ONTARIO COUNCIL FOR TECHNOLOGY EDUCATION

Grade 8 Fluids

ONLINE RESOURCE

June 2020

Fluids Grade 8

Activity 1: Density Diver

Development of Curiosity and Wonder

Scientific and Technological Concepts:

Buoyancy is defined as the ability for something to float in a fluid. It is an upward force that is exerted by a fluid, that opposes the weight of the object, that is either partially or fully immersed. For example, the water in a pool will exert an upward force that will act in the direction opposite to the swimmer's weight. The strength of the buoyant force will be dependent on the volume of the object that is submerged.

Archimedes' Principle states that the upward buoyant force that is exerted on an object immersed in a fluid (fully or partially) is equal to the weight (downward force of gravity acting on mass) of the fluid that the object displaces.

Density is the mass per unit volume. In other words, the average density of an object is equal to its mass divided by its volume. Density will determine whether an object will sink or if it will float. An object with an apparent density that is less than that of the fluid will float. An object with an apparent density more than that of the fluid will sink.

Compressibility is the ability of a substance to become more compact when squeezed. This is due to particles. According to the Particle Theory of Matter, gas particles are spaced further away from each other compared to a liquid's particles. Therefore, gases are more easily compressed. If you squeezed an empty water bottle, it would be easier to compress the gas particles compared to a bottle filled with water particles. The reason why fluids can be compressed is because of the spaces between those particles.

Pressure affects the amount of compressibility in a fluid. Pressure is the force per unit of area.

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Pascal's Law states that a force applied to a fluid is distributed equally through all parts of the fluid. If you connect two syringes of different sizes, you will notice that the plunger of the smaller syringe moves farther than the larger syringe.

How it works:
When the bottle is squeezed, the pressure of the water is increased and the air in the diver is compressed. This reduces the buoyancy of the diver but increases the mass and density, which causes it to sink. When the bottle is released, the water pressure returns to normal and so does the buoyancy of the diver, which makes it rise back up.

Learning Goal:
Students will
- Create a buoyant diver
- Investigate the effects of Pascal's Law and Archimedes Principle on the diver in the water bottle

Expectations (Overall & specific):
Overall:
2. investigate the properties of fluids
3. demonstrate an understanding of the properties and uses of fluids
Specific:
2.1 follow established safety practices for using apparatus, tools, and materials
2.4 investigate applications of the principles of fluid mechanics
2.7 use appropriate science and technology vocabulary, including viscosity, density, particle theory of matter, hydraulic, and pneumatic, in oral and written communication
2.8 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes
3.4 explain the difference between liquids and gases in terms of their compressibility (e.g., gases are more compressible than liquids) and how their compressibility affects their usage
3.5 determine the buoyancy of an object, given its density, in a variety of fluids
3.7 explain how forces are transferred in all directions in fluids (Pascal's law)

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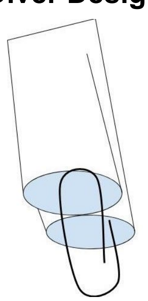
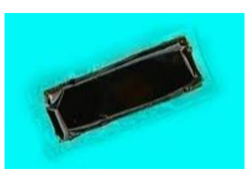
<table>
<tr><th>Equipment & Materials</th><th>Personal Protective Equipment (PPE)</th></tr>
<tr><td>

Diver Design #1



- Water for the plastic bottle
- Transparent plastic bottle (e.g., soda bottle or a water bottle)
- Plastic straws (e.g., juice box straw)
- Paper Clips
- Scissors
- Glass of water

Diver Design #2

- Water for the plastic bottle
- Transparent plastic bottle (e.g., soda bottle or a water bottle)
- Ketchup-like packet or soya sauce packet (full)
- Hot glue gun
- Glass of water

</td><td>

- Eye protection must be worn if using a hot glue gun

</td></tr>
</table>

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Diver Design #3  • Water for the plastic bottle • Transparent plastic bottle (e.g., soda bottle or a water bottle) • Eyedropper • Glass of water **Diver Design #4**  • Water for the plastic bottle • Transparent plastic bottle (e.g., soda bottle or a water bottle) • Ballpoint pen cap with no holes at the top (or fill the hole with glue or clay) • Moulding clay/dough or a few elastics for the bottom	

