cardboard BOAT RACE CHALLENGE

Teacher Resource Package

STRUCTURES AND DESIGN
INTERGRATED MATH, SCIENCE, ENGLISH LANGUAGE ARTS,
CAREER EDUCATION, AND PAA-DESIGN STUDIES UNIT

Edited 2019

INTRODUCTION

This unit is designed for use in grade eight as a pre-unit of study for the Cardboard Boat Race Challenge or as an integrated Practical and Applied Arts unit of study. The Cardboard Boat Race Challenge is coordinated by the Saskatoon Industry-Education Council (SIEC)**. This unit was developed for use in the school divisions represented by the SIEC. Copyright is reserved.**

The SIEC would like to thank contributors from Greater Saskatoon Catholic School, Prairie Spirit School Division, Saskatoon Public Schools, and the Saskatoon Tribal Council for their support in creating this evolving teaching resource.

This unit encompasses outcomes from the following Saskatchewan Learning Grade 8 curricula:

Science

- Develop Scientific and Technological Skills – Students will develop the skills required for scientific and technological inquiry, problem-solving, and communicating; for working collaboratively; and for making informed decisions. (p. 6)
- The Saskatchewan Curriculum also emphasizes inquiry:
  - Identify questions that can be answered through scientific investigations
  - Design and conduct a scientific investigation
  - Use appropriate tools and techniques to gather, analyze, and interpret data
  - Develop descriptions, explanations, predictions, and models using evidence
  - Think critically and logically to make the relationships between evidence and explanations
  - Recognize and analyze alternative explanations and predictions
  - Communicate scientific procedures and explanations
  - Use mathematics in all aspects of scientific inquiry (p. 7-8)

Math

- Logical Thinking – students should develop and be able to apply mathematical reasoning processes, skills, and strategies to new situations and problems. (p. 7)

English Language Arts

- Compose and Create (CC) – students will extend their abilities to represent, speak, and write to explore and present thoughts, feelings, and experiences in a variety of forms for a variety of purposes and audiences. (p. 4)

Practical and Applied Arts – Design Studies

- Design Studies aim to provide experiences for developing proficiency in problem-solving, goal setting, critical thinking, and to provide opportunities to develop co-operative work skills and technical skills using a design process. (p. 1)

Career Education

- The goals of Career Education are to:
  - Develop career management competencies through an exploration of personal change and growth
  - Explore the connections between learning and work pathways and their connections to community
  - Engage in inquiry to construct a personal life and work plan. (p. 4)

Unit Outline and Curricular Outcomes

Lesson		Outcomes	Activity	Materials	Assessment	Hours*
#1	Introduction to Cardboard Boat Race Unit	This unit meets outcomes from the following Saskatchewan Learning curricula: **Science, Math, English Language Arts, PAA: Design Studies, Career Education**	Overview of unit: show video from previous years and introduce design log/journal. Organize teams of 4 students (max)	Projector Boat Race video and photos Design Log	None	1
#2	Principles of Design	***Design Studies:*** 1.1 – 1.5 ***Mathematics:*** SS8.2 ***ELA:*** CC8.4, CC8.5	Students collaborate to make a box out of tag paper to learn about measurement, construction, and building to spec.	Handouts - "Package Design"	Lesson #2 - Principles of Design: Package Design Rubric Optional journal entry	1 – 2
#3	Buoyant Forces	***Science:*** FD8.1 (a, b, c, d) FD8.2 (a, b, c)	View Bill Nye Buoyancy video. Review buoyant forces Read "The Story of Archimedes" and examine key terms. Conduct experiment on Buoyance and Archimedes Principle.	Bill Nye – Buoyancy video and Questions The Story of Archimedes Buoyant Forces: SINK or SAIL Lesson #3 Activity: Buoyancy and Archimedes' Principle *Student Observation Recording Sheet* Materials for Experiments	Lesson #3: Buoyancy and Archimedes' Principle *Student Observation Recording Sheet* Optional journal entry	2 – 3
#4	Density	***Science:*** FD8.1 (a, b) FD8.2 (a, f, g)	Conduct density experiment with egg and water by adding salt to water. Students complete "Egg in Salt Water Worksheet."	Beaker, raw egg, salt, water, a stirrer for each station Copies of "Egg in Salt Water" worksheet for all students	Lesson #4: Egg in Salt Water: Worksheet	1
#5	All About Boats	***Science:*** FD82. (l) ***ELA:*** CC8.4	Brainstorm parts, names, and structures of boats. Different *Types of Boats* activity	Computers Copies of the "*Different Types of Boats"* activity	Optional journal entry	1 – 2

Lesson		Outcomes	Activity	Materials	Assessment	Hours*
#6	Boat Research Activity (Optional)	***Design Studies:*** 1.2, 1.4 ***Science:*** FD82. (k, l) ***ELA:*** CR8.2, CR8.7	Have students prepare a short report of a type of boat or have students research two different boat designs.	Books on boats Computer access Library access to encyclopedias Saskatchewan Science 8 textbook	Lesson #6: Boat Research Rubric	2 -3
#7	Buoyancy and Water Displacement	***Design Studies:*** 1.1 – 1.6 ***Science:*** FD8.1 (a, b) FD8.2 (a, c, d, f, g, h, l) ***Mathematics:*** SS8.2, SS8.3	Students will create a tinfoil boat that will carry the greatest amount of mass without sinking. They will complete an experiment to explain how water density, mass and volume all play a part in why a boat floats.	Tin foil, rulers, scissors, paper towels, plastic tub for water, washers or weights Hairdryer and meter sticks (for enrichment opportunity) Rags/mop for clean-up Lesson #7 – Buoyancy and Water Displacement: "Building a Tinfoil Boat" worksheet	Lesson #7 – Buoyancy and Water Displacement: "Building a Tinfoil Boat" questions. Optional journal entry	1 – 2
#8	Recognizing Water Resistance	***Science:*** FD82. (c, d, f)	Discuss "Key Terms." View Olympic Sculling video Discuss how the shape/design of boats affect speed.	Projector to watch video	Optional journal activity	1
#9	Center of Gravity	***Science:*** FD82. (a, b, c, d, f) ***ELA:*** CR8.3	Students will design an experiment to test for the center of gravity or use of the experiment options. Each experiment will consist of a problem, hypothesis, materials, method, observations, conclusion, application to real life, and application to boat design.	Textbooks Equal sized objects or weights to drop on each stack Forks, corks, carrots, glasses, pencils Lollies (sugary-powdery lollipops that are pink/blue, etc.) Lesson #9 - Center of Gravity Experiment student worksheets	Lesson #9 - Center of Gravity Experiment student worksheets Optional journal entry	1 – 2

Lesson		Outcomes	Activity	Materials	Assessment	Hours*
#10	Create your own Boat Design Sketch & Prototype	***Design Studies:*** 1.1 – 1.5 ***Science:*** FD82. (a, c, d, f, g, h, I) ***Mathematics:*** SS8.2., N8.3	In their Cardboard Boat Race Challenge teams of 4, students will create a sketch and prototype for their boat design. Groups must also create a team name incorporating terminology or slang pertaining to boats, the ocean, water, etc. Review the details and instructions for the cardboard boat race.	Cardboard Boat Graph Paper Template Rulers, Scissors, glue, tape, coloured pencils or markers, meter sticks, bristle board paper Prototype materials: 2 exacto knives; 2 pencils, ¼ roll of masking tape, sheets of Bristol board, a ¼ roll of duct tape	Student self-assessment using the Cardboard Boat Race Challenge Judging Criteria Rubric Lesson #10 - Create Your Own Design Evaluation Sheet	2- 5
Cardboard Boat Race Challenge		***Design Studies*** ***Science*** ***Math*** ***ELA*** ***Career Education***	Students will apply the knowledge they gained from this unit to design and construct a cardboard boat that can travel 50m as quick as possible while maintaining its structural integrity.	Provided by the SIEC: 1 roll packing tape 1 roll duct tape 1½ sheets of cardboard 2 exacto knives 2 pencils scissors	Students are assessed using the Judging Criteria Rubric	6
#11	Cardboard Boat Race Challenge Evaluation	***ELA:*** CC8.3, CC8.5, CC8.6	Students will provide an analysis of how the cardboard boat challenge process went for their team.	Lesson #11 - Cardboard Boat Challenge – Group Reflection	Lesson #11 - Cardboard Boat Challenge – Group Reflection Self-assessment	1
#12	Career Exploration in Design (optional)	***Career Education:*** CC8.1, CC8.2	Individually or in pairs, students will use websites resources or interview a professional to research careers in the Design field.	Computers Lesson #12 - Career Exploration in Design: Occupational Search Art supplies	Lesson #12 – Career Exploration in Design: Occupational Search Rubric	1-3
					***Total Instructional Time**	**20 – 30**

**Instructional time may vary depending on student comprehension and lesson selection*

Lesson #1 – Introduction to Cardboard Boat Race Unit

Curricular Outcomes:

- This unit will meet various outcomes from the following Saskatchewan Learning curricula: Science, Math, English Language Arts, PAA: Design Studies

Materials:

- Boat Race video and pictures teachers have from previous years
- If you do not have any resources to reference, use the following links:

  Cardboard Boat Races Saskatoon link or search "Cardboard Boat Races Saskatoon".

  Cardboard Boat Race Photos link

- Design Log

Procedures:

- Give an overview of what students will study in this unit.
- Show videos and photos from previous years.
- Have students make notes of what they notice about the build and the race in the videos and photos. These can aid in their design process later in the unit.
- Make teams of 4 students (max) who will work together throughout the unit and for the Cardboard Boat Race Challenge.

