Static fluids

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Videos by G. Planinsic

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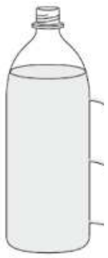
List of equipment



A plastic bottle with holes along a perimeter

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

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

Links to the folder and the documents with materials for today

E@AP Fluids Workshop April 2024

Please open ALG/OALG for Chapter 13

1st need to know

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?

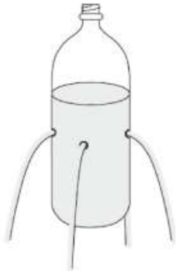
Now, open the other hole at the bottom. What do you observe?

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

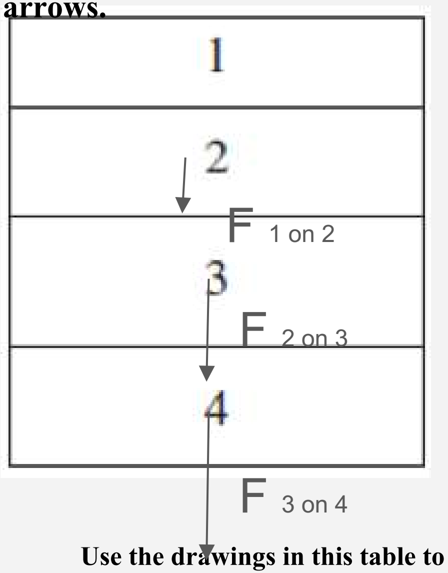
Equipment: plastic bottle with small holes made around the circumference, a tray to collect water.

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.

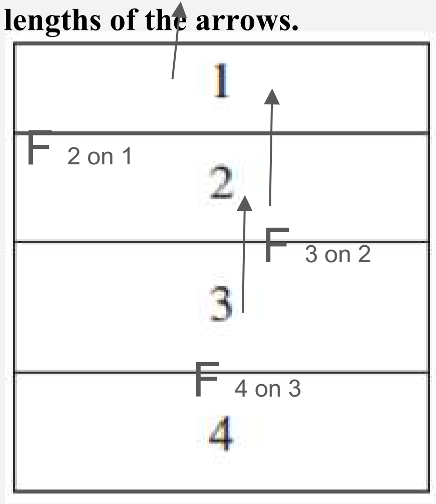
Explain your observation using the concept of pressure.

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

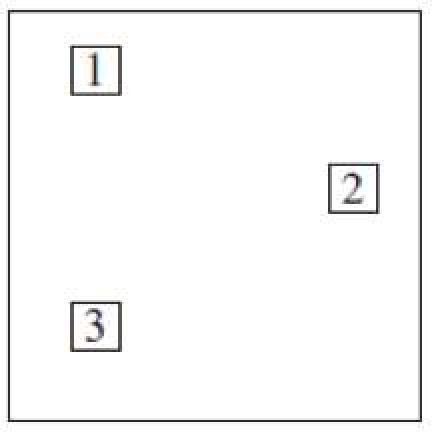
Draw force arrows to indicate the force that layer 1 exerts on layer 2, layer 2 exerts on layer 3, and layer 3 exerts on layer 4. Indicate the relative magnitudes of the forces by the lengths of the arrows.



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.



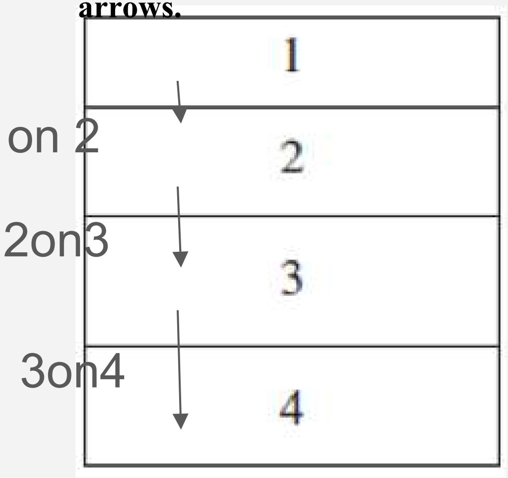
Draw arrows representing the pressure that the liquid exerts on very small surfaces inside the liquid shown below. Remember that liquids exert pressure in all directions. Check with https://www.youtube.com/watch?v=Y5ORCMxNUm8



