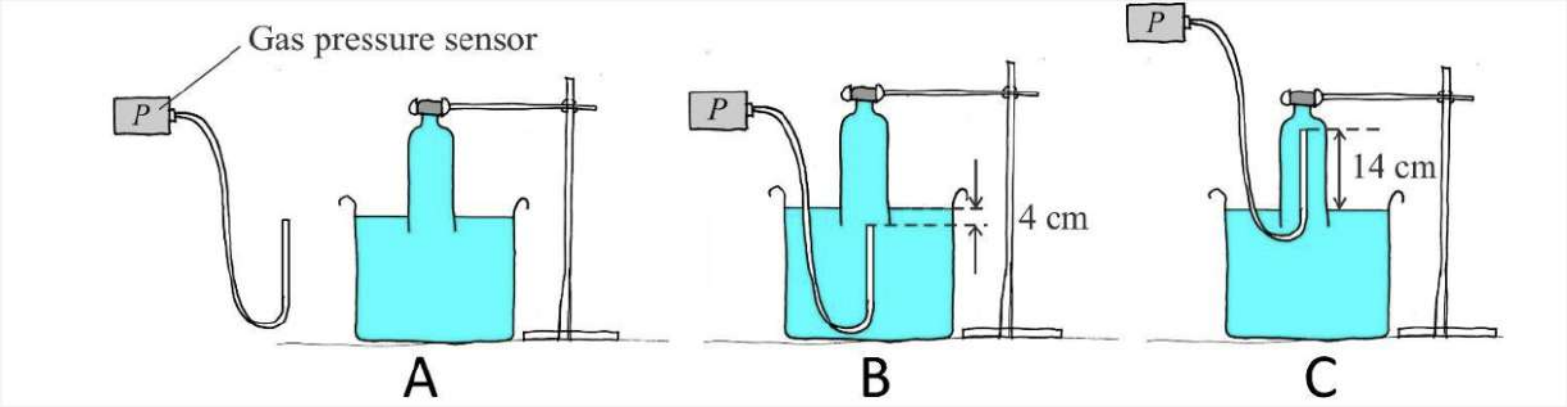
You have a plastic bottle with the bottom cut off and tightly sealed with a cap. The bottle contains water and is partly immersed in a large water container as shown in the figure below. You also have a gas-pressure sensor that is initially showing the ambient pressure. The sensor measures the pressure at the end of a tube that is connected to it. You first immerse the end of the tube into the larger container (figure XB) and then lift it inside the plastic bottle to reach the final situation shown in figure C



Compare the pressure readings in steps A, B, and C quantitatively. Assume that the ambient pressure outside water is 100.0 kPa. Explain your answers.

Team 2

You have a plastic bottle with the bottom cut off and tightly sealed with a cap. The bottle contains water and is partly immersed in a large water container as shown in the figure below. You also have a gas-pressure sensor that is initially showing the ambient pressure. The sensor measures the pressure at the end of a tube that is connected to it. You first immerse the end of the tube into the larger container (figure XB) and then lift it inside the plastic bottle to reach the final situation shown in figure C



