Educational Innovations INC.®

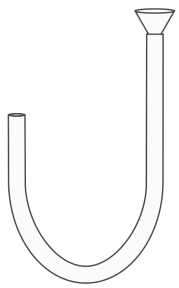
DEN-500

U-Tube Challenge

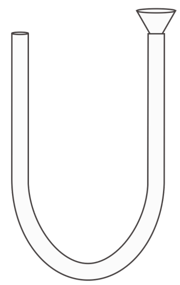
I. SIMPLE

Start class each day by asking students to predict what will happen when water is poured into the open right tube of one of the following:

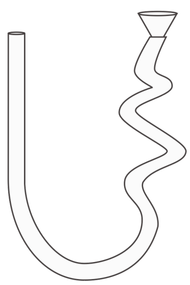
A.



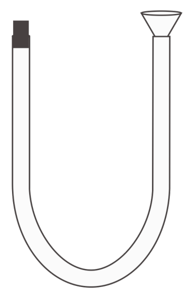
B.



C.



D. & E.



Teacher notes

<u>Example A</u>

When I began teaching, I started each class with a short single-question challenge quiz. The quizzes were easy to correct, revealed student misconceptions, and were useful at all levels, from elementary to advanced placement. The U-Tube Challenge became one of my favorites! Before clear tubing was available, I made a U-Tube out of glass. Inadvertently, I bent the glass off center; so one side was higher than the other (See Example A). Thinking that the crude shape of the tube wouldn't matter, I gave the following challenge quiz.

Name_____________________________ Date__________
When water is poured into the open right tube:
A. I think the water will be higher on the right.
B. I think the water will be higher on the left.
C. I think the water levels will be equal.
D. I do not think.

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It was fascinating to discover that a significant number of students at all levels predicted that the result would be water higher in the longer side of the tube. Incidentally, extra credit was given for a correct answer; the quiz was not counted for an incorrect answer; and negative credit was given for answer "D." Students soon learned that it was better to predict than "to not try."

Example B
After seeing Example A, most students predict the water levels to be equal in Example B. Point out to them that, assuming the tube is symmetrically bent, the mass of the liquid is the same on both sides, and the pressure is the same at the bottom of each side.

Example C
Some students will have trouble with Example C, reasoning that if the height of the liquid is the same on both sides, the mass is not. Even though there is more mass of liquid on one side, the pressure is the same at the bottom of each tube. Otherwise, the liquids would move to make the pressures equal. This demonstrates Pascal's Law.

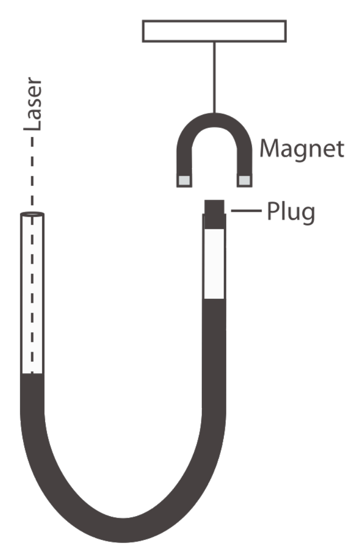
Example D
With one end plugged, many students will predict that you will not be able to pour water into the tube. However, if you **slowly** pour or pipet water into the tube, air will be able to escape, allowing water to fill the right side and a small amount of the left.

Example E
After completing Example D, ask students to predict what will happen when they remove the plug from the left side of the tube. Hopefully, by this time, most of your students will have learned that liquids of the same type seek the same level, but you may pick up a few with misconceptions.

II. MORE CHALLENGING

Present the students with the following:

Examples F, G, and H



Teacher Notes

Examples F, G, and H
This is a great activity to do with students, and it is also a good display case demonstration for the hallway. This one, however, requires a bit of advanced preparation on the part of the teacher. Pour water into one cup and a concentrated solution of sugar water into another. Add food coloring to each until both liquids are the same color. Fill the U-tube about ¼ full of the denser sugar-water solution, and add the colored water to the right side of the open tube. This will result in the liquid being considerably higher on the right. Loosely plug the right side. Position a laser or a flashlight over the left tube, and then hang a magnet over the right side. Note: Rather than sugar-water, you can replace the water with methanol, which is less dense. These two liquids are miscible, and both can be colored with food coloring. However, if this combination is used, pour the water in first. Ask students to predict the following:

What will happen when the plug is removed?
What will happen when the light is removed?
What will happen when the magnet is removed?

Explain that although light exerts a pressure, it is extremely weak and not enough that you could detect a change in the level of the liquids. Also, clear magnetic liquids do not seem to exist. Students may mention ferro-fluid, but that is really a suspension of small particles. Do not immediately explain why the liquids are at different levels. Leave it as a mystery until students experiment with solution density, e.g. The W-tube.

Example I - Alternative Version of above
Some teachers prefer to construct the unequal columns in front of their students. If you wish to prepare the unequal columns as a magic “trick” for the students to ponder, prepare the two identically colored solutions using the same type of containers, but show only one at a time. Begin by pouring in the denser solution, switching containers, and pouring in the less dense solution.

Example J
After experimenting with the W-Tube, ask students to propose a method for preparing the tube in the last example. Then try it.

Example K
Ask students to fill the U-tube with as many colored layers of sugar water as possible. This involves the problem of keeping both sides filled, as well as predicting which color combinations will mix to form a third color, e.g., blue and yellow. It is more difficult than it sounds!

Example L
Fill the tube with a solution of sodium nitrate and water containing a few drops of phenolphthalein. Immerse a graphite electrode in the top of each and connect to a 1.5 volt flashlight battery (D or C). Ask students to record their observations.

At the cathode (negative terminal), bubbles of hydrogen gas are formed leaving behind hydroxide ions that turn the phenolphthalein pink. At the anode (positive terminal) bubbles of oxygen gas are formed.

Example M
Repeat Example I using a copper salt solution. Notice that one of the graphite electrodes becomes plated with copper. This occurs at the cathode, the electrode connected to the negative terminal of the battery. Bubbles of oxygen gas appear at the other electrode, the anode.

Example N
Repeat Example L using two thin copper wires. Notice that one electrode becomes larger (the cathode) and the other becomes smaller (the anode).