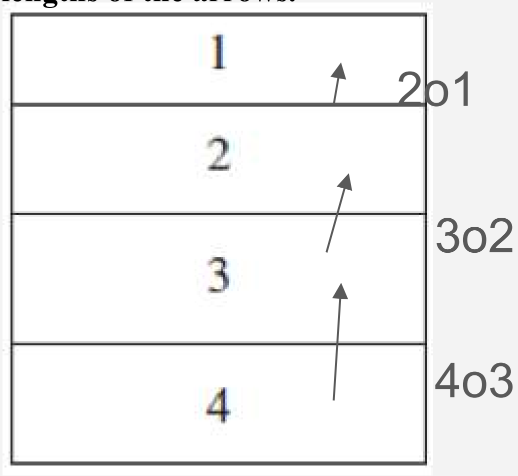
Use the drawings in this table to help explain the observations of the experiment with the three thumbtacks.

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.



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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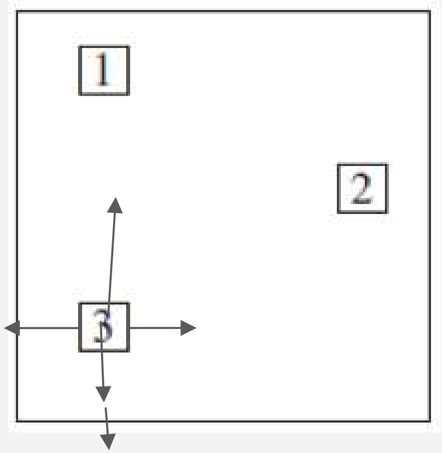

Use the drawings in this table to help explain the observations of the experiment with the three thumbtacks.

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

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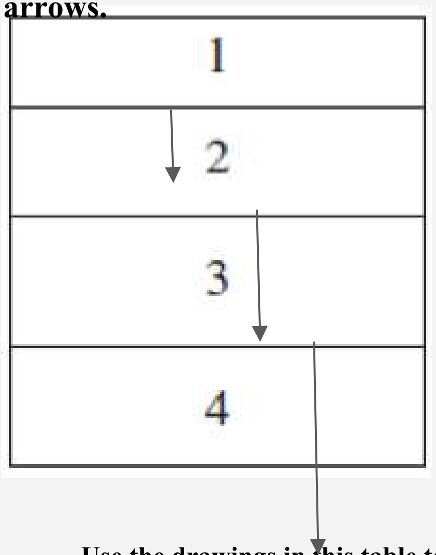
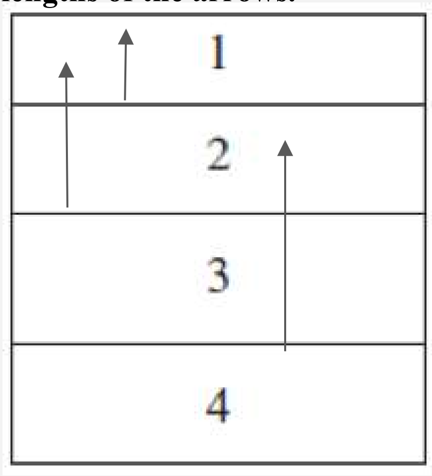


Draw force arrows to indicate the force that layer 4 exerts on layer 3, layer 3 on layer 2, and layer 2 on layer 1. Indicate the relative magnitudes of the forces by the lengths of the arrows.