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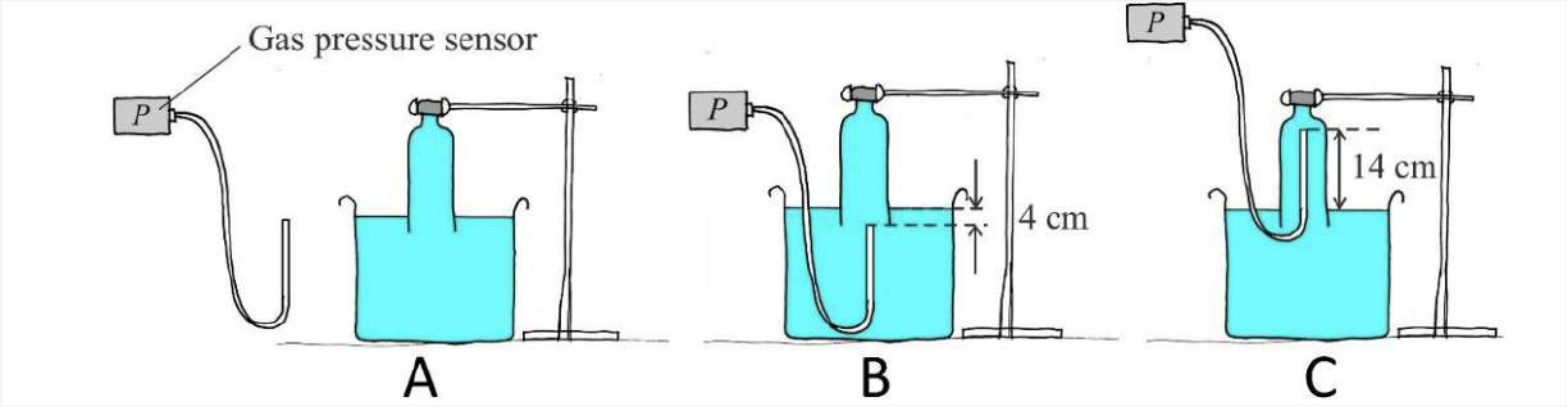

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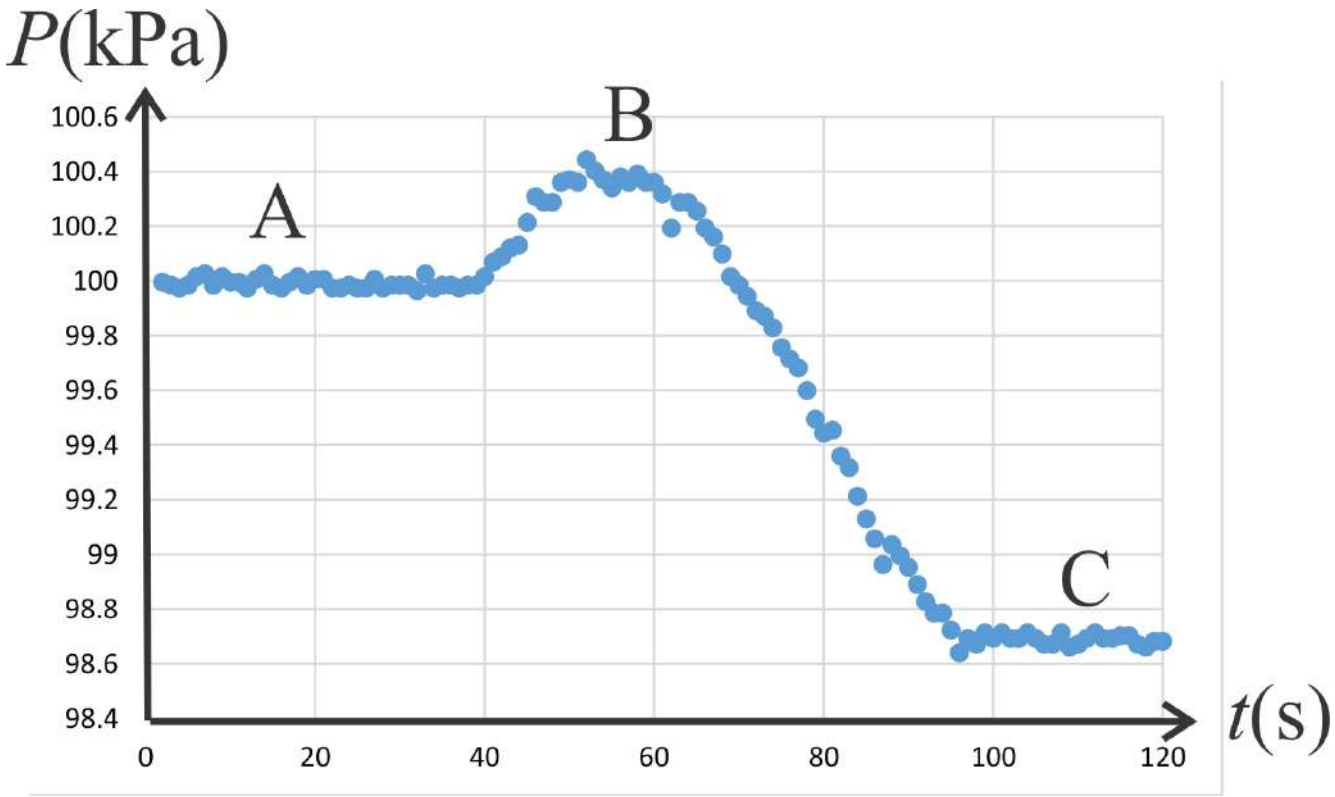