Safety Considerations:

- Students need to be cautious if using a glue gun to join materials. Glue gun use should be supervised and goggles need to be worn
- Loose hair and clothing tied back

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What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
Students should be familiar with the terms: density, compressibility, buoyancy and the concepts surrounding Pascal's Law and Archimedes' Principle. Hands-on experiences help students to understand. Examples for teaching these concepts are: ● Buoyancy and Archimedes Principle - students use different sizes of balloons in a bathtub and explain what they feel when they try to push one under the water versus the other size. Students should notice the displacement of water around the object. ● Density - students make a density tower using different liquids found in their kitchen (e.g., water, oil, dish soap, milk, maple syrup etc) and see how they layer differently. ● Pascal's Law - If syringes are available, students can investigate what happens when different size syringes are connected. Students should notice that the plunger of a smaller syringe will move more than that of the larger syringe. Students can also investigate the differences in how the syringes behave between pneumatics and hydraulics. ● Compressibility - Students can use a plastic bottle and investigate what happens when you squeeze or compress the plastic bottle when it is filled with air versus when it is filled with a little bit of water and a lot of water. Students should be able to explain compressibility using the Particle Theory of Matter.	**Initiating and Planning** Using Appendix A, *"Diver Models"*, students decide on a diver design based upon the materials they can collect and use at home. If students do not have specific materials, students can design their own design using the other designs as a model. Students select materials that take into account considerations such as function, aesthetics and environmental impact. Students draw a technical drawing of their chosen diver or their modified design. **Performing and Recording** Students design, build, and test their diver using Appendix B, *"Density Diver"*. Students record their observations in the chart provided. **Analysing and Interpreting** Students provide notes in Appendix B, *"Density Diver"* regarding any modifications made to their original design and provide reasons for those changes. **Communicating** Students use appropriate vocabulary to describe how the diver works.

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Provide students with Appendix A, *"Diver Models"* and let students choose their diver they wish to create. Alternatively, students can design their own diver. Students use Appendix B, *"Density Diver"* to plan out their diver and test it. Students should be aware of how this activity applies to real-world applications. Most boney fish rise and sink using this density-buoyancy relationship. Most fish have an air bladder inside their stomachs that they fill with air to control their upward and downward movement. Scuba divers also use this concept. Scuba gear is designed with weighting systems and buoyancy compensators to control buoyancy. Submarines use ballast tanks that are filled with water to make them sink. This makes the density of the ship higher than the surrounding water. When the submarine submerges into the water, compressed air is supplied to support the life inside the submarine. When the submarine rises, the tanks are then filled with air. **Sample accommodations:** ● Students do not need to create a diver like the models provided. Students can design their own using other found materials in the home. **Sample Troubleshooting:** ● If the diver sinks and never comes back up on the first try, reduce the water in the plastic bottle.	

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● If the diver sinks after playing for a while, take the diver out and empty the water from the straw, pen cap or packet. ● Make sure the plastic water bottle is filled to the top with water	

Opportunities for assessment (Links to assessment pieces, organizers):

CRITERIA	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Design Process Plan -at least one design is drawn -measurements are given -appropriate materials are chosen	Develops an unfinished plan with various considerations missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a workable plan with some considerations missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a clear workable plan using appropriate materials Uses the design process (plan, build, test, evaluate, communicate) as expected	Develops a workable plan and modifies the plan as necessary Demonstrates the design process (plan, build, test, evaluate, communicate) effectively
Model Translates plan to model	Design plans do not translate into a working model	Somewhat translates design plans into a working model based on some of the criteria Creates model that functions sometimes successfully according to specifications Predictable design and materials	Translates design plans into a working model based on criteria required Creates model that functions successfully according to specifications Predictable design and materials	Successfully translates design plans into a working model based on criteria required Creates model that functions successfully according to specifications Care is taken with construction Unique and creative design
Communication and Reflection -terms are used -knowledge of buoyancy, density, Pascal's Law and Archimedes' Principle are evident	Uses little appropriate terminology for grade level Does not communicate an basic understanding of the concepts	Uses some appropriate terminology for grade level Communicates understanding of some of the basic concepts	Uses most appropriate terminology Communicates understanding of most of the basic concepts Reflects on design process and makes	Uses all appropriate terminology Communicates understanding of all of the basic concepts Reflects on the process with an in-depth