***Ensure each team has a member who agrees to pilot the boat in the water. Should this be impossible for every group, you may need to have a student who is willing to pilot two boats.

- Introduce students to the design log which they will use throughout this unit.

***Tips for Using a Design Log:

- Keeping accurate records of experiments and designs is an important part of engineering design.
- A design log combines aspects of a journal and a laboratory notebook.
- A journal is often used to reflect on experiences or to express and develop ideas.
- Students are to use their design log to record procedures in words and pictures, to record experimental data and to analyze results.
- Students are all responsible for completing these tasks in a journal.
- Students must take time to express their thoughts in detail and keep their journal organized.
- Each team member completes his/her own journal entries.
- All entries must be organized in a duotang in sequential order.
- If students do not have a duotang, they must create a title page and staple all the entries together - in order.

Assessment:

- None

Cardboard Boat Race Design Log

Name: _____

Team Name: _____ **Date:** _____

- For everything that you create in this unit, you must record your design work in a design log.
- You need both verbal descriptions and drawings for each design that you create.
- You should record your design, the knowledge or assumptions on which your design is based, the tests performed on your design, the results of the tests, changes or modifications that would enhance performance, and any questions that you may have for your teacher.

Sketches	Observations & Data
Sketches	**Observations & Data**

Lesson #2 – Principles of Design

Curricular Outcomes:

PAA – Design Studies

- 1.1 To recognize the steps in the design process.
- 1.2 To explore the steps in the design process. (CCT, TL, NUM)
- 1.3 To discuss the project with the teacher using appropriate terminology.
- 1.4 To discuss the project with other students. (PSVS)
- 1.5 To maintain a written journal and a design portfolio. (COM)

Mathematics

- SS8.2: Demonstrate an understanding of the surface area of 3-D objects limited to right prisms and cylinders (concretely, pictorially, and symbolically) by:
  - analyzing views; sketching and constructing 3-D objects, nets, and top, side, and front views; generalizing strategies and formulae; analyzing the effect of orientation; solving problems.

English Language Arts

- CC8.4: Use pragmatic, textual, syntactical, semantic/lexical/ morphological, graphophonic, and other cues to construct and to communicate meaning.
- CC8.5: Create and present a variety of visual and multimedia presentations including an illustrated report, a role play that ends with a tableau, a dramatization, presentation software, a newscast with adequate detail, clarity, and organization to explain, to persuade, and to entertain.

Materials:

- Lesson #2 – Principles of Design: Package Design Assignment
- Design log

Procedures:

1. Review how to complete a design log properly.
2. Students will collaborate within their group to make a box out of tag paper to learn about measurement, construction, building to specifications, and using a log to record their work.
3. Design Practice: Students will design a product package according to the specs presented on the handout titled, **"Package Design."**

Follow-up Activities/Assignment:

- Optional journal activity: have students create a journal entry for the lesson, outlining:
  1. Their thoughts so far and what they have learned about boat design
  2. Any other ideas so that they may refer to them for their final design.

Assessment:

- Lesson #2 - Principles of Design: Package Design Evaluation Rubric.
- Optional journal activity: assess students' understanding of how the principles of design may affect their boat design.

Lesson #2 – Principles of Design: Package Design Assignment

Purpose:

- Students will collaborate within their group to make a box out of tag paper to learn about measurement, construction, building to specifications, and using a log to record their work.

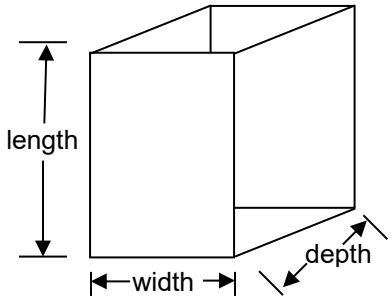
- "Bodily H'odeurs" is an international corporation based in France that is responsible for producing many beauty and bath consumer products. Their latest creation, "Non-Scents" body spray is ready to be sold. A new box is required to hold a bottle of "Non-Scents."

Challenge:

- Your challenge is to design and build a box to hold a bottle of "Non-Scents" body spray.

Specifications:

- Work in pairs
- The box dimensions must be:
  - Width: 5cm (2 inches)
  - Depth: 4cm (1.5 inches)
  - Length: 15 cm (6 inches)



- The box must be made of a biodegradable paper product.
- The package, or parts of the package, may be held together with an adhesive (glue/tape).
- The package must be able to be shipped flat and easily assembled upon reaching its destination
- The package must have the following information
  a) A company logo
  b) Company name
  c) Product name
  d) Your design team name…. (Designed by _____)
- The package must be attractive and appropriate for your target group.
- The package must be designed, built, and ready for evaluation by: _____.

Log:

- Be sure to complete a log of the design process.
- Make a note of your attempts and record what worked, what didn't and what improvements and changes you made during the planning process.

Lesson #2 – Principles of Design: Package Design Rubric

Student(s): _____ _____

_____ _____

Criteria	1	2	3	4
Preparation	Needed continual prompting to reach the goal	Needed occasional prompting to reach the goal	Did not need prompting to reach the goal	Worked consistently and actively to reach the goal
The structure is built to Spec. *check below*	One or fewer of the specs are met	Two of the specs are met	Three of the specs are met, but the measurements are off	All the specs are met and exact.
Design Sketches	Sketches are inaccurate and without detail	Sketches are present, but more detail is necessary	Sketches are present and labelled properly	Sketches are present and detailed with measurements
Design Description	Data is missing and inaccurate	One of the following areas is missing from the description: ▪ Changes, ▪ Modifications, ▪ Design ideas	Changes, modifications, and design ideas are all identified	Changes, modifications, and design ideas are all identified and descriptive.
Construction	The package is unstable, not easily accessible, and not built to spec.	The package is built to spec. but is not easily accessible or stable	The package is built to spec., easily accessible, and is stable	The package is built to spec., easily accessible, is stable, and all glued (or taped) joints are hidden from view.
Appearance	Artwork and logo are not appealing. Spelling and grammatical errors are present	Artwork, logo, and presentation need to be more creative	Artwork, logo, and presentation are creative and well organized	Artwork, logo, and presentation look professional, totally free of errors.
Total:	**/24 marks**			
Teacher Feedback:				

*Specs: Package must be shipped flat and easily shipped
Measurements, as mentioned, are used
Package shows name, logo, company name, and product name

Lesson #3 – Buoyant Forces

Curricular Outcomes:

Science

- FD8.1 Investigate and represent the density of solids, liquids, and gases based on the particle theory of matter.
  Indicators:
  a. Illustrate the relationship between mass, volume, and density of solids, liquids, and gases using the particle theory of matter.
  b. Design and carry out processes, including the water displacement method, to determine the density of various regularly shaped and irregularly shaped materials.
  c. Use instruments safely, effectively, and accurately for collecting data about the density of solids, liquids, and gases.
  d. Measure the mass and volume of a variety of objects, record the data in tabular form, and display the data graphically.
- FD8.2 Examine the effects of forces in and on objects in fluids, including the buoyant force
  Indicators:
  a. Identify questions to investigate arising from practical problems and issues involving floating, sinking, and buoyancy ("Why do some objects float, and some objects sink?")
  b. Examine contributions of people from various cultures to understanding the principles of buoyancy, including Archimedes Principle.
  c. Conduct a fair test to identify which factors determine whether a given object will float or sink. Discuss reasons why scientists control some variables when conducting a fair test.

Supportive Resources:

- Textbook resources about 'water displacement' and 'center of buoyancy'
- Online simulations for Buoyancy – PhET Interactive Simulations
- What is Buoyancy Website

Materials:

- Bill Nye the Science Guy – Buoyancy Video – or Search YouTube Bill Nye Buoyancy
- Bill Nye the Science Guy – Buoyancy Video Questions
- The Story of Archimedes
- Buoyant Forces: SINK or SAIL
- Buoyancy and Archimedes' Principle Activity and Student Observation Recording Sheet

Materials for Experiments:

- 2-litre bottles, cut in half or two glass beakers, with increments marked on the side
- Various objects that sink that will fit in the bottle, such as a padlock, hockey puck, can of pop (regular), rocks,
- Various objects that float ON THE SURFACE, such as a piece of flat foam, plastic discs or lids, diet pop; various objects that float, but partially submerged, such as fruit, tennis ball, a bar of soap, etc.
- Shallow dish
- Digital scale

Key Terms:

- *Archimedes Principle* – states that the buoyant force on a submerged object is equal to the weight of the fluid that is displaced by the object.
- *Force* – a push or a pull that tends to cause an object to move or change motion.
- *Contact vs. non-contact force* – quite simply, a contact force is when the object needs to be touched by the force, and a non-contact force doesn't require touching. Pushing your friend on a swing is a contact force while using a magnet is a non-contact force.
- *Gravitational force* – the amount of gravity that is pulling down on an object (pulls towards the center of the Earth)
- *Buoyant force* – the amount of force that tries to push up on an object (floating away from the Earth)
- *Balanced force* – when the gravitational and buoyant forces are at equal amounts, so the object is neither getting pulled towards the Earth or floating away from the Earth.
- *Non-balanced force* – when the gravitational force is larger than the buoyant force and the object sinks or vice versa

Procedures:

- Watch Bill Nye– Buoyancy Video. Have students complete Buoyancy Video Questions.
- Read the story of Archimedes.
- Hand out the information sheet titled, Buoyancy. Review with your students the different types of forces involved in buoyancy.

