“Basic Concepts in Fluid Flow”
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Summary:
In these two lessons, students will learn about basic concepts in fluid flow and perform experiments to help further understanding. In the first lesson, students will be introduced to the theory behind fluid flow, learn some of the basic concepts that are needed to understand fluids, and perform experiments. In the second lesson, students will expand upon some of the basic concepts and perform another experiment to increase understanding.

Learning Objectives:
Following participation in this lesson plan, students should be able to:

- Understand and explain what matter is considered to be a fluid
- Understand and explain the difference between laminar and turbulent flow
- Understand the concept of friction and how viscosity works
- Be able to perform simple experiments and present their results to the class

Lesson Plan:

Please note that the bolded words are key words that should be understood by the teacher before presenting this lesson to the class.

Lesson 1- Introduction to Fluids
Time: 60 minutes
Opening activity- What is a fluid?
Obtain different types of fluids and solid objects. (For example, a glass of water, corn syrup, a container filled with air, solid butter, pieces of paper, JELLO etc.) Have the class split up into groups and separate the objects into solids, liquids, and gases. Have the students explain why they put each object into each group to the class. Then have them separate the fluids from the group of objects. Again, have the students discuss why they choose the objects they did as fluids.

Lecture/Demonstration- Introduction to fluids
Explain the definition of a fluid and discuss what objects that were obtained were fluids (any liquid or gas is a fluid). Discuss the difference between laminar and turbulent flow (shearing is a good word/concept to use). To emphasize, perform a demonstration in front of the class using a sink. Turn the faucet on and ask the students what they observe and how the flow is. Explain that this is laminar flow.
Have the students split up into groups and perform the Twist in Time-Laminar Flow experiment. Materials include: clear liquid soap, two glasses (one glass must fit inside the other, and be taller), four large binder clips, food coloring, three graduated pipettes, three small cups, and water. The procedure can be found at the link referenced below.


Have the students present their thoughts and observations to the class. Go back to the faucet. Place a shallow cup in the bottom of the sink and turn the water on so that it hits the center of the cup. Ask the students to observe the flow now that it is hitting the cup. Explain how this is turbulent flow because the water sprays everywhere and is unpredictable. In addition, one could demonstrate laminar and turbulent flow by lighting a candle stick. Once lit, have the students observe the flow of the smoke (near the flame, flow will be laminar but then flow becomes unstable and turbulent as the smoke rises). Place a pen or an eraser in the smoke, close to the flame, and observe what the smoke does (the smoke will avoid the pen or eraser and will flow in different directions with different speeds). Also, introduce conservation of mass and the idea that in order to keep flow rate constant, the velocity of fluid must increase because of a smaller diameter. Ask the class if they can think of an example of when the conservation of mass applies. Explain that when a finger is placed across the outlet of a hose or sink, the velocity of the water increases because the diameter decreased. Make sure to emphasize that these concepts are not limited to liquids, but apply to gases as well.

Information about the laminar versus turbulent flow sink and smoke activities can be found at:


Discussion questions:

- What makes a fluid different from solids and what is an example of a fluid that was not presented in class?
- How many types of flow are there and give an example of each?
- Have you ever experienced laminar or turbulent flow in your life? (Direct the class discussion towards talking about sports-soccer, golf ball, tennis ball etc.)

Optional: If time does not permit for the Twist in Time-Laminar Flow experiment, there are several YouTube videos performing this experiment. An example can be found at:

https://www.youtube.com/watch?v=je0g8XSjvKU.
Lesson 2- Introduction to Viscosity and Newtonian/Non-Newtonian Fluids

Time: 60 minutes

Opening activity - Viscosity and Resistance to Movement in Fluids
Obtain a container filled with water, a container filled with corn syrup, a container filled with ketchup, a container filled with pudding, a container of frosting etc. Obtain a second set of containers filled with the same liquids and place them in the refrigerator or on ice to cool them, but do not let them freeze. With plastic spoons, have each student take turns stirring the liquids. After each student has stirred each liquid, discuss any observations they had. Specifically try to guide the students to make observations on which of the liquids were easiest and which were hardest to stir. Then, remove the containers from the refrigerator or ice. Have the students stir each liquid and make observations (specifically on whether it was harder or easier to stir the liquid).

Lecture/Demonstration - Introduction to Viscosity and Newtonian/Non-Newtonian Liquids
Explain the definition of viscosity (which also might consist of explaining the concept of friction) and order the liquids presented in the opening activity from least viscous to most viscous. Also, discuss how decreasing the temperature, or making the liquid cooler, increases viscosity, making it harder to stir. See reference: [http://www.tcrsb.ca/dhcs/grade10/Science%20Unit%202/Fluids/11.%20How%20Does%20Temperature%20Affect%20Viscosity.pdf](http://www.tcrsb.ca/dhcs/grade10/Science%20Unit%202/Fluids/11.%20How%20Does%20Temperature%20Affect%20Viscosity.pdf).
Introduce Isaac Newton, who he was and how he came up with a set of rules to describe fluid flow. Explain the difference between Newtonian and Non-Newtonian fluid behavior. If the students do not understand the Newtonian and Non-Newtonian words, explain it as liquids that follow Newton’s rule (Newtonian) or liquids that do not follow Newton’s rule (Non-Newtonian). See reference: [http://antoine.frostburg.edu/chem/senese/101/liquids/faq/non-newtonian.shtml](http://antoine.frostburg.edu/chem/senese/101/liquids/faq/non-newtonian.shtml)
Have the students split into groups of three or four and perform the cornstarch and water experiment. Materials needed are newspaper, measuring cups, one cup of dry cornstarch per a couple of students, a large bowl, and ½ cup of water per couple of students. The procedure can be referenced here: [https://www.exploratorium.edu/science_explorer/ooze.html](https://www.exploratorium.edu/science_explorer/ooze.html).
Have each group of students write down their observations and a conclusion about how the mixture behaves. Have each group present their findings to the class.

The website just listed also provides a very good explanation of why the mixture acts as a liquid when stirred slowly, but acts as a solid when tapped or hit with a spoon quickly. It also describes the difference between a Newtonian and Non-Newtonian fluid.

Discussion questions:

- How does temperature affect the viscosity of a fluid?
• What was the difference between a Newtonian and Non-Newtonian fluid?
• Describe what happened when the students slowly stirred the cornstarch/water mixture as opposed to when they smacked it with a spoon.
• Does water behave like the cornstarch mixture?
• What are other types of Newtonian and Non-Newtonian fluids?
• Who might consider or test liquids for viscosity? (see reference: http://www.cscscientific.com/viscosity)

Wisconsin academic standards covered in this lesson plan:

• A.4.1 When conducting science investigations, ask and answer questions that will help decide the general areas of science being addressed
• C.4.2 Use the science content being learned to ask questions, plan investigations, make observations, make predictions, and offer explanations
• C.4.7 Support their conclusions with logical arguments
• D.4.3 Understand that substances can exist in different states-solid, liquid, gas
• 4C3.a.5.m: Conduct a shared dialogue with others on a common problem or task
• 4.C.b.4.m: Use idea generating practices as part of a group
• D.12.11: Using the science themes, explain common occurrences in the physical world