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	Reflects on design process and makes limited suggestions for improvement	Reflects on design process and makes some suggestions for improvement	necessary suggestions for improvement	response. Makes necessary and insightful suggestions for improvement

Cross-Curricular Opportunities:
Language:
Writing Overall:
1. generate, gather, and organize ideas and information to write for an intended purpose and audience

References:
Buoyancy & Pressure in Fluids: Soda Bottle Cartesian Diver - Activity. (2020, March 07). Retrieved July 14, 2020, from https://www.teachengineering.org/activities/view/uoh_fluidmechanics_lesson01_activity1

Eye Dropper Cartesian Diver: Experiments: Steve Spangler Science. (n.d.). Retrieved July 14, 2020, from https://www.stevespanglerscience.com/lab/experiments/eye-dropper-cartesian-diver/

How to Make Cartesian Bottle Diver? (n.d.). Retrieved July 14, 2020, from https://www.ronyestech.com/2020/05/how-to-mak-cartesian-bottle-diver.html

Images:
Basu, T. (2015, February 04). The Mysterious, Murky Story Behind Soy-Sauce Packets. Retrieved July 14, 2020, from https://www.theatlantic.com/business/archive/2015/02/the-salty-murky-story-behind-soy-sauce-packets/382469/
Buoyancy & Pressure in Fluids: Soda Bottle Cartesian Diver - Activity. (2020, March 07). Retrieved July 14, 2020, from https://www.teachengineering.org/activities/view/uoh_fluidmechanics_lesson01_activity1

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Single ball pen with cap against the ...: Stock image. (n.d.). Retrieved July 14, 2020, from https://www.colourbox.com/image/single-ball-pen-with-cap-against-the-white-background-image-1712375

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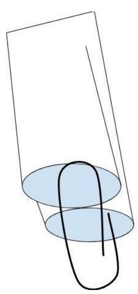
Appendix A:

Diver Models

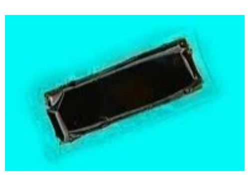
Diver Design #1



Materials:
- Water to fill plastic bottle
- Transparent plastic bottle (e.g., soda bottle or a water bottle)
- Plastic straws (e.g., juice box straw)
- Paper Clips
- Scissors
- Glass of water

Procedure:
1. Cut a 5cm piece of drinking straw and fold it in half
2. Attach a paperclip in both ends of the straw, but not to seal up the ends
3. Place it in a glass of water to make sure it will float
    a. If pressed down slightly, the diver should make its way to the bottom and come back to the surface to float
    b. If your diver does not come back up, make your straw piece larger
4. Fill plastic bottle with water and put the diver into the bottle and close the lid
5. When you squeeze the bottle see what happens! Then release. Record observations.

Diver Design #2



Materials:
- Water to fill plastic bottle
- Transparent plastic bottle (e.g., soda bottle or a water bottle)

- Ketchup-like packet (full) or soy sauce packet (full)
- Hot glue gun
- Glass of water

Procedure:

1. If using a ketchup packet, you can fold the narrow ends in, like you are making a paper airplane and glue the ends down
    a. Make these folds small so the packet does not explode or sink in the water
    b. Your packet will now look like a fish
2. Test out your fish packet to make sure that it floats in the glass of water
    a. If the packet does not float, re-distribute the air within it
3. Fill plastic bottle with water and put the fish diver into the plastic bottle and close the lid
4. When you squeeze the bottle see what happens! Then release. Record observations.

