Fluids in Motion

Eugenia Etkina
Videos of experiments by G. Planinsic
Experimental support G. Planinsic

Equipment

Three pieces of printing paper

Two empty soda cans (buy the healthiest and drink before the workshop)

Straws with the end that bends

A syringe

Straight straws (2 at least)

A container with water (a plastic water bottle will do)

Our bottles with holes that we used for the previous workshop

A hairdryer

Please rename yourself:

First name

Level that you teach

Country

Eugenia, University, USA

Links to the documents with activities

OALG Chapter 14 Final.docx

ALG Chapter 14 Final.Revised.docx

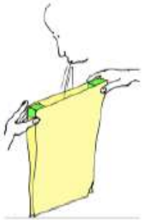
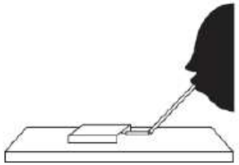
Need to know

https://www.youtube.com/watch?v=7qpEKm-M_x0

17-40 seconds

Team 2 OALG 14.1.1 OALG Chapter 14 Final.docx

Develop an explanation for the observations in these three experiments. Think about how the pressure of a fluid against a surface changes as the speed of the fluid moving across that surface increases.

Sketch and identify a system.	**Sketch a force diagram for the system. Include the force that the fluid exerts on the system on both sides.**
	*Immediately after you start blowing. Choose the left paper as the system and only consider horizontal forces.*
	Immediately after you start blowing. Choose one can as the system.
	*Immediately after you start blowing vigorously. The top surface of the card is the system. Only consider vertical forces.*

Team 4 OALG 14.1.1 [OALG Chapter 14 Final.docx]

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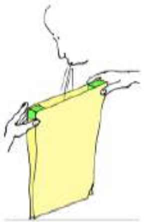	*Immediately after you start blowing. Choose the left paper as the system and only consider horizontal forces.*  $F_{A\ \text{on}\ P}$
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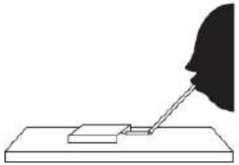
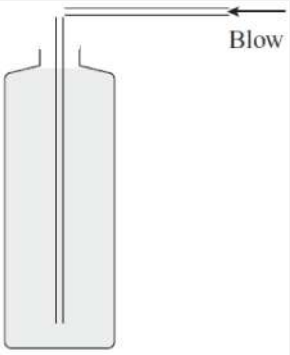
	*Immediately after you start blowing vigorously. The top surface of the card is the system. Only consider vertical forces.*  $F_{A\ \text{on}\ P}$

All together OALG 14.1.3

OALG 14.1.3 Test your idea

Equipment: water bottles, straws.



Use the ideas that you devised in Activities 14.1.1 and 14.1.2 to make a prediction about the experiment described below. Then, perform the experiment and compare the outcome to your prediction.

Experiment: Insert a straight straw into a bottle filled nearly to the top with water; the top of the straw should be just above the top of the water.

a. Predict what happens when you blow hard through a second straw placed horizontally so that the airstream moves across the top of the vertical straw in the water. Explain how you made your prediction.

b. Perform the experiment and record your results. Reconcile any discrepancies between the results and your prediction.

All together 14.2.1

OALG 14.2.1 Observe and explain

Equipment: syringe, water.

a. Observe how a syringe works and record your observations. Focus your attention on the speed with which the piston is moving and the speed with which the water is ejecting from the syringe.

b. Explain the difference in these speeds.

Let’s look at this process in a different context

Observe the experiment at

https://youtu.be/FJQYS9n9lDg

Can you describe what is happening to the small piece of paper?

How is it similar to the syringe experiment?

Team 2 OALG 14.2.3 Use the next slide to paste the screenshot of your whiteboard

OALG 14.2.3 Derive

The goal of this activity is to derive the relation between the speed of the fluid through a tube and the cross-sectional area of the tube and the flow rate. The flow rate $Q = \Delta V / \Delta t$ of a fluid through a tube is defined as the ratio of the volume ΔV of fluid passing a cross section in the tube and the time interval Δt needed for the fluid to pass that same cross section.

a. Sketch a tube filled with a liquid as seen from the side and indicate a cross section in the tube.

b. Suppose that all of the fluid a distance Δx from that cross section passes the cross section in time interval Δt. How does the flow rate depend on the average speed of the fluid through the tube v and the tube's cross sectional area A?

c. Under what conditions is the flow rate the same in a subsequent part of the tube where the cross-sectional area is different?

d. How does the speed compare between a narrower part of the tube and a wider part? Explain.