Experiment Procedures:

1. *After the Archimedes Principle is discussed, begin the experiment using the following steps:*
   a. Fill both containers with water (to the same level).
   b. Drop one item that floats into one of the bottles, and one item that sinks into the other bottle.
   c. Discuss the results as you repeat these steps, always starting with equal water levels.
   d. Students should come up with the ideas that the water levels change more with the items that sink.
   e. After the activity, inform them that the buoyant force is equal to the weight of the water it displaces.
2. Using copies of the data table, have students weigh each object for this experiment on a scale and record the weights in their data table.
3. Set one of the bottles into the shallow dish, and make sure that the bottle is full to the top, with no water in the shallow dish.
4. Drop the items that have been weighed into the bottle and let the water overflow into the dish. Be sure to use all water balloons, several objects that sink, larger floating objects, and those that will partially float.
5. Weigh the water in the dish (subtracting the weight of the dish itself) and record the weight in the table. Repeat measurements for all items weighed.
6. Complete the comprehension questions

Follow-up Activities/Assignment:

- Review the terms and have the students record thoughts and discoveries as a journal entry.

Assessment:

- Lesson #3: Buoyancy and Archimedes' Principle Student Observation Recording Sheet

Lesson #3 – Buoyant Forces

Bill Nye the Science Guy – Buoyancy Video Questions

Name: _____

1. Water is_____ so it makes things float.
2. The displaced water equals the _____of the boat.
3. The _____ of the clay/tin makes the difference and allows it to float.
4. What did Archimedes discover?

   _____

   _____
5. Objects will sink until _____
6. Explain the pen cap submarine and fish swim bladder.

   _____

   _____
7. Clarify positive, negative, and neutral buoyancy.

   _____

   _____

   _____
8. How does a compensator vest work?

   _____

   _____
9. When the fire heats the air in a hot air balloon, why does it rise?

   _____

   _____
10. When an object displaces an amount of water that weighs as much as it does, it

    _____.

Lesson #3 – Buoyant Forces

The Story of Archimedes

Archimedes was a Greek mathematician, physicist and inventor. He lived from 287-212 B.C. Well known for his ability to solve problems, he was summoned one day by King Hiero II to solve a problem. King Hiero II had given his goldsmith a brick of gold to make the king a crown. Upon receiving the crown, the king, being very suspicious that the goldsmith had stolen some of the gold, weighed the crown. The crown weighed the same as the golden brick so that the king could prove nothing. Still suspicious, the king summoned Archimedes to help him solve this dilemma.

Archimedes was stumped at first. Since the crown had such a different shape than the brick, it was difficult to compare the two. The weights were also the same so that nothing could be proven.

One day, Archimedes was climbing into his full bathtub to have a bath. As he was getting in, water spilled over the sides. He stopped scrubbing and declared “Eureka!” (I’ve found it!) What Archimedes discovered is that he could compare two different objects by measuring how much water they displace. He ran out of the tub, made a couple of experiments, and ran to meet the king.

After the king reminded him to get dressed, Archimedes told the king that he discovered that gold is more dense than silver, so a pound of gold will displace less water than a pound of silver. This is how he could compare the crown and the brick. If the goldsmith was honest, both the crown and the brick should weigh the same and should displace the same amount of water.

Archimedes filled two containers with the same amount of water. In one, he put in a gold brick identical to the one he gave the goldsmith. He measured the water that poured out. In the other, he placed the crown that the goldsmith made, and measured the water that poured out. More water spilled out of the container with the crown than the container with the brick. Conclusion: The goldsmith was a fraud!

*****Explanation:** Gold is more dense, so a pound of gold will be smaller than a pound of silver and will displace less water.

Archimedes’ Principle: Archimedes Principle states that the buoyant force on a submerged object is equal to the weight of the fluid that is displaced by the object.
Archimedes figured out that if the weight of the object being placed in the water is less than the weight of the water displaced, the object will float. This is known as buoyancy or the Archimedes principle.

Why does something float or sink?

Things float or sink because water is heavy. The weight of water determines if an object floats or sinks. An object will float if it displaces (pushes water out of the way) as much water as it weights. If an object displaces less water than it weighs, then it will sink.

Lesson #3 – Buoyant Forces

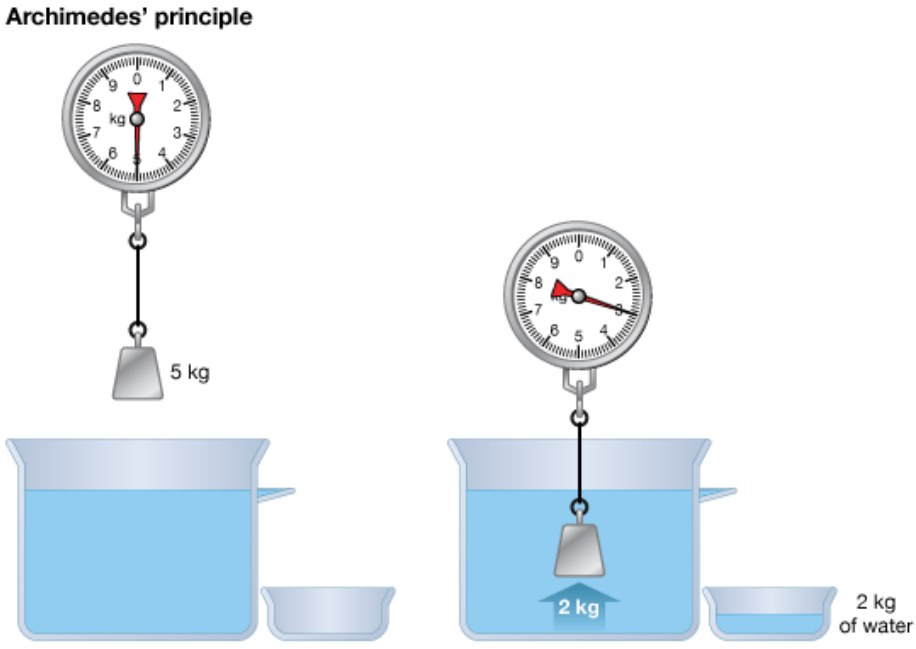
SINK or SAIL

If you drop a metal bar into the water, it will sink to the bottom. Yet, a ship made of the same metal can float. How can this happen?

Here are some terms that will help you understand our new topic - ***Buoyancy.***

- *Force* - a push or a pull that tends to cause an object to move or change motion.
- *Contact vs. non-contact force* - quite simply, a contact force is when the object needs to be touched by the force, and a non-contact force doesn't require touching. Pushing your friend on a swing is a contact force while using a magnet is a non-contact force.
- *Gravitational force* - the amount of gravity that is pulling down on an object (pulls towards the center of the Earth)
- *Buoyant force* - the amount of force that tries to push up on an object (floating away from the Earth)
- *Balanced force* - when the gravitational and buoyant forces are at equal amounts, so the object is neither getting pulled towards the Earth or floating away from the Earth.
- *Non-balanced force* - When the gravitational force is larger than the buoyant force and the object sinks or vice versa

Remember Archimedes? He did some more research into water displacement and discovered that the buoyant force acting on an object is equal to the weight (amount) of water displaced. If Archimedes had measured the water that spilled over his bathtub, that amount would be the buoyant force of the water that was pushing up on him. The device used in the diagram below is a spring scale. It measures the force or weight of an item, not the mass of the item. Notice how the 5 kg object below has displaced 2 kg of water, so it has a force of 3 Newtons (5-2=3).



Lesson #3: Buoyancy and Archimedes' Principle Activity

Purpose:

- Archimedes Principle states that the buoyant force on a submerged object is equal to the weight of the fluid that is displaced by the object. The purpose of this experiment is to determine the buoyancy of different objects in water and how water displacement can be used to determine the buoyant force of an object.

Hypothesis (an educated guess on what you think the results of the experiment will be):

Materials:

- 2-litre bottles, cut in half or two glass beakers, with increments marked on the side
- Various objects that sink that will fit in the bottle, such as a padlock, hockey puck, can of pop, rocks, ceramic coffee mug, etc.
- various objects that float ON THE SURFACE, such as a piece of flat foam, plastic discs or lids, etc. various objects that float, but are partially submerged, such as fruit, tennis ball, empty small pop bottle with the lid on it, a bar of soap, etc.
- water balloons (make 3 or 4 of different sizes that will fit in the 2 L bottle)
- shallow dish
- scale

Procedure:

1. Fill both containers with water to the same level.
2. Drop one item that floats into one of the bottles and one that sinks into the other bottle.
3. Observe the water levels of the containers and make notes on how the water levels are dependent on whether the item sinks or not.
4. Using copies of the data table, weigh each item and record the weight of each item.
5. Weigh the shallow dish and record its weight.
6. Set one of the containers into a shallow dish, ensuring that the container is full to the top.
7. Drop the items that have been weighed into the container one at a time and let the water overflow into the shallow dish.
8. Record the weight of the shallow dish with the overflow water. Subtract the weight the dish from the total weight of dish and water to discover the Displaced Water Weight. Record your data into the table. Repeat for each item.
9. Complete the data table and complete the comprehension questions.

2-litre pop bottle filled to the top

Place tennis ball in bottle

Weight of dry tennis ball

Weight of water displaced (the weight of the glass bowl was tared (or zeroed).

Lesson #3: Buoyancy and Archimedes' Principle Activity

Student Observation Recording Sheet

Name: _____

Hypothesis (an educated guess on what you think the results of the experiment will be):

_____

_____

Item Description	Weight	Displaced Water Weight	Float or Sink?