P(kPa)
100.6
100.4
100.2
100
99.8
99.6
99.4
99.2
99
98.8
98.6
98.4
A
B
C
0
20
40
60
80
100
120
t(s)

Why did we spend so much on hydrostatic pressure?

Need to know 2

Take a glass and pour some oil into it. Then add water. What do you observe?

For the next activity use the right part of the slide to write/draw. You can use the whiteboard and paste the screenshot or you can use the graphing tool for arrows here in the slides.

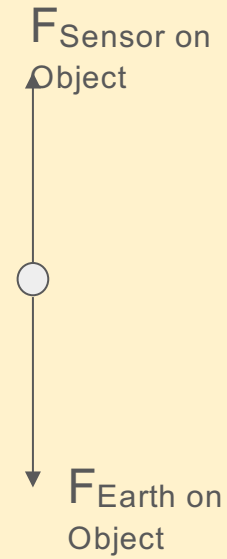
Team 1 OALG 13.5.1

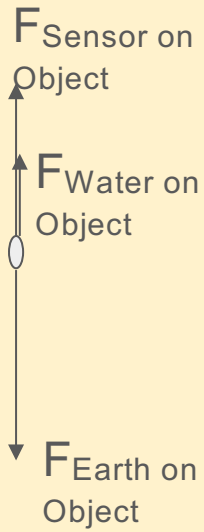
a. Observe the experiment https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-13-5-1 and make a list of patterns you notice.

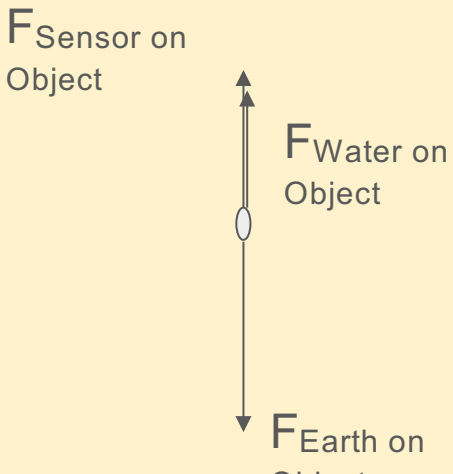
b. Draw force diagrams for the object above water, half submerged and totally submerged at two different depths.

c. What can you conclude about the force that water exerts on the object when it is totally submerged: does it increase with depth or stay constant? Devise an explanation for your conclusion.

The force that the water exerts on the object when it is totally submerged stays the same (does not change with depth).





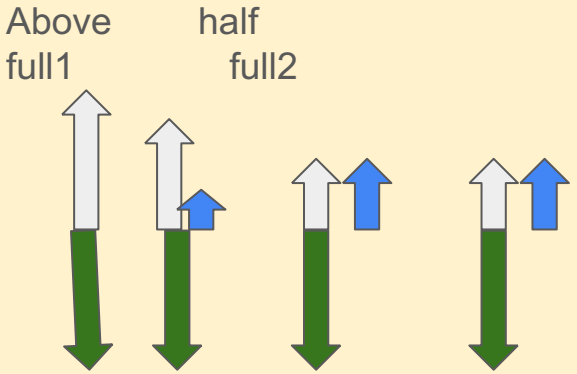


Team 2 OALG 13.5.1

a. Observe the experiment https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-13-5-1 and make a list of patterns you notice.