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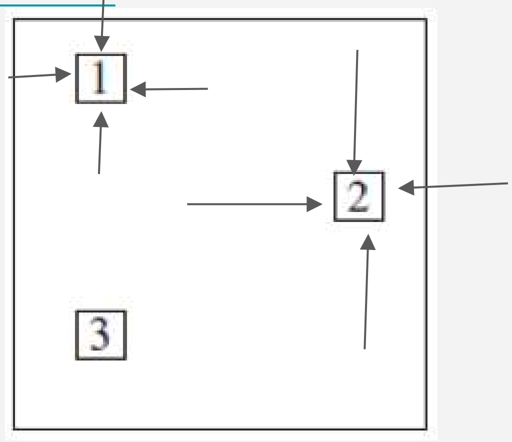
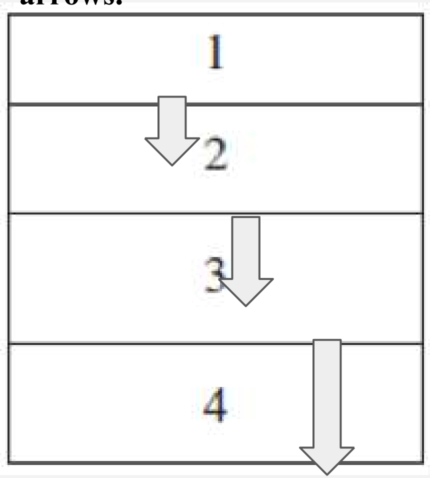


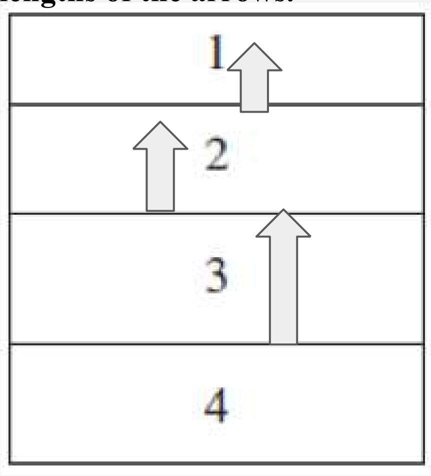
Use the drawings in this table to help explain the observations of the experiment with the three thumbtacks.

Team 4 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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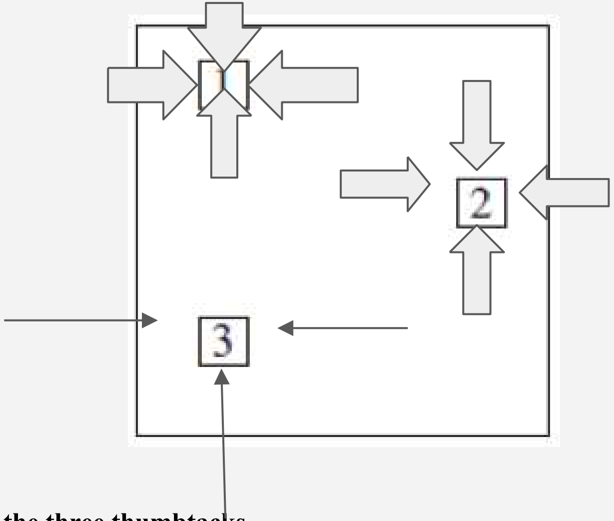


Use the drawings in this table to help explain the observations of the experiment with the three thumbtacks.

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.

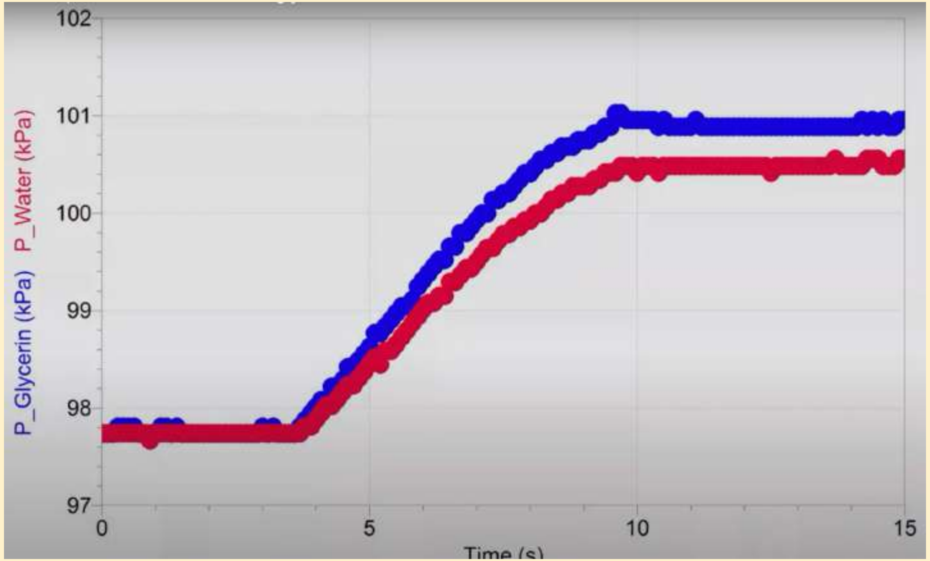
b. Explain how you made your prediction.