Comprehension Questions:

1. **After completing the experiment and filling in your "Student Observation Recording Sheet", how would you explain to someone whether something will float or sink?**

   _____

   _____

2. **How does this experiment support or refute the Archimedes Principle?**

   _____

   _____

3. **Was your hypothesis correct?**

   _____

4. **Were there any "Sources of Error" in the experiment that may have affected the recorded data?**

   _____

   _____

5. **How can you use this knowledge to assist with the building of your cardboard boat?**

   _____

   _____

Lesson #4 - Density

Curricular Outcomes:

Science

- FD8.1 Investigate and represent the density of solids, liquids, and gases based on the particle theory of matter.
  Indicators:
  a. Illustrate the relationship between mass, volume, and density of solids, liquids, and gases using the particle theory of matter.
  b. Design and carry out processes, including the water displacement method, to determine the density of various regularly shaped and irregularly shaped materials.
- FD8.2 Examine the effects of forces in and on objects in fluids, including the buoyant force
  Indicators:
  a. Identify questions to investigate arising from practical problems and issues involving floating, sinking, and buoyancy ("Why do some objects float, and some objects sink?")
  f. Express the quantitative relationship between pressure, force, and area in fluids.
  g. Conduct a fair test to identify which factors determine whether a given object will float or sink, and discuss reasons why scientists control some variables when conducting a fair test

Supportive Resources:

- Density Definition Website (or any other website or resource on density)
- Online simulations for Density – PhET Interactive Simulations

Materials:

- Beaker, raw egg, salt, water, a stirrer for each station
- Copies of "Egg in Salt Water" worksheet for all students

Procedures:

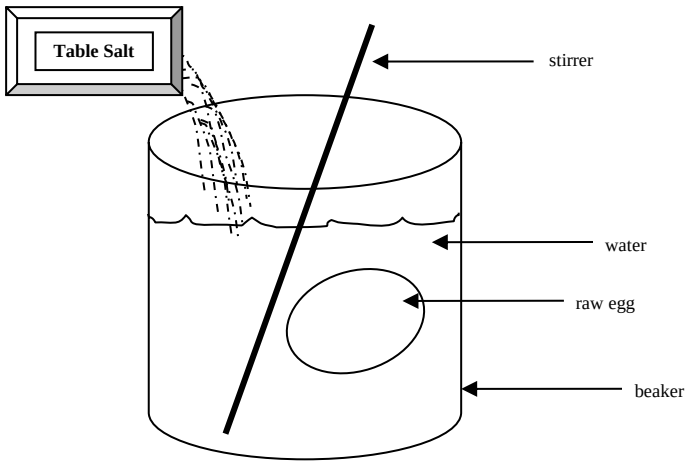
- Motivate students with the following 'useless trivia question': If you have eggs in the fridge and you are wondering if they are still fresh, what can you do?
- Answer: You can set the eggs in a jar full of water. Those that float are 'expired,' and those that sink are still fresh.
- The science behind this: Eggs that are old begin to decompose, or 'gas up.' As the level of gas increases, they are less dense, and will no longer rest on the bottom of the jar. Instead, they will begin to float or partially float.
- Keeping the trivia question in mind, conduct the following experiment:
  - Fill a beaker 2/3 full of water (see diagram on next page).
  - Ask students, "What will the egg do in the water, sink or float?"
  - Put the egg in the beaker of water. Slowly pour salt into the water and stir carefully.
- Answer the questions on the "Egg in Salt Water" worksheet.
- Discuss discoveries and extend the discussion to applying knowledge to the building of boats.

Assessment:

- Lesson #4: Egg in Salt Water: Worksheet

Lesson #4 – Egg in Salt Water: Worksheet
Name: _____

Diagram of Egg and Salt Experiment



Answer the following questions in complete sentences:

1. What is density?

   _____
   _____

2. a) When the egg is on the bottom of the beaker, what is denser, the water or the egg?

   _____
   _____

   b) How do you know this?

   _____
   _____

3. a) When salt is added to the water, what happens to the water's density?

   _____
   _____

   b) What proof did you see of this?

   _____
   _____

4. If you know the density of two objects, how can you tell which one will sink and which one will float?

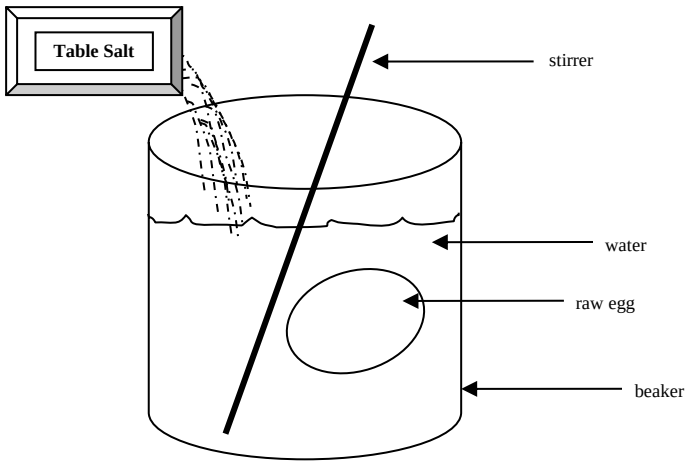
   _____
   _____

5. What does it mean if the egg sits suspended in the mixture, neither at the top nor the bottom?

   _____
   _____

Lesson #4 – Egg in Salt Water: Worksheet
Name: Answer Key

Diagram of Egg and Salt Experiment



Answer the following questions in complete sentences:

1. What is density?

   Density is a measurement that compares the amount of matter an object has to its volume.

   Density is the degree of compactness of a substance or how tightly that stuff is packed together.

2. a) When the egg is on the bottom of the beaker, what is denser, the water or the egg?

   The egg is more dense.

   b) How do you know this?

   The egg is 'heavier' than the same volume of water, and it sinks to the bottom. It is more dense.

   There is more 'stuff' in it compared to the same volume of water.

3. a) When salt is added to the water, what happens to the water's density?

   The water becomes more dense. There is more 'stuff' added to it.

   b) What proof did you see of this?

   The proof was that the egg started to rise. It was no longer the denser object.

4. If you know the density of two objects, how can you tell which one will sink and which will float?

   The object with the greater density will sink, while the one with relatively less density will float.

5. What does it mean if the egg sits suspended in the mixture, neither at the top nor the bottom?

   This means that the egg has the same density as the water.

Lesson #5 – All About Boats

Curriculum Outcomes:

Science

- FD8.2 Examine the effects of forces in and on objects in fluids, including the buoyant force.
  I. Analyze designs of traditional and contemporary watercraft (e.g., canoe, kayak, lake boat, catamaran, and jet-ski) with respect to the principles of buoyancy.

English Language Arts

- CC8.4: Use pragmatic, textual, syntactical, semantic/lexical/ morphological, graphophonic, and other cues to construct and to communicate meaning.

Supportive Resources:

- Types of boats website & Parts of a boat website
- Other websites of your choice

Materials:

- Computers
- Copies of the "*Different Types of Boats"* activity for all students

Procedures:

1. Brainstorm parts, names, and structures of boats.
2. Accept answers without worrying about proper terms. Use prompting questions such as:
   a. Why does a boat float?
   b. What are the names of some boats?
   c. What are the terms for the front/back of a boat?
   d. What are boats used for?
   e. How do boats stay together?
3. Use the websites or portions of the websites you selected to take the discussion further.
4. Option: have students answer specific questions or draw/label a boat or the parts of a boat.
5. Have students present their finding to the class and discuss.
6. Have students complete the Different *Types of Boats* activity

Follow-up Activities/Assignment:

- Optional journal activity: have students create a journal entry for the lesson, outlining:
  1. Their thoughts so far and what they have learned about boat design
  2. Any other ideas so that they may refer to them for their final design.

Assessment:

- For journal activity, assess students' understanding of the elements from the brainstorming activity and the online resources in their answers.

Lesson #5 – All About Boats

DIFFERENT TYPES OF BOATS MATCHING PAGE

Name: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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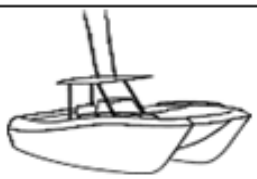
Lesson #5 – All About Boats