Team 2

V = volume

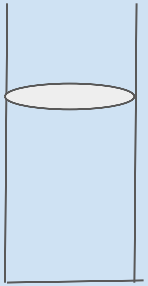
v = velocity

$$Q = \frac{\Delta V}{\Delta t}$$

$$\frac{V}{A}$$

$$Q = \frac{\cancel{\Delta t}\, v A}{\cancel{\Delta t}} = vA$$

Team 2 OALG 14.2.3



A=pi r^2

Q =   V/   t = 2   r^2 L/ delta t = 2   r^2 v/ t

Team 4 OALG 14.2.3 Use the next slide to paste the screenshot of your whiteboard

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Team 4 OALG 14.2.3

Explanation of the finding in 14.2.3 - what makes the water speed up? - analysis of the video

Let’s draw a motion diagram and a force diagram (whiteboard).

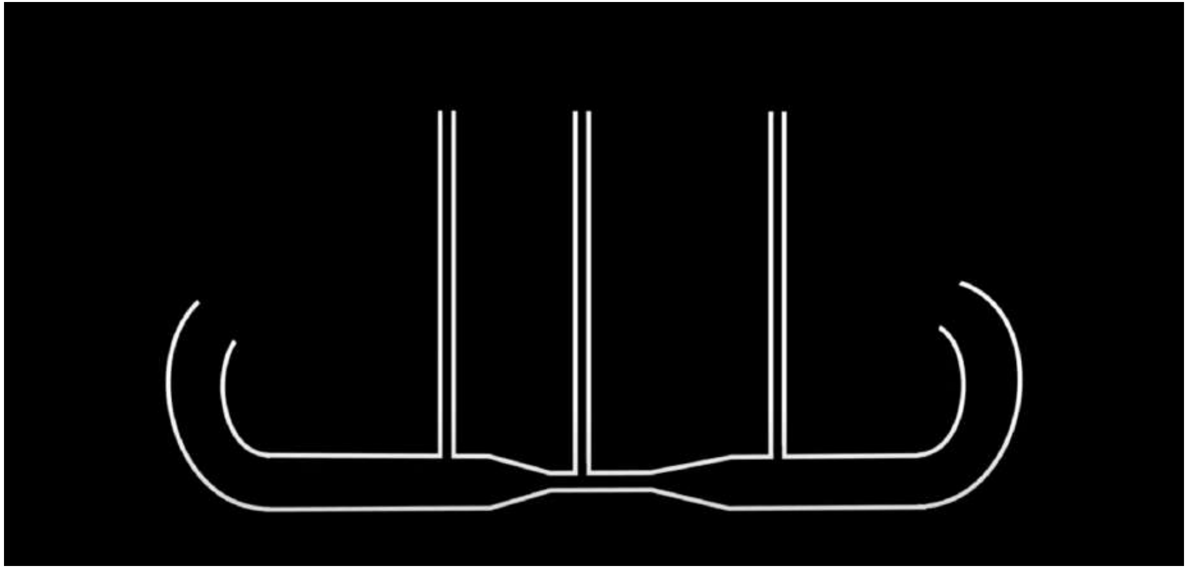
What should happen to the pressure to create this force?

(Think of the water bottle with jets that we used in the previous workshop.)

What can we conclude about the relationship between the speed of the fluid and the pressure inside?

Testing experiment - Venturi tubes

Giovanni Battista Venturi, an Italian physicist and engineer. Venturi developed the device in the 18th century while studying fluid dynamics.



https://youtu.be/_mZDm1KdNjQ

Team 1 14.4.1 OALG Chapter 14 Final.docx

List moments where you had difficulty

Remembering the def of work
Remembering the P A = Force
Have students make energy conservation bar graph under the tube
What is work being done on and by?
Why is the W_{right} negative?

Team 2 14.4.1 [OALG Chapter 14 Final.docx]

List moments where you had difficulty

b. Show that the fluid on the right does work $\Delta W_{\text{right}} = -P_2 A_2 \Delta x_2 = -P_2 \Delta V$. Note that Δx_2 is the distance that the fluid system moves to the right.

c. Show that the fluid that has moved from the left side to the right side has mass $\rho \Delta V$ and has effectively changed elevation by $y_2 - y_1$. In other words, show that the change in gravitational potential energy is $\Delta U_g = \rho \Delta V g (y_2 - y_1)$.

d. Show that $\rho \Delta V$, the mass of fluid that has moved forward, has effectively changed kinetic energy by $\Delta K = (1/2) \rho \Delta V \left(v_2^2 - v_1^2\right)$.