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 [OAL Chapter 13 Final.docx]

supporting video, different environment https://youtu.be/Udp1ZyIMWok



(blu) P2-P1=(101 kPa-98.5 kPa)/

Different value of pressure at the end

blu one has a higher slope

Team 2 OALG 13.3.4 OALGChapter 13 Final.docx

supporting video, different environment https://youtu.be/Udp1ZyIMWok

Pressure	Distance below surface (m)
103,000	0
207,000	10
313,000	20
420,000	30

Ocean Water pressure 1027 kg/m3

Linear relationship between pressure and depth with liquids at different densities

Team 3 OALG 13.3.4 OALGChapter 13 Final.docx

supporting video, different environment https://youtu.be/Udp1ZyIMWok

Density has an impact on pressure as well as depth.

Glycerin pressure increases more with depth.

Team 4 OALG 13.3.4 OALGChapter 13 Final.docx

supporting video, different environment https://youtu.be/Udp1ZyIMWok

Increased density increases pressure at the same depth.

Glycerin is more dense than water.

Pressure increases as probes are lowered below the surface of the liquids.

Steadily lowering the probes (measuring at the same depth) shows a lower gradient for water than glycerin.

Atmospheric pressure is transmitted through the fluid and adds to the fluid pressure.

All together - discuss but do not collect the data

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.

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 1

- Use different width vessels (differente horizontal cross section). For example: graduated cylinder vs a tall beaker, if there is access to a pressure meter.
- (c) Or plastic bottles with different diameters (1L and 2L). If only the depth influences the pressure then the stream would be the same at the same depth for the different bottles. If the amount of water influences pressure then the stream for the larger diameter bottle would be longer.
-

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

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

What does it mean to have a testing experiment?

a) We can test with different size containers Compare a swimming pool to the ocean, if the area matters, no one could swim in the ocean.	
c)	

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

OALG 13.3.7 Test an idea

Equipment: to be determined in the activity.

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Team 3

- Use different width vessels (differente horizontal cross section). For example: graduated cylinder vs a tall beaker, if there is access to a pressure meter.
- (c) Or plastic bottles with different diameters (1L and 2L). **If** only the depth influences the pressure **then** the stream would be the same at the same depth for the different bottles. If the amount of water influences pressure then the stream for the larger diameter bottle would be longer.

Team 4 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.

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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.

Experiment - Use two bottles with a different diameter and pull out two pins at the same level. Open the bottle. Watch what happens. Measure how far the stream travels away from the bottle.

If Ari is right, both will travel the same distance. If Maria is right the larger diameter bottle will travel further.

Predicted outcome - both bottles will have fluid that travels the same distance. (Why? As the diameter of the bottle increases, the area that the force is exerted on also increases. This means that the pressure is independent of diameter.

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.

Why did we spend so much on hydrostatic pressure?