DIFFERENT TYPES OF BOATs MATCHING PAGE
ANSWER KEY

pedal boat



center console fishing boat

airboat

inflatable boat

kayak

cruising sailboat

waterski boat

pontoon

dinghies, rowing

houseboat

sailboard

trawler

high performance

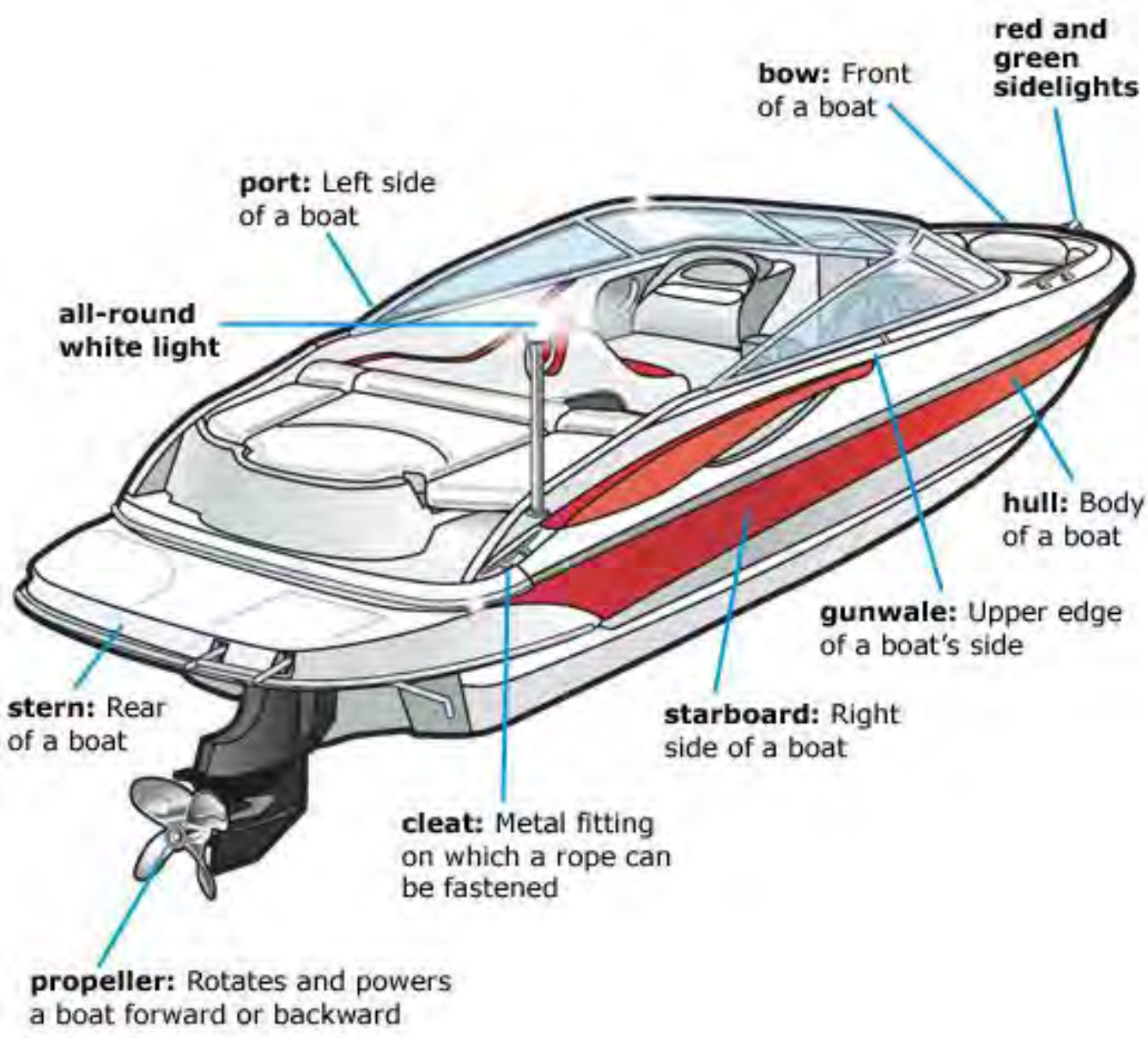
canoe

personal watercraft

folding

multihulls, sail

Lesson #5 – All About Boats



Lesson #6 – Boat Research Activity (Optional)

Curricular Outcomes:

PAA – Design Studies

- 1.2 To explore the steps in the design process. (CCT, TL, NUM)
- 1.4 To discuss the project with other students. (PSVS)

Science

- FD8.2 Examine the effects of forces in and on objects in fluids, including the buoyant force
  - k. Explain the operation of technologies whose development is based on scientific understanding of the properties of fluids (e.g., personal flotation devices, float planes, surfboards, gliders, anti-freeze tester, and heart pumps).
  - l. Analyze designs of traditional and contemporary watercraft (e.g., canoe, kayak, lake boat, catamaran, and jet-ski) with respect to the principles of buoyancy.

English Language Arts

- CR8.2 Select and use appropriate strategies to construct meaning before, during, and after viewing, listening, and reading.
- CR8.7 Read independently and demonstrate comprehension of a variety of informational texts including understanding the main ideas and supporting evidence, explaining connections between new ideas and information and previous thoughts, and recognizing any biases or false reasoning.

Supportive Resources/Materials:

- Books on boats, computer access, library access to encyclopedias
- Page 226 of the Sask Science 8 textbook (comparison of kayaks vs canoes)

Procedures:

Option #1: *Have students prepare a short report on a type of boat chosen from the Different Types of Boats Matching page.*

1. Students should create a handout with a diagram for the rest of the class and be prepared to orally present (teach) their findings.
2. Presentations should focus on the technical, social and cultural implications of design and construction, the technical parts of the boat, its functions, and where we might see it.
3. Reports require a cover page, a body of one to two pages, a bibliography, and a diagram.

Option #2: *Research 2 boat designs 1 with a motor, 1 without a motor. A list of possible boat designs can be found on Different Types of Boats activity from last day.*

1. For each boat design describe how the boat looks and functions then provide details relating to the *history, use, strengths and weaknesses of each boat design*.
2. This assignment should be completed on loose leaf and kept in your journal.
3. Each boat write-up must be at least 100 words in complete sentences.

Assessment:

- Use rubric to assess the students' ability to create reasons and defend their boat design.

Lesson #6 – Boat Research Activity (Optional)

Student Name(s):				
Both students and teachers assess the research report. All points are awarded to a specific category if the listed criteria are met, while partial points are awarded if partial criteria are met.				
Category	**Scoring Criteria**	**Points**	**Student Evaluation**	**Teacher Evaluation**
Title Page ***5 points***	This page must include a title, the names of the authors, the date, and an illustration relevant to the research.	**5**		
Introduction ***15 points***	A statement makes the research topic clear, and three to four supporting statements describe the contents of the research paper.	**10**		
	The introduction motivates the reader to read on.	**5**		
Report of Research 30 ***points***	An effort is present to use terms and concepts from the brainstorming portions, as well as those discovered in research.	**10**		
	Research findings are presented in the student's words, not "cut and pasted."	**10**		
	The work is divided into necessary sentences and paragraphs.	**10**		
Conclusion ***15 points***	The most important research findings are restated.	**5**		
	Student's final thoughts about the research topic are stated .	**5**		
	No new information is introduced.	**5**		
Bibliography ***5 points***	A single page listing bibliography is provided according to classroom instructions.	**5**		
Diagram ***15 points***	Diagram relates to the boat researched.	**5**		
	The diagram is useful in understanding the topic.	**5**		
	The diagram includes labels or a legend.	**5**		
Presentation ***15 points***	Evidence of proofreading and rewriting exists.	**10**		
	Paper is neat, in order and submitted on time.	**5**		
Score	**Total Points**	**100**		

Lesson #7 – Buoyancy and Water Displacement

Curricular Outcomes:

PAA – Design Studies

- 1.1 To recognize the steps in the design process.
- 1.2 To explore the steps in the design process. (CCT, TL, NUM)
- 1.3 To discuss the project with the teacher using appropriate terminology.
- 1.4 To discuss the project with other students. (PSVS)
- 1.5 To maintain a written journal and a design portfolio. (COM)
- 1.6 To conduct a presentation for a project outlining the design process development as it applies to the project. (IL)

Science

- FD8.1 Investigate and represent the density of solids, liquids, and gases based on the particle theory of matter.
  Indicators:
  a. Illustrate the relationship between mass, volume, and density of solids, liquids, and gases using the particle theory of matter.
  b. Design and carry out processes, including the water displacement method, to determine the density of various regularly shaped and irregularly shaped materials.
- FD8.2 Examine the effects of forces in and on objects in fluids, including the buoyant force
  Indicators:
  a. Identify questions to investigate arising from practical problems and issues involving floating, sinking, and buoyancy (e.g., “What factors affect the amount of cargo a barge can hold?”, “Why do some objects float and some objects sink?”, and “How can a ship made of steel float in the ocean?”).
  c. Explain the concept of force and provide examples of different types of contact and non-contact forces.
  d. Illustrate, using force diagrams, the movement of objects in fluids in terms of balanced and unbalanced forces acting on the objects.
  f. Express the quantitative relationship between pressure, force, and area in fluids.
  g. Conduct a fair test to identify which factors determine whether a given object will float or sink and discuss reasons why scientists control some variables when conducting a fair test.
  h. Use a technological problem-solving process to design, construct, and evaluate a prototype of an object that floats and can carry the greatest amount of cargo.
  l. Analyze designs of traditional and contemporary watercraft (e.g., canoe, kayak, lake boat, catamaran, and jet-ski) with respect to the principles of buoyancy.

Mathematics

- SS8.2 Demonstrate understanding of the surface area of 3-D objects limited to right prisms and cylinders (concretely, pictorially, and symbolically) by:
  - analyzing views, sketching and constructing 3-D objects, nets, and top, side, and front views, generalizing strategies and formulae, analyzing the effect of orientation, solving problems.
- SS8.3 Demonstrate understanding of volume limited to right prisms and cylinders (concretely, pictorially, or symbolically) by:
  - relating area to volume, generalizing strategies and formulae, analyzing the effect of orientation, solving problems.

Supportive Resources:

- Online simulations for Buoyancy – PhET Interactive Simulations
- Pages 224 – 225 in Pearson Sask Science 8 textbook

Materials:

- Sheets of tin foil, rulers, scissors, paper towels, washers or weights
- Plastic tub for water
- Hairdryer and meter sticks (for enrichment opportunity)
- Rags/mop for clean-up
- Lesson #7 – Buoyancy and Water Displacement: Building a Tinfoil Boat worksheet

Procedures:

- Give details of tinfoil boat competition.
- Explain that they are developing methods to test boats when they are built.
- The task is to create a tinfoil boat that will carry the greatest amount of mass without sinking.
- Have students create their boats. Allow approximately 15 minutes of build time.
    - Distribute 2 sheets of 20 x 20 cm tinfoil (tape is optional).
    - Create a boat. Students may form it any way they like but add no other materials.
    - Each group test their boat in the tub of water to see if it floats, but you may not test how many washers/weights it can hold.
    - Sketch the design of the boat.
- Teams present boats and use a T-chart to predict the strengths and weaknesses of their boat.
- Complete the experiment to explain how water density, mass and volume all play a part in why a boat floats.
- Begin by gently placing one washer at a time in each boat.
- Be sure to count the number of washers that each boat can hold before it sinks, and to 'balance out' or evenly distribute the washers so that the boat sinks from weight, rather than because it tipped over from lopsided weight in it.
- Option: place washers in two different boats – one where they are well balanced, and the other where they are placed all on one side or end.
- When the one with the unbalanced weight tips over, students justify why this happened.
- Determine as a class which group's boat has held the most washers.
- Have the winning team share their boat's design with the class.
- Have students discuss the pros and cons of their design.
- Discuss the outcomes of the experiment and debrief as a group.
- Which boat holds the most weight? (should be a square boat) Why?
- Show images of barges heavily laden with cargo.
- Have students complete the "Building a Tin Foil Boat Questions" or a journal entry.