Diver Design #3

Materials:

- Water to fill water bottle
- Transparent plastic bottle (e.g., soda bottle or a water bottle)
- Eye dropper
- Glass of water

Procedure:

1. Fill the eyedropper about ¼ full
2. Place eyedropper in the glass of water
    a. The eyedropper should be filled enough that it is barely floating on top of the water - you might need to fill it more or less than a ¼ to make sure that it floats
3. Fill plastic bottle with water and put the eye dropper into the plastic bottle and close the lid
4. When you squeeze the bottle see what happens! Then release. Record observations.

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Diver Design #4

Materials:
- Water to fill plastic bottle
- Transparent plastic bottle (e.g., soda bottle or a water bottle)
- Ballpoint pen cap with no holes at the top (or fill hole with glue)
- Molding clay/dough or a few elastics for the bottom
- Glass of water

Procedure:
1. Fill the hole at the top of the pen cap (if you haven't done so already)
2. Place some weight on the end of the pen cap - either using modelling clay or some elastics
3. Place the cap in the glass of water (elastic or clay end first) to make sure it floats
    a. If it sinks, remove some of the elastics or clay; if it floats too much, add more weight
4. Fill plastic bottle with water and put the pen cap diver into the plastic bottle and close the lid
5. When you squeeze the bottle see what happens! Then release. Record observations.

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Appendix B

Density Divers

Planning:
Using the space provided below, sketch out your design. Provide measurements where appropriate.

Diver Sketch:

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Observations:

Trial	When Plastic Bottle is Squeezed	When Plastic Bottle is Released	Modifications to Design and Reasoning
1			
2			
3			
4			
5			

Reflection and Analysis:

1. Identify what happened to the diver when the bottle was squeezed and released. Use a diagram to help explain.
2. What variables affected the diver's ability to float?
3. Using your knowledge of Archimedes' Principle and Pascal's Law, explain what made the diver rise and fall. Remember to use your terms: buoyancy, density, pressure.
4. What types of animals, structures or technology use these principles in real life? Provide two examples and explain.
5. If you were given the opportunity to design and build another model, what would you do differently?
6. Include a picture or a video of your diver in action.

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Activity 2: Capillary Action

Structured to develop technological problem solving skills

Scientific and Technological Concepts:

Sometimes, fluids flow upwards! This is called capillary action. Capillary action is when a solid and a liquid interact with one another, like water and a straw. The water particles become attracted to the straw due to the forces of adhesion, cohesion and surface tension.

Water has a strong cohesion force, meaning that water particles stay close to one another. Water particles often are attracted and stick to other materials, which is called adhesion. Capillary action is when the adhesion to the walls is stronger than the cohesion forces between the liquid particles. The height the liquid rises in a capillary tube depends on the diameter of the capillary tube. A tube that has a smaller diameter, will have liquids that rise higher.

Plants rely on capillary action to bring water and dissolved nutrients up into the roots. To get water to the branches and leaves of trees, the forces of adhesion and cohesion take place within the plant's xylem to move the water after it cannot overcome gravity.

Capillary action is also important in the drainage of tear fluid in our eyes from the lacrimal ducts in the inner corner of the eyelid. Other examples of capillary action are: the mercury in a thermometer rising as the temperature rises, absorption of sweat from fabrics, paper towel soaking up a spill and the chromatography process.

Learning Goal:

Students will

- Design a self-watering planter using their knowledge of the properties of fluids and the concept of capillary action

Expectations (Overall & specific):

Overall:

2. investigate the properties of fluids;

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3. demonstrate an understanding of the properties and uses of fluids
Specific:
2.1 follow established safety practices for using apparatus, tools, and materials
2.7 use appropriate science and technology vocabulary, including viscosity, density, particle theory of matter, hydraulic, and pneumatic, in oral and written communication
2.8 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes
3.8 compare the ways in which fluids are used and controlled in living things to the ways in which they are used and controlled in manufactured devices