b. Draw force diagrams for the object above water, half submerged and totally submerged at two different depths.

c. What can you conclude about the force that water exerts on the object when it is totally submerged: does it increase with depth or stay constant? Devise an explanation for your conclusion. → **Since pressure increases with depth, we have greater pressure at the bottom of the object than higher up on the object, resulting in an apparent upward force from the water on the object. Since the pressure-depth function is linear, the pressure differential between the top and bottom of the object (once fully submerged) is always the same.**



Gray $F_{String\ on\ Object}$

Green $F_{Earth\ on\ Object}$

Blue $F_{Water\ on\ Object}$

Team 3 OALG 13.5.1

a. Observe the experiment https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-13-5-1 and make a list of patterns you notice.

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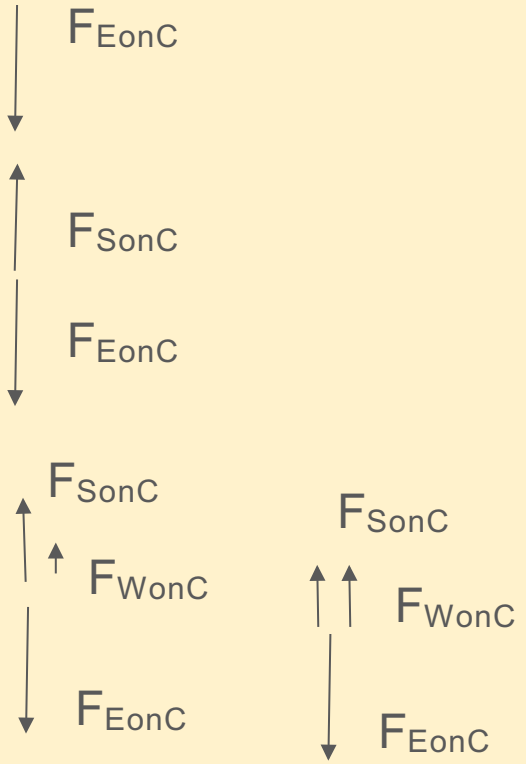


Team 1 OALG 13.5.2 OALGChapter 13 Final.docx

The magnitude of the upward force that the water exerts on each block is the same when equal volumes of each block are submerged in the water.

Force that water exerts on a submerged object is equal in magnitude to the force that Earth exerts on the water in the volume that was displaced.

Team 2 OALG 13.5.2 OALGChapter 13 Final.docx

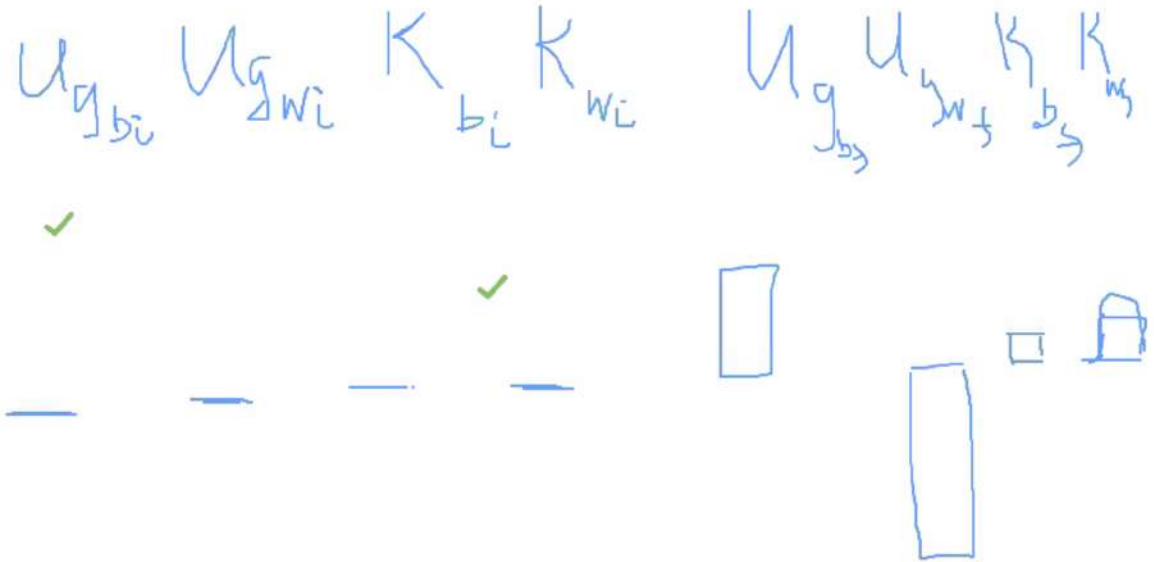
a. $F_{\text{Water on Block}} = F_{\text{Earth on Displaced Water}}$