Follow-up Activities/Assignment:

- Optional journal activity: have students create a journal entry for the lesson, outlining:
    1. Their thoughts so far and what they have learned about boat design
    2. Any other ideas so that they may refer to them for their final design.

Assessment:

- "Building a Tinfoil Boat" questions.
- Optional journal activity: assess students understanding of how the principles of buoyancy and water displacement may affect their boat design.

Enrichment Opportunity: "Blow dryer wind tunnel"

- Place each boat on a table between two meter sticks. The boat that moves the least in the wind tunnel wins.
- Discuss the following question, "Why do canoes have braces?"
- Braces are used to hold the sides of a hull in place. This keeps the sides of the boat from collapsing due to the pressure the water creates on the sides of a boat.
- You can demonstrate this point by creating a tinfoil boat with a V-shaped hull.
- After placing washers into it, the students will see the inferiority of this model.

Lesson #7 – Buoyancy and Water Displacement

Building a Tinfoil Boat

Materials:

- Sheets of tinfoil
- Rulers
- Scissors
- Paper towels
- Tub of water
- Washers or weights

Challenge:

- To complete this task, you will need to think like a boat builder.
- A customer has come to you and asked you to build a boat to transport some cargo.
- You need to build a boat that can hold the most cargo possible.
- You are competing with other boat builders in the area (your classmates) for the job.
- The boat builders who can build the boat that holds the greatest amount of cargo without sinking will get the job.

Specifications:

- The boat is to be constructed out of a piece of tinfoil 20 cm x 20 cm.
- You may alter the square of tinfoil in any way you like, but no other materials may be added (such as tape, glue, etc.).
- The cargo you will be carrying is washers/weights.

Instructions:

- Measure out a square of tinfoil 20 cm x 20 cm.
- Form your boat any way you like but add no other materials.
- You may test your boat in the tub of water to see if it floats, but you may not test how much cargo it will carry.
- Sketch a drawing of your boat.
- Do you think your boat will hold a lot of cargo? Explain why.
- When everyone has completed these instructions, you will test how many washers each boat will hold before it sinks.
- When your teacher directs you, take your boat to the tub of water.
- When it is your turn, you will place your boat in the water.
- Place **one washer/weight at a time** inside your boat.
- Make sure you count how many washers/weights you place in your boat.
- Stop counting when a washer/weight causes your boat to sink.
- Take your boat and the washer/weights out of the water; place them on paper towels to dry.
- BE CAREFUL! (And good luck!)
- Once you have found the winning boat, answer the following questions:

Lesson #7 – Buoyancy and Water Displacement

Building a Tinfoil Boat Questions

Name: _____

Sketch of your Boat

1. Whose boat was able to hold the most washers/weights? _____
2. How many washers/weights did the winning boat hold? _____
3. How many washers/weights did your boat hold? _____
4. Make a sketch of the shape of the following boats:

1st Place boat	Last Place Boat

5. Describe how your boat and the winning boat were different.
   _____
   _____
6. Why do you think the winning boat was able to hold more washers/weights than yours?
   _____
   _____
7. What ideas did you learn from this lesson to incorporate into your cardboard boat design?
   _____
   _____

Lesson #8 – Recognizing Water Resistance

Curricular Outcomes:

Science

- FD8.2 Examine the effects of forces in and on objects in fluids, including the buoyant force.
  - c. Explain the concept of force and provide examples of different types of contact and non-contact forces.
  - d. Illustrate, using force diagrams, the movement of objects in fluids in terms of balanced and unbalanced forces acting on the objects.
  - f. Express the quantitative relationship between pressure, force, and area in fluids.

Supportive Resources:

- Key terms (below)
- Olympic Sculling Final Video

Key Terms:

- **Archimedes principle:** The buoyant force on an object immersed in a fluid is equal to the weight of the fluid displaced.
- **Buoyancy:** The upward force on an object produced by a surrounding gas or liquid, such as water.
- **Center of gravity:** An imaginary point in a body of matter where the total weight of the body is concentrated.
- **Displacement:** In fluid mechanics, displacement occurs when an object is immersed in a fluid, pushing it out of the way and taking its place.
- **Friction:** The force which pushes against an object when it tries to slide over or on another object.
- **Frontal Resistance:** The concept that the more surface area that you present in the direction of the movement, the more resistance you create and the more force you need to overcome that resistance.
- **Water Resistance:** The forces which act upon an object's movement when placed in water.
- **Structural support:** Part of a structure providing the necessary stiffness and strength in order to resist the internal forces.

Procedure:

- View the *Olympic Sculling* video and discuss how the shape/design of their boats affects their speed in the water.

Follow-up Activity/Discussion questions (optional journal entry):

1. What is water resistance?
2. How can water resistance be reduced? (material of the object / streamlining the object)
3. How can this information be applied to the materials in building a boat?
4. How can this information be applied to the shape or design of the boat? (apply what you have learned from the tinfoil boats)

Lesson #9 – Center of Gravity

Curricular Outcomes:

Science

- FD8.2 Examine the effects of forces in and on objects in fluids, including the buoyant force
  Indicators:
  a. Identify questions to investigate arising from practical problems and issues involving floating, sinking, and buoyancy (e.g., "What factors affect the amount of cargo a barge can hold?", "Why do some objects float and some objects sink?", and "How can a ship made of steel float in the ocean?").
  b. Examine contributions of people from various cultures to understanding the principles of buoyancy, including Archimedes Principle, and the development of watercraft such as canoes and kayaks.
  c. Explain the concept of force and provide examples of different types of contact and non-contact forces.
  d. Illustrate, using force diagrams, the movement of objects in fluids in terms of balanced and unbalanced forces acting on the objects.
  f. Express the quantitative relationship between pressure, force, and area in fluids.

English Language Arts

- CC8.3 Select and use the appropriate strategies to communicate meaning before, during, and after speaking, writing, and other representing activities.

Supportive Resources:

- Who Sank the Vasa? YouTube video
- Mystery of the Great Mary Rose YouTube video (key material begins at 31-minute mark)

Key Terms/Concepts:

- **Center of Gravity:** This is the position where all the weight of an object is considered to be centred or balanced. It is not necessarily inside the object. The lower the center of gravity, the greater the stability of the object, or the closer the center of gravity to the base, the greater the stability.

Materials (dependent on experiments):

- Textbooks (uniform and stackable)
- Equal sized objects or weights to drop on each stack
- Forks, corks, carrots, glasses, pencils
- Lollies (sugary-powdery lollipops that are pink/blue, etc.)
- Lesson #9 - Center of Gravity Experiment student worksheets

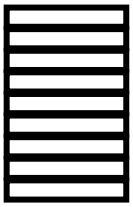
Procedure:

- Have students design their own experiment to test for the center of gravity or use of the experiment options listed below.
- Each experiment will consist of a problem, hypothesis, materials, method, observations, conclusion, application to real life, and application to boat design.

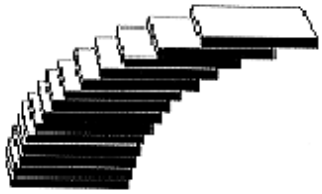
Experiment Option #1

- Have the students use the scientific method for the following problem: How does center of gravity influence a stack of books, stacked uniformly, versus a stack of books stacked in an offset manner when an object or weight is dropped on each stack?

Uniform stack



Offset stack



- Have students complete Lesson #9 - Center of Gravity Experiment worksheet.

Experiment Option #2

- Have the students use the scientific method for the following problem: How is the center of gravity affected when the shape of an object is altered?

Method:

- Insert the forks into a cork or carrot on opposite sides, so the forks stick straight out.
- Balance the cork on the edge of the glass.
- Describe where the center of gravity is located. Draw a diagram showing where you think it is located.
- Change the position of the forks so that they are both angled downward.
- Balance the cork on the point of a sharpened pencil.
- Describe where the center of gravity is located and draw a diagram showing where you think it is located.
- Have students complete Lesson #9 - Center of Gravity Experiment worksheet.

Experiment Option #3

- Have the students use the scientific method for the following problem: How is the balance of an item change when its center of gravity is lowered?

Method:

- Use 2 lollies per station. These are the sugary-powdery lollipops that are pink/blue, etc.
- Cut one lollie down so that there is only a little of the stick left and leave the other lollie as is.
- Have the students try to spin the lollies on the stick ends. Students should record their attempts and their findings.
- The lollie with the shorter stick should spin like a top on its stick, and the other one will probably never successfully spin on its end.
- Have students complete Lesson #9 - Center of Gravity Experiment worksheet.

Follow-up Activities/Assignment: (optional journal entry)

Have students answer the following questions and discuss.

1. How can you predict where the center of gravity is on an object based on its appearance?
2. Further hypothesize: Does the weight of each object make a difference?
3. Draw a boat that would have a problematic center of gravity (will tip easily). Where would that center of gravity be?
4. Draw a boat that would have a more stable center of gravity. Where would that center of gravity be?

