Lesson Title: Plumbing Systems **Part One**

Total Time: Two 60 Minutes classes

Brief Description: In this lesson, students will watch ***The House That STEM Built*** video titled *"Plumbing Systems"*. This video will discuss the physics elements involved in plumbing such as fluid flow, pressure, and Bernoulli's Principle. The video introduces an experiment to determine flow rate. The experiment will be completed by students during the second lesson.

Curriculum Outcomes: Taken from the New Brunswick Physics 11 curriculum

General Curriculum Outcomes: Work and Energy

Specific Curriculum Outcomes: 116-6: Describe and evaluate the design of technological solutions and the way they function using principles of energy and momentum

New Brunswick Global Competencies Achieved:
https://www2.gnb.ca/content/dam/gnb/Departments/ed/pdf/K12/curric/competencies/NBCompetencies.pdf?fbclid=IwAR1ldrZs1gFgiNm8rC4oz7Fmx6mSn-6t_QJkenev0eD33rZ-foYYn6bmdmc
Critical Thinking and Problem Solving

- Learners formulate and express questions to further their understanding, thinking, and problem-solving.

Learning Objectives:
The learner will be able to:

- Solve the flow rate using an equation
- Successfully describe Bernoulli's Principle

Materials:

- Loose Leaf Paper
- Pencil/Pen
- Calculator
- SMART Board

Warm-up: 15 Minutes

- Students will complete a notice and wonder activity using a photo of plumbing in a house
- There is a photo attached to this document labelled **Photo for Notice and Wonder,** put this picture up on the SMART Board
- Ask students to make a list of things they notice from the picture and a list of

things that they wonder from the picture
- Some things that students may notice:
    - There are various sizes and colors of pipe shown in the picture
    - The pipes are positioned inside what will become a wall
    - The pipes go up into the ceiling
    - There is a shower near the pipes
- Some things students may wonder:
    - How do the pipes attach to each other?
    - What do these pipes carry?
    - Do the pipes have to be in the walls?
    - Are there always pipes in the ceiling?
    - How does the water move upwards or downwards in the pipes?
- Have students share their answers for the notice and wonder
- While students are sharing, write out the answers on the whiteboard
- Alternative: If students are able to use technology in the classroom, a Jamboard could be used for students to post their answers for the class to see. The Jamboard can then be saved for future use.

Activity: 35 Minutes

- Start watching ***The House That STEM Built*** video titled *"Plumbing Systems"*
- At minute 2:03, pause the video and have students draw the pipe diameters in their notes
- At minute 2:16, pause the video and ask students if they know the difference between imperial and metric units. Take the time to explain the imperial and metric units. Write the following notes on the board and have the students copy them into their notes
    - Imperial Units:
        - Common units used in the imperial system are Inches (in), Feet (ft), Yards (yd), and Miles (mi)
        - This form of measurement is commonly used in the United States
    - Metric Units:
        - Common units used in the metric system are Millimetres (mm), Centimetres (cm), Meters (m), and Kilometres (km)
        - This form of measurement is the most commonly used system throughout the world
- At minute 3:46, pause the video and have students copy the equation for atmospheric pressure in their notes
- At minute 5:10, pause the video and have students copy the definition of flow in their notes
- At minute 5:18, pause the video and have students copy the equation for flow in their notes
- At minute 7:09, pause the video and have students copy this example in their notes. Mention to the students that they will be doing a similar experiment, so it is important to have this example written down
- The video shows the measurement first in litres and then in millilitres. Show students how to convert litres to millilitres on the board. Have students copy

the conversion in their notes
    - Given in video — 3.5 L and 70 seconds
    - 1 L = 1 000 mL
    - (3.5 L) X (1 000 mL / 1 L)
        - Litres cancel out
    - 3.5 x 1 000 mL = 3 500 mL
    - 3 500 mL / 70 s
        - The time is staying the same
    - 3 500 mL / 70 s = 50 mL/s
- At minute 7:55, pause the video and have students copy the equation for Bernoulli's Principle

Conclusion: 10 Minutes

- Rewatch the video starting at 6:34 and ending at 7:24
- Explain to students that tomorrow they will be doing a similar experiment
- Ask students how they would create an experiment that determines flow rate the same way that the video demonstrated during minute 6:34 until 7:24
- Here are some guiding questions to ask students. Below each guiding question is the ideal answer that you want students to reach
    - What materials are needed?
        - **Answer**: Buckets (preferably different sizes), stop watches, scales, multiple water sources
    - What values do we need to solve for flow rate?
        - **Answer**: Time and volume
    - If we want to determine the flow rate of one water source vs two, should each group use their own tap at the same time?
        - **Answer**: To start, only **one** tap can be used so an accurate flow rate is calculated. Then, groups can open more than one tap. Groups can take their final answers and see how the flow rate is affected with one water source vs two. Therefore, this experiment will need to be done twice
    - In order to calculate the volume of the water collected in the bucket, what needs to be done?
        - **Answer:** The first step would be to find the mass of the empty bucket by placing it on the scale. Second, fill the bucket with water and place the water filled bucket on the scale. Third, take the initial mass of the empty bucket and subtract it from the mass of the bucket filled with water. Finally, since we know that 1 kg of pure water is equal to 1 L, we can convert the kg to L to find the volume of water.
    - Now that all the data is recorded, what is the equation to determine flow rate?
        - **Answer**: Flow = volume / time
    - Finally, students will explain using information from the video why the flow rate was different in each experiment

Differentiation:

Content:

- During the notice and wonder activity, the teacher can separate students into groups and provide different versions of a notice and wonder. For example, one group gets the picture, another group gets a statement about plumbing, and another group gets a house plan that shows the plumbing.