e. Combine the results of parts **a.**–**d.** to show that:

$$P_1 - P_2 = (1/2)\rho\left(v_2^2 - v_1^2\right) + \rho g\left(y_2 - y_1\right)$$

Point **e**

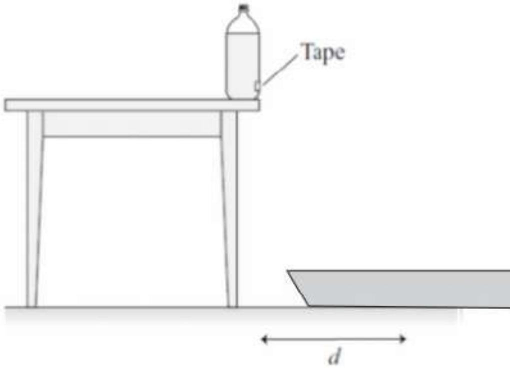
W=DeltaK+DeltaU

All together OALG 14.4.2 (use the whiteboard)

OALG 14.4.2 Test your idea

Equipment: a 2-L plastic bottle with a 4-mm-diameter hole on the side near the bottom (initially covered with tape), a wide container to collect water, a ruler or another distance measuring instrument.

Fill a bottle with water and place it at the edge of a table with the hole facing away from the table and toward the floor, as shown in the figure below. Use Bernoulli's equation to predict quantitatively the largest distance from the table's edge at which the water will reach the floor if you remove the tape and thus open the hole. (Make sure the top of the bottle is open.) Answer the questions below to make your prediction and to evaluate your result.



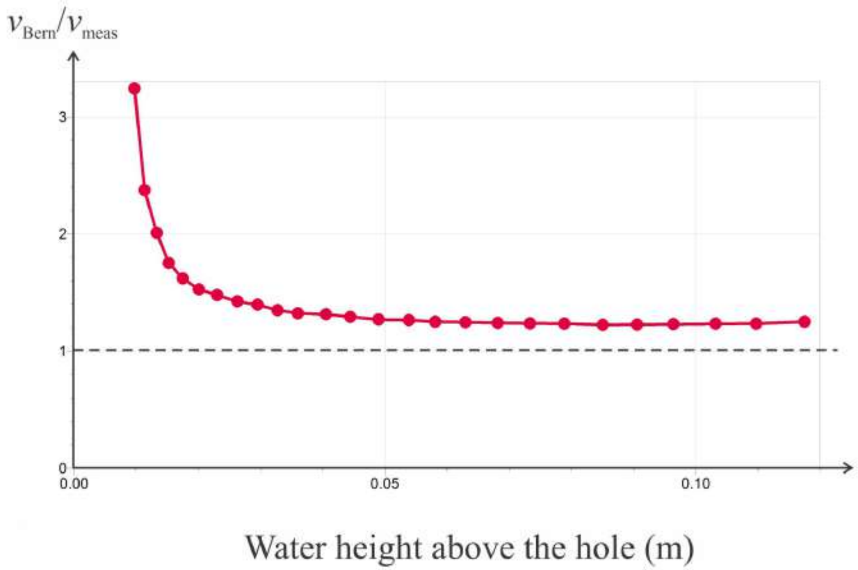
a. On the sketch, label physical quantities that you will measure and physical quantities that you will calculate. Measure the needed quantities and record them.

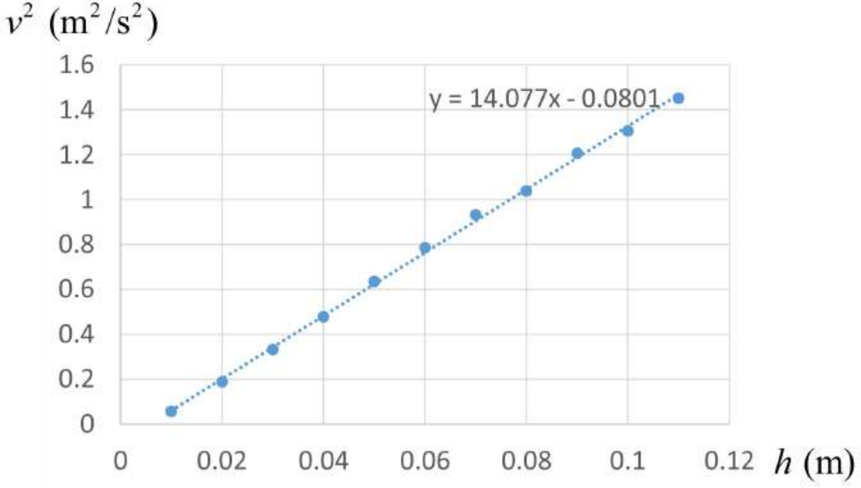
b. Outline a mathematical procedure to make your prediction. Then, complete the procedure to predict where the water will reach the floor: Use Bernoulli's equation to find the speed of the water leaving the hole. Then, use your knowledge of kinematics to calculate how far the water jet will travel horizontally. If you are having difficulties, consult Example 14.2 on page 424 in the textbook.