Lesson #9 – Center of Gravity: Experiment Worksheet

The Scientific Method

Name(s): _____

Problem:	
Hypothesis:	
Materials:	
Method:	
Observations: (included sketches on the back side of paper)	
Conclusion:	
Applications to real life:	
Applications to boat design:	

1. How can you predict where the center of gravity is on an object based on its appearance?

   _____

   _____

2. Further hypothesize: Does the weight of each object make a difference?

   _____

   _____

3. Draw a boat that would have a problematic center of gravity (will tip easily). Where would that center of gravity be?	4. Draw a boat that would have a more stable center of gravity. Where would that center of gravity be?

Lesson #10 – Create your own Boat Design Sketch & Prototype

Curricular Outcomes:

PAA – Design Studies

- 1.1 To recognize the steps in the design process.
- 1.2 To explore the steps in the design process. (CCT, TL, NUM)
- 1.3 To discuss the project with the teacher using appropriate terminology.
- 1.4 To discuss the project with other students. (PSVS)
- 1.5 To maintain a written journal and a design portfolio. (COM)

Science

- FD8.2 Examine the effects of forces in and on objects in fluids, including the buoyant force.
  a. Identify questions to investigate arising from practical problems and issues involving floating, sinking, and buoyancy (e.g., "What factors affect the amount of cargo a barge can hold?", "Why do some objects float and some objects sink?", and "How can a ship made of steel float in the ocean?").
  g. Conduct a fair test to identify which factors determine whether a given object will float or sink and discuss reasons why scientists control some variables when conducting a fair test.
  h. Use a technological problem-solving process to design, construct, and evaluate a prototype of an object that floats and can carry the greatest amount of cargo.
  k. Explain the operation of technologies whose development is based on scientific understanding of the properties of fluids (e.g., personal flotation devices, float planes, surfboards, gliders, anti-freeze tester, and heart pumps).
  l. Analyze designs of traditional and contemporary watercraft (e.g., canoe, kayak, lake boat, catamaran, and jet-ski) with respect to the principles of buoyancy.

Mathematics

- SS8.2 Demonstrate understanding of the surface area of 3-D objects limited to right prisms and cylinders (concretely, pictorially, and symbolically) by:
  analyzing views, sketching and constructing 3-D objects, nets, and top, side, and front views
  generalizing strategies and formulae, analyzing the effect of orientation, solving problems.
- N8.3 Demonstrate understanding of rates, ratios, and proportional reasoning concretely, pictorially, and symbolically.

Supportive Resources:

- Prior teaching/resources on "Nets" and "Scale"
- 12"x12" Tile floors (commonly found in schools)
- Online photos of cardboard boats
- Cardboard Boat Race Photos link
- Photos/videos you have from previous Boat Race events
  Cardboard Boat Races Saskatoon video link
- Cardboard Boat Race Challenge Teacher Information Package
- Student notes, design logs, journals, all learnings and resources that they have collected

Materials:

- Provide students with the Cardboard Boat Graph Paper Template copied on 11 X 17 paper
- Rulers, Scissors, glue, tape, coloured pencils or markers, meter sticks, Bristol board paper
- Prototype materials: 2 exacto knives; 2 pencils, ¼ roll of masking tape, sheets of Bristol board, a ¼ roll of duct tape.

Procedures:

- Put students into teams of 4 which will be the groups for the Cardboard Challenge.
- Together, they must design and construct a cardboard boat that can travel 50m as quickly as possible while maintaining its structural integrity.
- Students should create a name for their group incorporating terminology or slang pertaining to boats, the ocean, water, etc.… (Make sure they are school appropriate!)
- Review cardboard boat photos and discuss the shapes, supports, pros and cons of each.
- Focus on buoyancy, balance, and displacement.
- Review the details and instructions for the cardboard boat race.

Option #1: Individual Sketch and Prototype

- Students will sketch a design of their cardboard boat.
- In at least 50 words, members will convince their team why their design is the best.
- They will share this sketch with their group members to guide their design process.
- All sketches go into their design log when they are done sharing it with their group.
- As a team, they will choose a design for their boat.
- Teams will create a prototype using the graph paper provided.
- Every team member must submit a sketch of the prototype (optional net) in their duotang.
- *The net (a pattern that you can cut and fold to make a model of a solid shape)* has a scale of ***1 cm = 12 cm or 1 inch = 1 foot***
- That is, each 1-centimetre (1 inch) square on this paper net will be 12 centimetres (1 foot) on the cardboard grid.
- Students may want to reproduce this grid on the cardboard they are given on race day.

Option #2: Team Sketch and Prototype

- Provide each group with copies of the design grid, informing them that scale is important since they will build a prototype for their boat in the following lesson.
- Using the grids, students will make one-dimensional “nets” of what their cardboard boat is going to look like.
- Encourage students to maximize their paper and use all edges (avoid the “donut” cut).
- Once the net is made, students can cut out their parts and make a boat by folding paper or by cutting the pieces and taping them together to make a boat.
- After testing to see if it works, make a final net template for building the boat.
- Photocopy the design plan so that you have the original and a copy. Students can use the copy to build another paper boat.
- Once satisfied with their design, students will then make a prototype out of Bristol board using a scale of 1:2.

Final Design Plan:

- Ensure students bring their design plan (with measurements) and their prototype to the Cardboard Boat Competition.
- Each group will create a scaled sketch (net), a prototype, a write-up and list of instructions.
- Each team must create a poster (on bristle board) with the following:
- Scaled Sketch (Net): This sketch (Net) must include a title and state the dimension of each edge/side. *Remember a net is a pattern that you can cut and fold to make a model of a solid shape*. It has a scale of **1 cm = 12 cm or 1 inch = 1 foot**
- A written explanation, in point form of the design principles considered in the development of the boat – buoyancy, density, water resistance, displacement, the center of gravity, structural support, etc. Students must use at least three of the terms mentioned above.
- Prototype: A small model of students' boat created out of gridded paper, e.g., Bristol board.
- Instructions: Step by step instruction outlining who will do what on race day.
- **Each group must present their prototype and poster to the judges on race day**

Follow-up Activities/Assignment:

- Comment on the elements of the students' designs.
- Have students discuss and defend components of their design.

Assessment:

- Have students' self-asses their boats using the Cardboard Boat Race Challenge Judging Criteria Rubric
- Provide feedback to the students that will assist them in further thinking and planning.
- Create anecdotal records on them working in their groups, as well as their problem-solving ability.
- Ensure that the scale has been addressed.
- Lesson #10 - Create Your Own Design Evaluation Sheet

Lesson #10 – Create your own Boat Design Sketch & Prototype: Rubric

Team Name: _____

Student Names:				
Both students and teachers assess the sketch and prototype. All points are awarded to a specific category if the listed criteria are met, while partial points are awarded if partial criteria are met.				
Category	**Scoring Criteria**	**Points**	**Student Evaluation**	**Teacher Evaluation**
Sketch & Innovation ***10 points***	The design of the boat appears to be sound and well thought out. The design reflects elements discussed in the unit.	**10**		
Construction 30 *points*	An effort is visible in the design to use knowledge gathered from the unit.	**10**		
	The prototype is constructed accurately from the design.	**10**		
	The prototype has visual appeal, is neat, and put together according to scale.	**10**		
Quality of Construction ***20 points***	The prototype is tested for stability.	**5**		
	The prototype is tested for buoyancy with different loads.	**5**		
	The prototype is tested for maneuverability.	**5**		
	The boat's construction is sound in at least one category.	**5**		
Design Changes ***15 points***	Areas of weakness are identified.	**10**		
	Areas for change are discussed.	**5**		
	The design is modified and submitted to account for required changes.	**15**		
Teamwork &Conduct ***15 points***	All team members contributed appropriately.	**5**		
	All team members can relate to the terms and knowledge learned from the unit.	**5**		
Score	**Total Points**	**100**		

Lesson #10 – Create your own Boat Design Sketch & Prototype

Evaluation Sheet

Team Name: _____

Group Members: _____

1. Did you use folds or cuts to create your boat? What would the pros of using folds with cardboard be? What would the cons be? Try folding a piece of cardboard to test your theory.

   _____
   _____
   _____

2. Did you maximize the use of your materials? What could you have done differently to maximize your materials?

   _____
   _____
   _____

3. Did you consider buoyancy, water displacement, and balance in your design? How are each area incorporated into your design?

   _____
   _____
   _____

4. Push on the front of your paper boat and on its sides to test its strength (remember it is paper so don't crush it). However, if it is built using principles of design, it should be tough to crush! What could you do to strengthen your boat?

   _____
   _____
   _____

5. What modifications should you make to your boat? Create another net with the modifications and have your teacher make a photocopy. Use the photocopy to make another new and improved paper boat.

   _____
   _____
   _____

6. How will you ensure all team members are contributing to the build of your cardboard boat? What will each team member's role be on the day of the boat build?

   _____
   _____
   _____
   _____

Lesson #11: Cardboard Boat Race Challenge Evaluation

Curricular Objectives:

English Language Arts

- CC8.3 Select and use the appropriate strategies to communicate meaning before, during, and after speaking, writing, and other representing activities.
- CC8.5 Create and present a variety of visual and multimedia presentations including an illustrated report, a role play that ends with a tableau, a dramatization, presentation software, a newscast with adequate detail, clarity, and organization to explain, to persuade, and to entertain.
- CC8.6 Use oral language to interact purposefully, confidently, and respectfully in a variety of situations including one-to-one, small group, and large group discussions.

Materials:

- Lesson #11 - Cardboard Boat Challenge Reflection
- MS Word or paper and pen

Procedures:

- Students will provide an analysis of how the cardboard boat challenge process went.
- The purpose is for the students to evaluate their process, preparation, and final project.
- They will share areas of strength and improvements they felt could have been made to be more successful.