Practice:

- Some students may struggle to work in groups. If this is the case, the teacher could provide the option of working individually for the experiment

Product:

- During the note taking some students may take longer than others. If the teacher thinks it is necessary, a notes sheet with fill in the blanks can be given to select students to follow along

Extension:

- The experiment can be done multiple times. After the flow rate is solved with and without the tap on, groups can then use a new size bucket and determine the flow rates again. Or, if there is more than one sink in the room, turn on as many as possible to solve the flow rate.

Photo For Notice and Wonder

Lesson Title: Plumbing Systems **Part Two**

Total Time: 60 Minutes

Brief Description: During this second lesson, students will complete an experiment to determine the flow rate. This experiment was first outlined in ***The House That STEM Built*** video titled *"Plumbing Systems"*.

Curriculum Outcomes: Taken from the New Brunswick Physics 11 curriculum

General Curriculum Outcomes: Work and Energy

Specific Curriculum Outcomes: 116-6 : Describe and evaluate the design of technological solutions and the way they function using principles of energy and momentum

New Brunswick Global Competencies Achieved:
https://www2.gnb.ca/content/dam/gnb/Departments/ed/pdf/K12/curric/competencies/NBCompetencies.pdf?fbclid=IwAR1ldrZs1gFgiNm8rC4oz7Fmx6mSn-6t_QJkenev0eD33rZ-foYYn6bmdmc
Critical Thinking and Problem Solving

- Learners formulate and express questions to further their understanding, thinking, and problem-solving.
- Learners solve complex problems by taking concrete steps to design and manage solutions.

Collaboration

- Learners learn from and contribute to the learning of others by co-constructing knowledge, meaning, and content.
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Learning Objectives:
The learner will be able to:

- Solve the flow rate using an equation
- Successfully describe Bernoulli's Principle

Materials:

- Loose Leaf
- Pencil/Pen
- Buckets
- Scales
- Lab room with more than one water source (i.e. more than one sink, or a sink and a shower and an eye wash station)
- Stopwatch (one per group)
- Calculator
- Plumbing Systems Experiment Handout

Before Class:

- Print **one** copy of the Plumbing Systems Experiment handout for **each** student

Warm-up: 10 Minutes

- Pass out the handout titled Plumbing Systems Experiment to **each** student. This handout outlines the experiment so all students will be able to have the directions in front of them
- Review the directions for the experiment
    - Students will work in groups of 3-4
    - Each group will obtain one bucket
    - The empty bucket will be placed on a scale to determine its mass.
    - Groups will take turns filling their bucket to about 4-5 cm from the top using the **same** tap. While filling the bucket one member of the group should be recording the time it takes to fill the bucket
    - The bucket will be placed back on the scale to determine the mass of the bucket and the water in it.
        - Remember that students must subtract the mass of the empty bucket from the mass of the water-filled bucket to determine the mass of the water itself.
        - After subtracting the two values, students can convert the mass of the water in kg to the volume of water in L.
        - Keep in mind that 1 kg of water equals 1 L
    - Using the litres and time, students can solve for the flow rate and then **convert** the value into millilitres/ sec.
    - Students will repeat the above steps **but** this time have another tap open somewhere in the classroom
    - Each student is responsible for completing their own sheet even though they are working in groups

Activity: 30 Minutes

- Students will get into their groups of 3-4
    - Alternative: the teacher can assign students into their groups. This decision is up to the teacher
- Groups will gather all the supplies they need (bucket, scale, stopwatch)
- Groups will start working on their experiment
- While groups are working, the teacher should be circulating the room to answer any questions that students may have and ensure groups are staying on task

Conclusion: 20 Minutes

- Play ***The House That STEM Built*** video titled *"Plumbing Systems"* all the way through without any breaks. This will be the second time students have viewed the video.
- While the video is playing, students are to answer the final lab question
    - Using ***The House That STEM Built*** video titled "Plumbing Systems",

explain why the flow rates are different for each experiment

- After the video is done playing, give students time to write their response
- Collect all of the Plumbing Systems Experiment handouts

Differentiation:

Content:

- Use ***The House That STEM Built*** video to discuss other examples where Bernoulli's Principal applies
    - For example
        - How an airplane takes off
        - In a chimney, the air rising because of the low pressure

Practice:

- Some students may struggle working in groups. If this is the case, the teacher could provide the option of working individually for the experiment

Product:

- If a student is struggling to follow along with all the steps, the teacher could provide a sheet that has all the data the student will need. The student will use the given data to solve for the flow rate

Extension:

- The experiment can be done multiple times. After the flow rate is solved with and without the tap on, groups can then use a new size bucket and determine the flow rate again. Or, if there is more than one sink in the room being used, turn on as many as possible to solve for the flow rate.

Name: _____ Class:_____ Date:_____

Plumbing Systems Experiment

Directions:

- Work in groups of 3-4
- Each group will obtain one bucket
- Take the initial mass of the empty bucket
- Groups will take turns filling their bucket (to about 4-5 cm from the top) using the same tap. While filling the bucket one member of the group should be recording the time it takes to fill the bucket
- Place the bucket on the scale to measure the mass of the water and the bucket together
    - subtract the mass of the empty bucket from the mass of the water filled bucket to find the mass of the water alone
    - Convert the mass of the water in Kg to its volume in litres
- Using the volume in litres and time, solve for the flow rate.
- **Convert** the result into millilitres/ sec.
- Repeat the above steps **but** this time have another tap open somewhere in the classroom

Solution for one water source on:

Solution for more than one water source:

Final Question:

1. Using ***The House That STEM Built*** video titled “Plumbing Systems”, explain why the flow rates are different for each experiment. Is the difference in flow rates between the two experiments what you expected? Did you anticipate the difference in flow rates would be more or less and why?