Equipment & Materials	**Personal Protective Equipment (PPE)**
● Plastic water bottle cut in half ● Soil to fill top of water bottle ● A seed to grow (preferably of the climbing variety) ● A piece of cloth or piece of coffee filter ● Sticks for a trellis ● If available: ○ Penny ○ Eyedropper ○ Three different diameters of straws	● Goggles must be worn if using a hot glue gun

Safety Considerations:
- Students must be careful cutting the plastic water bottle in half. Supervision is recommended
- Loose hair and clothing must be secured
- Students need to be cautious if using a glue gun to join materials. Glue gun use should be supervised and goggles need to be worn

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What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
Teachers introduce the concept of cohesion, adhesion and surface tension using the water on a penny experiment by either demonstrating, showing a video (https://www.youtube.com/watch?v=XQbr9Ic8_hA&feature=emb_logo) or having students try it themselves, (if equipment is available). As water is dropped onto the penny, a bubble on top of the penny begins to form. This is due to the cohesion of water particles (attraction), which is surface tension. Students attempt to see how many drops of water can hold on the penny before the forces release. Students are then introduced to the concept of capillary action. Students might try or teacher might demonstrate this straw experiment: 1. Take a glass of water and immerse three different diameters of straws into the water. 2. Students notice after a minute which straw has the most water in it. 3. Students will notice that the straw with the smallest diameter has the most, whereas a straw with a wide diameter might have none. Pose to students the question, “How do plants and trees receive water and nutrients that reach their far leaves and branches?” Explain what capillary action is and how the two activities that are related to adhesion, cohesion and surface tension relate to the concept of capillary action.	**Initiating and Planning** Using Appendix C, “*Up, Up and Away”*, students come up with a solution and design for their self-watering planter that utilizes capillary action. Provides a technical drawing, using Appendix C and outlines steps for completion. **Performing and Recording** Students build their design and test for efficacy. **Analysing and Interpreting** Students use the reflection questions of Appendix C to explain how well their solution worked. Students identify how they would change or modify their design if they were to do it again. **Communicating** Students use grade appropriate vocabulary, including: surface tension, adhesion, cohesion and capillary action.

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Provide students with Appendix C, *"Up, Up and Away".* Students use the handout to design a planter out of a plastic water bottle that will be self-watering using capillary action. ● Students may be given the icon that shows how this could be designed or teachers might wish not to show the picture and have students problem-solve on their own ● Students might wish to make pores to draw in the water or use a coffee filter strip/piece of cloth/string to act as a wick to draw the water up through the soil. **Extensions:** How capillary action is used in space: https://www.youtube.com/watch?v=v85keaWuxIo Students could take data of the growth of their plant and display their data using graphs	

Opportunities for assessment (Links to assessment pieces, organizers):

Up, Up and Away Boat Criteria

CRITERIA	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Design Process Plan -at least one design with two different views are made -measurements are given -appropriate materials are chosen and listed	Develops an unfinished plan with various considerations missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a workable plan with some steps missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a clear workable plan using appropriate materials Uses the design process (plan, build, test, evaluate, communicate) as expected	Develops a workable plan and modifies the plan as necessary Demonstrates the design process (plan, build, test, evaluate, communicate) effectively
Model Translates plan to model	Design plans do not translate into a working model	Somewhat translates design plans into a working model based on some of the criteria	Translates design plans into a working model based on criteria required	Successfully translates design plans into a working model based on criteria required

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		Creates model that functions sometimes successfully according to specifications Predictable design and materials	Creates model that functions successfully according to specifications Predictable design and materials	Creates model that functions successfully according to specifications Care is taken with construction Unique and creative design
Communication and Reflection -terms are used: adhesion, cohesion and surface tension -knowledge of capillary action is evident	Uses little appropriate terminology for grade level Does not communicate an basic understanding of the concepts Reflects on design process and makes limited suggestions for improvement	Uses some appropriate terminology for grade level Communicates understanding of some of the basic concepts Reflects on design process and makes some suggestions for improvement	Uses most appropriate terminology Communicates understanding of most of the basic concepts Reflects on design process and makes necessary suggestions for improvement	Uses all appropriate terminology Communicates understanding of all of the basic concepts Reflects on the process with an in-depth response. Makes necessary and insightful suggestions for improvement

Cross Curricular Opportunities:
Science and Technology
Understanding Life Systems Overall:
2. investigate functions and processes of plant and animal cells
3. demonstrate an understanding of the basic structure and function of plant and animal cells and cell processes.