Option #1: Have students answer the following in their journals:

- What were your results in the race? Why?
- If you were to race again next week, how would you improve your boat?
- What are your thoughts on your teamwork and preparations? Minimum of 150 words.

Option #2: Have students individually or in their teams complete the given questionnaire.

- Groups will debrief the event and submit their questionnaire.

Follow-up Activities/Assignment:

- Create a document that shares the data taken in from the questionnaire.
- This data could include the most common or original strengths and areas of improvement that were shared from the class.

Career Exploration Option:

- Have students research types of businesses that would employ designers.
- Have students research the required training for the different design professions
- Students create a career pamphlet/poster to showcase their design career and present it to the class.

Assessment:

- There is no formal assessment included in the lesson.
- The purpose is for groups to self-assess and to foster their learning by reflecting on the experience.

Lesson #11: Cardboard Boat Race Challenge - GROUP REFLECTION

Team Name:	
Team Members:	**1) _____** **2) _____** **3) _____** **4) _____**
Race Performance:	
Did your boat complete the first heat undamaged, partially damaged, or was it unable to complete the challenge?	
Did your boat finish in a time that you expected? (did your performance exceed expectations or not meet expectations?)	
Explain your answer to the above questions. These can be positive or constructive. Reflect on the preparation, design, construction, and navigation.	
Design:	
List two things about your design that you feel made you boat successful. Explain why!	
Where could you have made improvements with your design? Explain how!	
Reflection:	
A group of grade 7 students have come to you for advice for next year's Cardboard Boat Competition; make a list of 3 do's and 3 don'ts for them to ensure their success.	

Lesson #12 – Career Exploration in Design (Optional)

Curricular Outcomes:

Career Education

- CC81. Examine how a disposition for lifelong learning connects to potential career pathways.
- CC8.2 Determine the contributions that work and work alternatives such as volunteerism make to the community and identify their importance to society.

Supportive Resources:

- Professional designers in the community (check yellow pages for associations for graphic arts, interior design, fashion design, web design, drafting/architectural design)
- Websites: http://www.designschoolresource.com/
  http://jobfutures.ca/noc/browse-occupations-alphabet.shtml#D

Materials:

- Computers
- Lesson #12 - Career Exploration in Design: Occupational Search
- Art supplies

Procedures:

1. Have students individually or in pairs interview a design professional or have a design professional come to the class.
2. Have students research types of businesses that would employ designers. Use websites resources to research careers.
3. Have students research the required training for the different design professions
4. Have students create a career pamphlet/poster to showcase their design career and present it to the class.

Follow-up Activities/Assignment:

1. Create a bulletin board of all the design careers.
2. Students complete “Is this For Me?” assessing if their design career is for them.

Assessment:

- Lesson #12 – Career Exploration in Design: Occupational Search Rubric
- Using the included rubric assess the individual student and/or pair’s completed interview sheet, web research, career pamphlet and presentation.

Lesson #12 – Career Exploration in Design: <u>OCCUPATIONAL SEARCH</u>

Name(s): _____

Job Title_____ Date of Research _____

Interview Questions:	Interview Answers:	Websites or other career information sources
Person interviewed:		List websites or resources used:
Job Title:		
Company Name:		
Number of years in the field:		
Related work experience:		
Personal interests associated to work:		

1. **Job Requirements**

What education and/or training is needed? Where can the training be received?

Interview Answers	Websites or other career information sources

Do you need a license or special certificate or other special requirements to do this work?

Interview Answers	Websites or other career information sources

List the special abilities you need (verbal, numerical, mechanical, etc.).

Interview Answers	Websites or other career information sources

2. **Job Description**

What are the main duties/task/ or responsibilities?

Interview Answers	Websites or other career information sources

What are the working conditions associated with this occupation?

Interview Answers	Websites or other career information sources

What personal qualities are required?

Interview Answers	Websites or other career information sources

What is the pay range for this occupation?

Interview Answers	Websites or other career information sources

3. **Job Future**

What are the chances for advancement within this occupation?

Interview Answers	Websites or other career information sources

What are the chances of staying employed in this occupation? (employment outlook?)

Interview Answers	Websites or other career information sources

4. **It's a matter of Opinion**

What are the major advantages of this occupation?

Interview Answers	Websites or other career information sources

What are the major disadvantages of this occupation?

Interview Answers	Websites or other career information sources

What school subjects are most important to or related to this occupation?

Interview Answers	Websites or other career information sources

5. **Related Occupations**

List some occupations that are related or similar.

Interview Answers	Websites or other career information sources

What are some of the different types of companies that might employ a worker trained in this career?

Interview Answers	Websites or other career information sources

6. **Your Question: _____**

Interview Answers	Websites or other career information sources

Lesson #12 – Career Exploration in Design: Occupational Search Rubric

Student(s): _____

Occupational Title: _____

Occupational Research:

Criteria	1	2	3	4
Sources	Needed frequent assistance to access various sources	Needed minimal assistance to access various sources	Accesses sources easily but only gathers some relevant information	Easily accesses sources and gathers and records meaningful information efficiently.
Data	Data is missing and is inaccurate	Answers all questions but data is general and has some inaccuracies	Answers all questions and includes some interesting facts but is missing some details	Answers questions accurately and gives details
Teacher Feedback				

Pamphlet/Poster:

Criteria	1	2	3	4
Purpose	Communicates irrelevant information **and** is inappropriate for the audience	Communicates irrelevant information **or** is inappropriate for the audience	Communicates relevant information appropriately to the audience	Communicates relevant information appropriately and effectively to an audience
Organization	Is a series of random images, captions, labels	Is organized clearly and logically	Is organized logically and coherently	Is organized logically. Coherently, and is unified.
Design Elements	Uses a few design elements to communicate information	Uses some design elements to communicate information	Uses design elements to communicate key messages	Uses design elements to communicate an impact
Teacher Feedback				

Presentation:

Criteria	1	2	3	4
Organization	No sequence of information and can't follow	Student jumps around and is difficult to follow	Information is presented logically and easy to follow	Information is presented logically and interestingly and is easy to follow
Knowledge	Lacks understanding and cannot answer questions	Uncomfortable with information and answers only basic questions	At ease with information and expected questions but does not elaborate	Has full knowledge of information and answers questions with explanation and elaboration.
Elocution	Mumbles, pronounces incorrectly, speaks too softly.	Voice is low and some incorrect pronunciations	Voice is clear, most words pronounced correctly	Clear voice with correct, precise pronunciation.
Teacher Feedback				

Collaboration (if paired/grouped):

Criteria	1	2	3	4
Preparation	Needed continual prompting to reach the goal	Needed occasional prompting to reach the goal	Did not need prompting to reach the goal	Worked consistently and actively to reach the goal
Teamwork	Individuals needed encouragement to share in the goal	Individuals needed occasional encouragement to share in the goal	Individuals did not need encouragement to share in the goal	Individuals willingly accepted and fulfilled role for completion of the goal
Teacher Feedback				

Comments:

_____
_____
_____
_____
_____

Lesson #12 – Career Exploration in Design: OCCUPATIONAL SEARCH

Part 2

"IS THIS FOR ME?"

Name_____

Occupational Title _____

1. Using a scale of 1 to 5, with 5 as high, rate how well the occupation suits your:

   (a) interests _____
   (b) abilities _____
   (c) educational plans _____
   (d) desired working conditions _____
   (e) desired salary _____
   (f) lifestyle/leisure _____

2. What would you like about this job?

   _____

   _____

3. What would you dislike about this job?

   _____

   _____

4. Do you need to explore more careers? Why?

   _____

   _____

5. Has your search affected your educational plans? If so, how?

   _____

   _____

Additional Optional Lessons

Project Management – Project Management Institute Educational Foundation (PMIef)

Free online resources for teacher

- https://pmief.org/
- https://pmief.org/library/resources?filter=A-03240

Digital Resources

- PMIef Project Management Skills for Life pdf
- PMIef Project Management Skills for Life PowerPoint
- PMIef Toolkit for Teachers
- PMIef The Tower Game

****A trained Project Manager may be available upon request to come into your class and discuss this topic further. Please contact the Saskatoon Industry-Education Council if you are interested.*

Online Resources for Unit

(Listed in the order in which they appear)

https://www.curriculum.gov.sk.ca/webapps/moe-curriculum-BBLEARN/index.jsp

Cardboard Boat Races Saskatoon https://www.youtube.com/watch?v=PgIZZwPLhSY&t=2s

Online simulations for Buoyancy https://phet.colorado.edu/en/simulation/buoyancy

What is Buoyancy Website https://mocomi.com/buoyancy/#commentss-section

Bill Nye the Science Guy – Buoyancy https://www.youtube.com/watch?v=qV8Y50tDmIE

Density Definition https://www.thoughtco.com/what-is-density-definition-and-calculation-2698950

Online simulation for Density https://phet.colorado.edu/en/simulation/legacy/density

Types of Boat https://hartley-boats.com/

Parts of a boat https://www.boat-ed.com/pennsylvania/studyGuide/Parts-of-a-Boat-Front-and-Side-Views/101039_101039008/

Online simulations for Buoyancy https://phet.colorado.edu/en/simulation/buoyancy

Olympic Sculling Video https://www.youtube.com/watch?v=w_m7UYr9qvE

Who Sank the Vasa? https://www.youtube.com/watch?v=JEEVvKqI_Ig

Mystery of the Great Mary Rose https://www.youtube.com/watch?v=ns8Ej22hKVk

Carboard Boat Race Photos http://www.blue-room.com/onetruth/archive/000591.html

Career Website http://www.designschoolresource.com/

Career Website http://jobfutures.ca/noc/browse-occupations-alphabet.shtml#D