So, this means it must depend on the density OF THE LIQUID.

Team 3 OALG 13.5.2 OALGChapter 13 Final.docx

https://www.youtube.com/watch?v=ODlBug8fI_Y

Draw a work-energy bar chart for the second experiment. The system is the ball, water, and Earth. The Initial state is when the ball is under water, the final state is when the ball is moving up *in water* in a considerable speed.



All together 13.5.3 and 13.5.4 OALGChapter 13 Final.docx

Force that fluid exerts on a submerged object = F Earth on displaced fluid = mg = density of the fluid times the volume displaced times g (gravit constant)

Team 1 OALG 13.5.6 OALGChapter 13 Final.docx

Team 2 OALG 13.5.6 OALGChapter 13 Final.docx

Team 3 OALG 13.5.6 OALGChapter 13 Final.docx

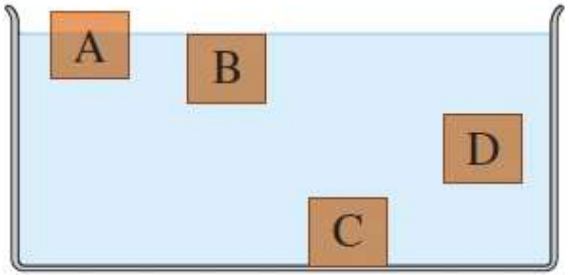
Team 4 OALG 13.5.6 OALGChapter 13 Final.docx

All together Work-energy problem Work Energy Fluids.docx

Team 1

59. * You have four objects at rest, each of the same volume. Object A is partially submerged, and objects B, C, and D are totally submerged in the same container of liquid, as shown in **Figure P13.59**. Draw a force diagram for each object. Rank the densities of the objects from least to greatest and indicate whether any objects have the same density.

FIGURE P13.59

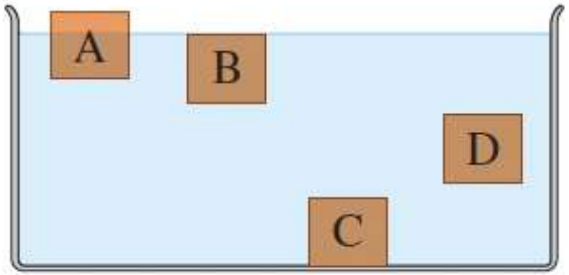


Team 2

59. * You have four objects at rest, each of the same volume. Object A is partially submerged, and objects B, C, and D are totally submerged in the same container of liquid, as shown in **Figure P13.59**. Draw a force diagram for each object. Rank the densities of the objects from least to greatest and indicate whether any objects have the same density.