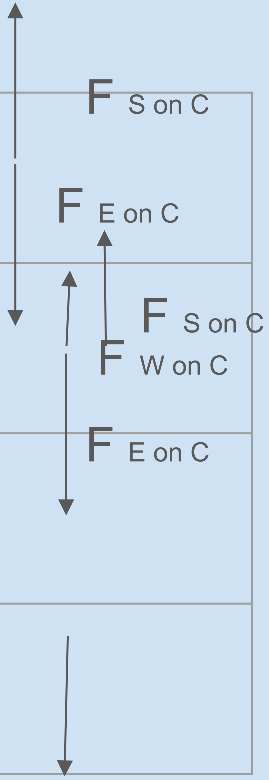
P = p atm + rho g h

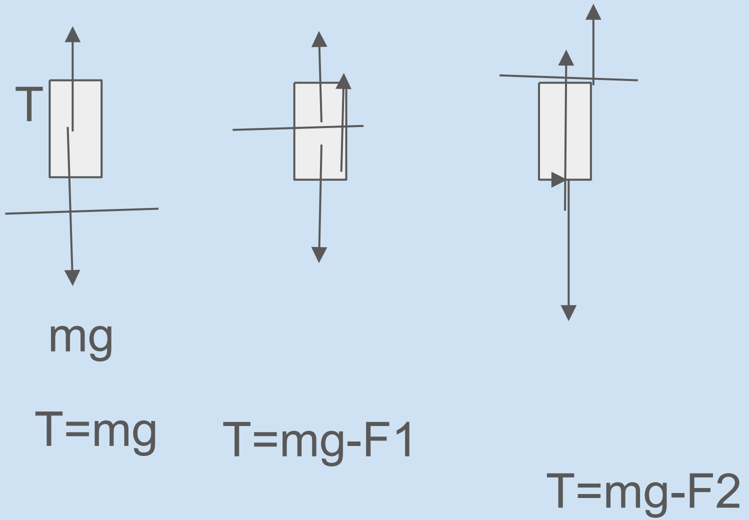
Need to know 2

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

Team 1 OALG 13.5.1 and 13.5.2 [OALGChapter 13 Final.docx]

1. Above water
2. half submerged
3. Totally submerge ad h1
4. 4. . Totally submerge ad h2





13.5.2 team 1

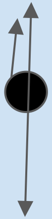
Team 2 OALG 13.5.1 and 13.5.2 [OALGChapter 13 Final.docx]

B = block, W = water, e = earth

F spring on block

Fe o B

F_{wb}

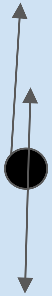


F_{sB} force of spring on block

$F_{E\ on\ B}$ force of earth on block

13.5.2 the force depends on $\rho_B - \rho_W$

F_{w} B



F_{sB} force of spring on block

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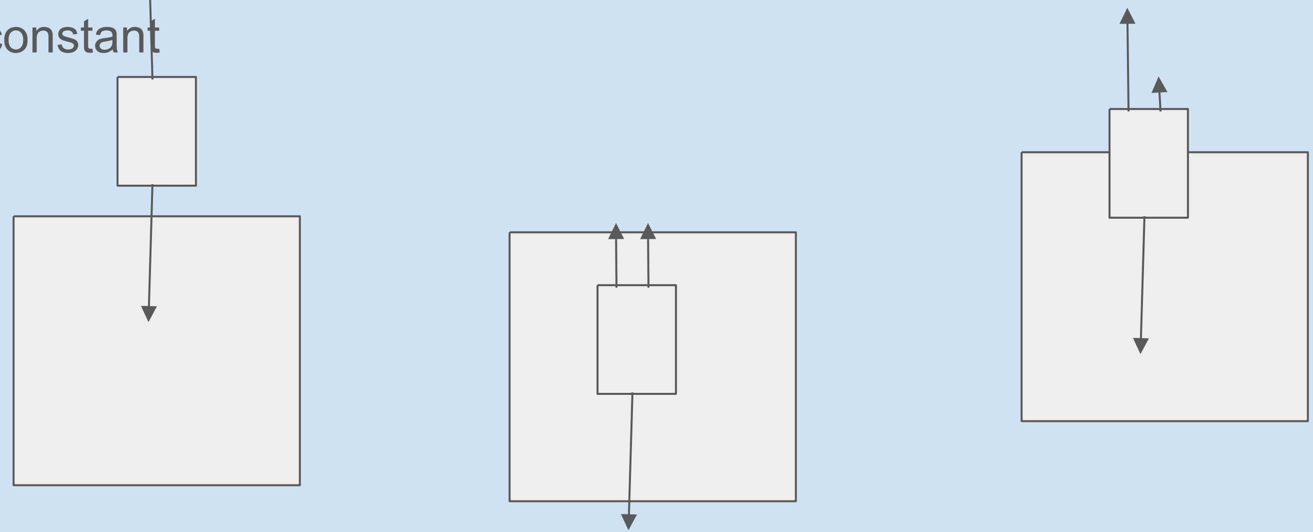
Team 3 OALG 13.5.1 and 13.5.2 OAL Chapter 13 Final.docx