Language:
Writing Overall:
1. generate, gather, and organize ideas and information to write for an intended purpose and audience

Math:
Data Management Overall:
• collect and organize categorical, discrete, or continuous primary data and secondary data and display the data using charts and graphs, including frequency tables with intervals, histograms, and scatter plots;

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Appendix C:

Up, Up and Away! Design Challenge

Problem: Plants for our classroom are great, but sometimes they become overwatered or underwatered. Wouldn't it be great for a plant to decide how much water it requires and water itself? Design a planter that will hold a seed and will mimic capillary action to bring the water to the soil to self-water. If you plant a climbing plant, don't forget to design and build a trellis that will help stabilize your chosen plant.

Materials:

- Water bottle cut in half
- string/cloth/coffee filter
- Soil
- Seed
- Water to fill the bottom
- Sticks (if building a trellis)

Checklist:

- Does your design allow the capillary action to occur to "self water" the plant? (you will only fill the bottom with water)
- Does your design have a trellis if you are planting a seed that will eventually climb?

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<u>Design:</u> Sketch three possible designs for your planter, or at least one design and two different views:
*Include materials & dimensions (how big is each part?)

<u>Construct:</u> How are you going to make your chosen design? Write the steps you are going to take (hint: think procedural writing).

Step	Method	Materials needed
1		
2		
3		

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4		
5		
6		
7		
8		
9		
10		

Evaluate:

1. With your understanding of capillary action, explain how your plant seed will get water in order for the plant to be nourished and to function properly?

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2. What would happen if you used a viscous liquid instead of water? Would the capillary action be the same?

3. If I were to do this project again, two things I would do differently:

    1.

    2.

4. Research two ways in which capillary action is used in everyday life. Explain how capillary action works in each example and use the terms: adhesion, cohesion and surface tension.

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Activity 3: Float your Boat

Guided development of technological problem solving skills

Scientific and Technological Concepts:

Buoyancy is defined as the ability for something to float in a fluid. It is an upward force that is exerted by a fluid, that opposes the weight of the object, that is either partially or fully immersed. For example, the water in a pool will exert an upward force that will act in the direction opposite to the swimmer's weight. The strength of the buoyant force will be dependent on the volume of the object that is submerged.

When the weight of an object is more than its buoyant force, it will sink and when the weight is less than its buoyant force it will float. If an object's weight is equal to its buoyant force, the object will essentially just sit in the water.

Surface area is important when it comes to buoyancy. The more surface area an object has, the more buoyant force it will have to keep it afloat.

Learning Goal:

Students will

- Design a tin foil boat using a limited amount of material that will be designed to hold the most weight
- Use their previous knowledge to design a boat that is primarily made up of materials from nature or strictly recycled materials, that will hold the most amount of weight

Expectations (Overall & specific):

Overall:

2. investigate the properties of fluids;
3. demonstrate an understanding of the properties and uses of fluids

Specific:

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2.7 use appropriate science and technology vocabulary, including viscosity, density, particle theory of matter, hydraulic, and pneumatic, in oral and written communication
2.8 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes
3.2 describe the relationship between mass, volume, and density as a property of matter
3.5 determine the buoyancy of an object, given its density, in a variety of fluids

Equipment & Materials	Personal Protective Equipment (PPE)
Tin Foil Boat Challenge: ● 30 cm of tin foil from a regular roll ● Coin or washers to use as weight for testing Boat Challenge: ● Materials found in nature: ○ Fallen leaves ○ Sticks ○ Fallen bark etc., Or ● Recycled materials: ○ Cartons ○ Plastic bottles ○ Straws ○ Newspaper ○ Plastic bag	● Eye protection must be worn if using a hot glue gun