A, B/D, C

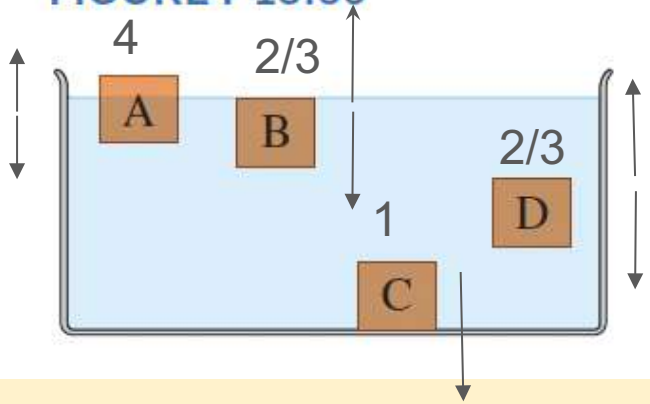
FIGURE P13.59



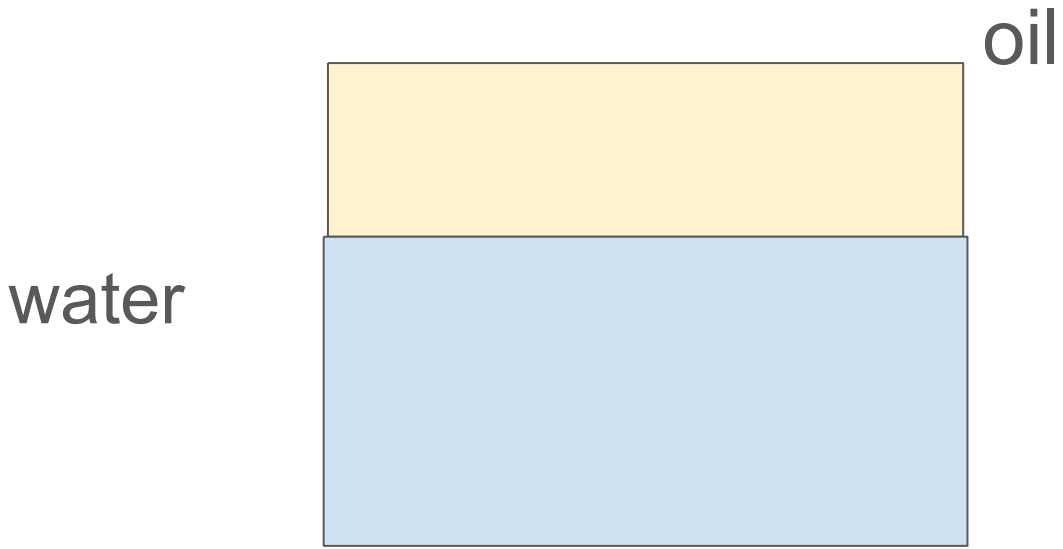
Team 3

59. * You have four objects at rest, each of the same volume. Object A is partially submerged, and objects B, C, and D are totally submerged in the same container of liquid, as shown in **Figure P13.59**. Draw a force diagram for each object. Rank the densities of the objects from least to greatest and indicate whether any objects have the same density.

FIGURE P13.59



Return to the need to know 2 - Why is oil always on top?



If time permits OALG 13.6.6

What did you learn today?

beyond purely scientific deductions, today I was encouraged in the possibility of learning through direct personal experience even out of lesson experiments; for ex., I remember what happens to me when I swim in the sea and I remember now this experience in a different way, not only in a emotional way of remembering, also in a scientific way of thinking… that make me more curious, more careful to how understand the things of the world in a wider way

I learned a lot. My head is full. Thank you. I realized that what we show to our students is important.

Experiments in which we also see measurements.
Analysis of data that we can use in class.

The inverted bottle is very thought provoking, and also I saw experiments that I can use to demonstrate projectile motion

Better understanding of how density and volume and depth relate to buoyant forces and weight of displaced water

Activity of analyzing the pressure in water pulled upward helps ensure that we truly understand how pressure varies with pressure.
Why the water doesn't come out of a hole helps reinforce the mechanical thinking that students should already have developed.