Team 4 OALG 13.5.1 and 13.5.2 OALGChapter 13 Final.docx

5.1: Patterns - gradual increase in force as the person lifts the object - top horizontal line is full weight - measured force decreases as the object is lowered into the liquid - once the object is fully submerged, the measured force remains constant



https://www.youtube.com/watch?v=ODIBug8fI_Y

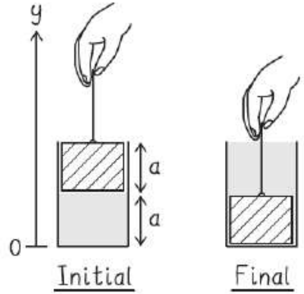
Draw a work-energy bar chart for the second experiment. The system is the ball, water, and Earth. The Initial state is when the ball is under water, the final state is when the ball is moving up in water in a considerable speed.

https://www.youtube.com/watch?v=Cb1P7V1JrL4

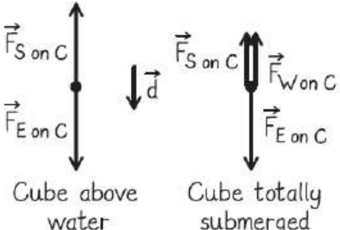
CONCEPTUAL EXERCISE 13.6 Qualitative force and energy analysis for an object in a fluid

You hang a solid metal cube (with side a) by a string over a rectangular container filled with water up to height a. The cube barely fits inside the container. Starting when the cube is just above the water in the container, you very slowly lower the cube into the water until it is totally submerged. Represent this process by drawing force diagrams for the cube when it is above the water and when it is totally submerged. Also draw an energy bar chart for the cube, Earth, and the water as the system for those states.

Sketch and translate We draw a sketch of the situation; the system and the initial and final states are specified in the problem statement. The submerged cube displaces water that is now above the cube. The volumes of the cube and water are the same, but the water has less mass due to its smaller density.

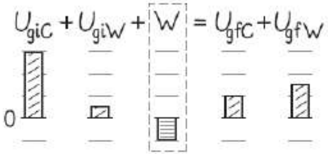


Simplify and diagram Because you are moving the cube very slowly, we can neglect the kinetic energy of the cube and the water in this process. We also assume that the cube has no acceleration during this motion and all friction effects are



we show the three forces exerted by the three objects with which the cube interacts: Earth, the water, and the string. Because there is no acceleration, the sum of the forces is zero.

The string does negative work on the cube because the force it exerts on the cube points opposite to the cube's displacement. Given that both water and the cube interact with Earth, we consider the gravitational potential energies of these interactions separately. We take zero gravitational potential energy to be at the bottom of the container. In the initial state, the system has initial gravitational potential energy due to the location of the cube and water. The gravitational potential energy of cube-Earth interaction decreases as the cube moves down; the gravitational potential energy of water-Earth interaction increases as some water moves up (being replaced by the cube). However, the total gravitational potential energy of the system must decrease due to the negative work done by the string.



Try it yourself Draw the bar charts for the two states, choosing the cube and Earth as a system.

Answer

All together 13.5.3 and 13.5.4 OALGChapter 13 Final.docx

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]

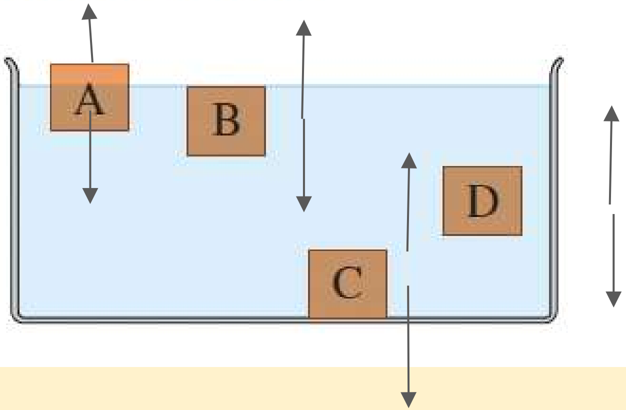
Team 4 OALG 13.5.6 OALGChapter 13 Final.docx