Safety Considerations:

- Students need to be cautious if using a glue gun to join materials. Glue gun use should be supervised and goggles need to be worn
- Loose hair and clothing tied back

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What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
This activity is best used as a hook given to students without a lot of previous content given. Instruct students to build a boat that will float in a sink or bathtub. The boat must be designed to hold the maximum number of coins/washers/other objects to add mass that can be calculated or at least counted. Students are only given a specific amount of tin foil and that is it. No tape, glue or other materials can be used for the first creation. Students may wish to modify their boat as they test. Students may not be given a second set of materials to use. Students can submit video documentation of their process (e.g., designs and modifications, testing) or submit Appendix D, "*Tin Foil Boat Challenge*". Teachers compile the designs and outcomes of the boats. Generate discussion surrounding the following topics: ● Original designs and any modifications that took place due to testing ● Design features of successful boats ● Design features of unsuccessful boats ● Any reflections from students regarding what they would do differently if given the opportunity The concept of buoyancy can be taught using these discussion points and the importance of surface area	***Tin Foil Boat Challenge*** **Initiating and Planning** Students identify and design a tin foil boat using only a piece of tin foil that is designed to hold the most amount of weight. Students provide a technical drawing of their original design, using Appendix D *"Tin Foil Boat Challenge".* **Performing and Recording** Students design and build their tin foil boats. Students test their boats in either a sink or a bathtub while incrementally increasing the amount of mass by placing objects into it. Students record how many objects the boat was able to withstand before sinking and records any notable observations of the process, using Appendix D. **Analysing and Interpreting** Students reflect upon their design and note their reasoning for any modifications made to their design throughout the process of testing. **Communicating** Students use Appendix D to document in written form their process or use Appendix D as a prompt as to what to include in an oral video to record their process. ***Float Your Boat Challenge***

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along with volume and mass. Discussion can be centered around the fact that ocean liners are made of steel and iron. If a pellet of steel or iron was dropped into a bathtub, it would sink. Ocean liners need to have the mass of the steel distributed over a larger surface area in order for it to stay afloat. Provide students with Appendix E, "*Float Your Boat*". Students will use the handout to design and test a boat to carry at least double the amount of mass that the tin foil boat carried. **Extension Opportunities:** Consider the Skills Ontario, Cardboard Boat Race Challenge found here: http://www.skillsontario.com/competitions/cardboard-boat-races-and-video-challenges **Sample accommodations:** Students may wish to submit their design process for the Tinfoil Boat Challenge in either writing or by a video recording.	**Initiating and Planning** Students identify and design a boat using only either materials found in nature or only recycled materials. The boat must be designed to hold the most amount of weight. The boat must not surpass a 30 cm size. Students provide a technical drawing of their original design, using Appendix E *"Float Your Boat Challenge"* **Performing and Recording** Students design and build their boats. Students test their boats in either a sink or a bathtub while incrementally increasing the amount of mass by placing objects into it, just like they did in the Tinfoil Boat Challenge. Students record how many objects the boat was able to withstand before sinking and records any notable observations of the process, using Appendix E. **Analysing and Interpreting** Students reflect upon their design and note their reasoning for any modifications made to their design throughout the process of testing. **Communicating** Students use Appendix E to document in written form their process.

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Opportunities for assessment (Links to assessment pieces, organizers):

Tin Foil Boat Success Criteria

Criteria	Met	Not There Yet
Student creates a model that floats and appropriately holds objects for testing		
Student documents or records how the boat design was modified during the testing process and gives reasons for the changes		
Student provides qualitative observations and provides a final count of the number of objects the boat successfully held (quantitative)		
Student appropriately reflects upon the design and testing process		