c. List the assumptions you made and describe how they will affect your result.

d. Perform the experiment. Record your results and make a judgment about whether Bernoulli's equation applies to the water flowing out of the bottle.

https://youtu.be/qML9JUzkZmQ

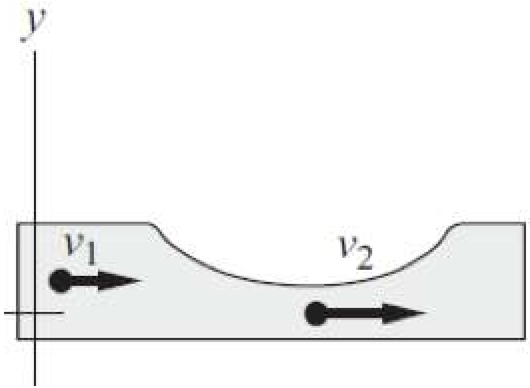


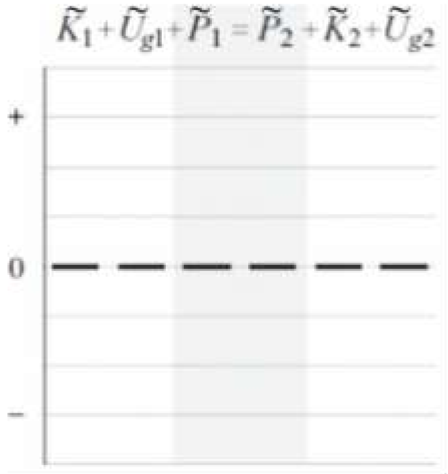


OALG 14.4.3 great activity, please do after the workshop

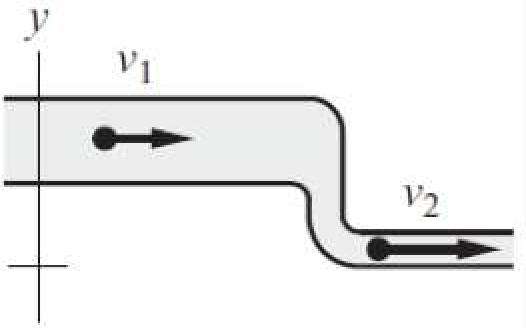
All together 14.5.1 OALG Chapter 14 Final.docx

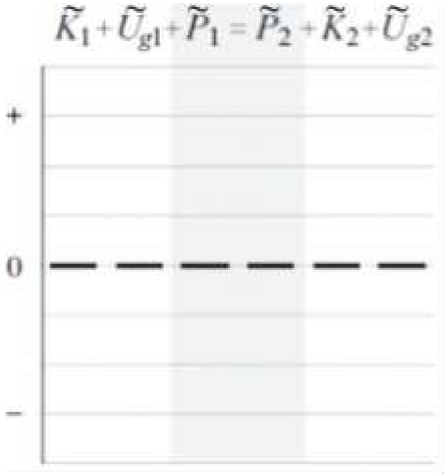
All together 14.5.2 OALG Chapter 14 Final.docx





Bernoulli equation





Apply Bernoulli equation

If time permits [OALG Chapter 14 Final.docx]

14.5.3; 14.5.4 - all together orally

Return to the need to know

Why do roofs fly off during tornadoes?

What did you learn in the workshop?

Practical activities that I can use to teach Fluids in motion, using testing experiment as a follow up of the observational experiment

It has been a while since I have taught fluids and this was a good refresher for me. I liked doing the bar graphs with Bernoulli's principle. The idea of using the outline of the derivation while the students work in groups.

Work group in derivation of more complex relationship, they have to interrogate the text, and try to recover the previous knowledge (eventually with the aid of the teacher).

Great experiments!

My head is already full and I think it will take some time to sort it out.I will watch the video again and review. thank you very much.

Showing the friction effect so clearly. Also, it is always useful to move to the students' frame of reference