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.

dA < dW
dB = dW=
dC > dW
dD = dW

FIGURE P13.59



Buoyant force
For B, C and D, is the same
Instead for A is lower

Team 2

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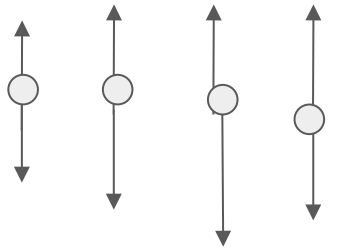
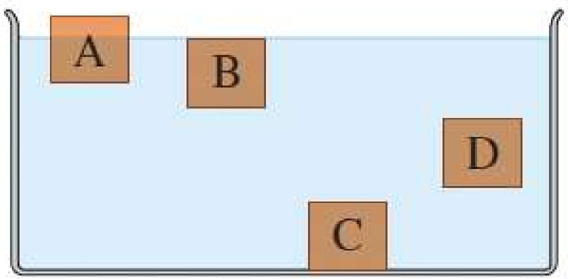


A B C D

$\rho A < \rho B = \rho D = \rho f < \rho C$

FIGURE P13.59



Team 3

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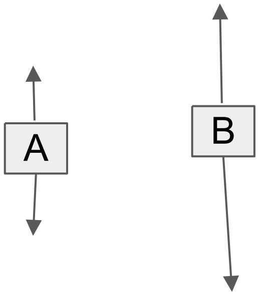
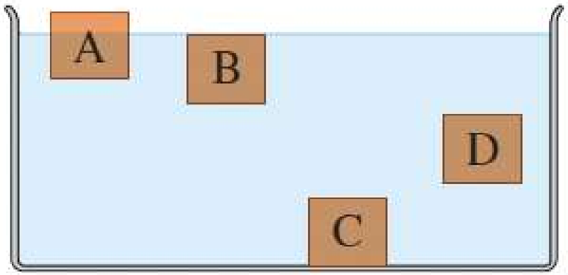
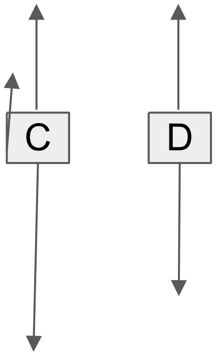


FIGURE P13.59

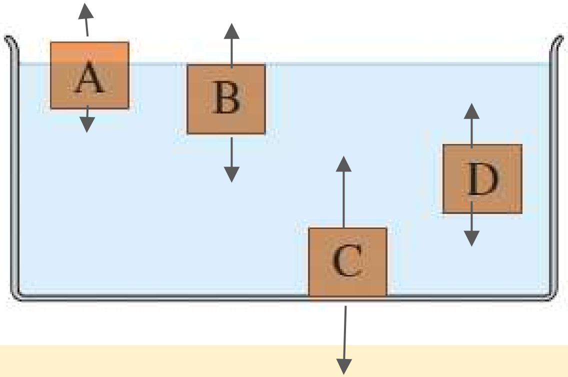




Team 4

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

If time permits Team 13.6.6 OALGChapter 13 Final.docx

What did you learn today?

Importance of teaching gases, density of air, pressure, pressure prior to teaching fluids, then elegant way to explain buoyancy

Concepts working together: forces, energy

I also appreciated the super short videos of experiments

Starting with a qualitative approach

THEN the equations

How to use energy bar charts to discuss buoyancy

I really liked the experiments with the suspended object measuring force as the object is submerged.

I got reminded that water is part of the system and when talking about energy, work by B. force does not change the energy of the system

I learned a lot! I am always surprised by your passion.

I appreciate the need to progressively build physical models.

How to talk about prediction and hypothesis at the beginning of all labs

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I appreciate the need to progressively build physical models.

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How to talk about prediction and hypothesis at the beginning of all labs