Float Your Boat Criteria

CRITERIA	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Design Process Plan -at least one design with two different views are made -measurements are given -appropriate materials are chosen and listed	Develops an unfinished plan with various considerations missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a workable plan with some steps missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a clear workable plan using appropriate materials Uses the design process (plan, build, test, evaluate, communicate) as expected	Develops a workable plan and modifies the plan as necessary Demonstrates the design process (plan, build, test, evaluate, communicate) effectively
Model Translates plan to model	Design plans do not translate into a working model	Somewhat translates design plans into a working model based on some of the criteria Creates model that functions sometimes successfully according	Translates design plans into a working model based on criteria required Creates model that functions successfully according to	Successfully translates design plans into a working model based on criteria required Creates model that functions successfully according to

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		to specifications Predictable design and materials	specifications Predictable design and materials	specifications Care is taken with construction Unique and creative design
Communication and Reflection -terms are used -knowledge of buoyancy and density is evident	Uses little appropriate terminology for grade level Does not communicate an basic understanding of the concepts Reflects on design process and makes limited suggestions for improvement	Uses some appropriate terminology for grade level Communicates understanding of some of the basic concepts Reflects on design process and makes some suggestions for improvement	Uses most appropriate terminology Communicates understanding of most of the basic concepts Reflects on design process and makes necessary suggestions for improvement	Uses all appropriate terminology Communicates understanding of all of the basic concepts Reflects on the process with an in-depth response. Makes necessary and insightful suggestions for improvement

Cross Curricular Opportunities:
Language:
Oral Communication Overall:
1. listen in order to understand and respond appropriately in a variety of situations for a variety of purposes
Writing Overall:
1. generate, gather, and organize ideas and information to write for an intended purpose
and audience

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Appendix D

Tin Foil Boat Challenge

Use the following page to document your Tin Foil Boat Challenge! Alternatively, record a video that shows your design and your process. Use the following page as prompts as to what to include in your video.

Design:
Engineers often modify their original design as testing happens. Modifications are necessary in the engineering and design process. Sketch your original design that you started with. What did your boat look like after your testing was complete?

Original Design	Final Design

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Modifications:

Modifications are necessary and demonstrate problem-solving skills and learning. What modifications did you make to your design and why?

Design	Modification Made	Reasoning
Design #1		
Design #2		
Design #3		

Observations:

Testing object (e.g., pennies, washers, beads etc)	
Number of objects your boat held SUCCESSFULLY before it sank? (e.g., it sank when I put the 38th penny in...so your boat successfully held 37)	

Notable Observations (e.g., the sides started to collapse in at object #_)

Reflection:

1. What made your design successful or not so successful?
2. If you were to try again with a new piece of tin foil, what would you change or modify from the beginning?

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Appendix E

Float Your Boat Challenge

Buoyancy is the upward force that keeps objects afloat. An object will float if its buoyancy is greater than its weight. It will sink if the object's weight is greater than its buoyant force.

Using your knowledge of buoyancy and expertise picked up from your Tinfoil Boat Challenge, you are to design a new and better boat. You may choose your materials, but they must either be all from nature (e.g., leaves, sticks, fallen bark) or all recycled materials (e.g., egg carton, newspaper, plastic bag). Your design must not exceed 30cm in any direction. Your goal is to at least double the amount of weight your tinfoil boat held before sinking.

Design:
Engineers often modify their original design as testing happens. Modifications are necessary in the engineering and design process. Sketch your original design that you started with. Include measurements and a materials list on the side.

Original Design view #1	Original Design view #2

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Modifications:
Modifications are necessary and demonstrate problem-solving skills and learning. What modifications did you make to your design and why?

Design	Modification Made	Reasoning
Design #1		
Design #2		
Design #3		

Draw your final design. Include measurements and a materials list on the side.

Final Design:

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Observations:

Testing object (e.g., pennies, washers, beads etc)	
Number of objects your boat held SUCCESSFULLY before it sank? (e.g., it sank when I put the 38th penny in...so your boat successfully held 37)	

Notable Observations (e.g., the sides started to collapse in at object #_)

Reflection:

1. What made your design successful or not so successful?
2. What do you think would happen if you used another liquid for your boat to rest in? Do you think you would get the same results? Why or why not?
3. Do you think the shape of your boat contributed to its buoyancy? What shape is best for the hull of the boat?
4. What would you like me to notice about your boat?