BOAT DESIGN
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Target Grade/Subject

FOCUS QUESTION: Can a solid piece of clay, which normally sinks in fresh water, be used to build a boat that will float and carry a cargo of a metal ore?

OVERVIEW: Students will design and build a clay boat that will carry the native ore from Marquette, Mi through the Sault Saint Marie Locks to the processing mill in Dearborn, Mi. The boat’s cargo will be nickel sulfide (old copper pennies) and be restricted to the size of the locks 30 cm by 15 cm.

LEARNING OBJECTIVES

DESIGN CRITERIA:
1. Design a boat that will transport the cargo.
2. The boat must be able to pass through the Sabin Locks (411 m x 24 m)
3. Build a boat from the design that will carry the cargo.
4. Demonstrate the boat can carry the cargo.

BENCHMARKS: (Michigan)
• Math N.FL.07.07 Solve problems involving operations with integers.
• Social Studies 7-G4.2.1 List and describe the advantages and disadvantages of different technologies use to move people, products and ideas throughout the world.
• Science S.IP.07.12 Design and conduct scientific investigations.
• Science S.IP.0714 Use metric measurement devices in an investigation.

MATERIALS:
Florist clay 2 cm x 2 cm x 10 cm
Aquarium filled with water
Metric ruler
50 pennies
Triple beam balance
rolling pin

VOCABULARY:
Buoyant Force
Pressure
Water displacement
Density

STUDENT INSTRUCTIONS:
1. Determine the clay’s mass ______________ g
2. Determine the clay’s volume.
   Length = _________ cm
   Width = __________ cm
   Height = __________ cm
   Vol = Length x Width x Height
   Vol = _____ cm x _______ cm x _______ cm
3. Calculate the density.
   Density = mass/volume
   Density = __________ g/cm³
4. Design a boat.
5. Show dimensions from three views
   Top View    Side View    Rear View
6. Calculate the area of the boat.
   \[ \text{Length} = \underline{\hspace{2cm}} \text{cm} \quad \text{Area} = \text{Length} \times \text{Width} \]
   \[ \text{Width} = \underline{\hspace{2cm}} \text{cm} \quad \text{Area} = \underline{\hspace{2cm}} \text{cm} \times \underline{\hspace{2cm}} \text{cm} \]
   \[ \text{Area} = \underline{\hspace{2cm}} \text{cm}^2 \]

7. Calculate the pressure of the boat.
   \[ \text{Force} = \underline{\hspace{2cm}} \text{N} \quad \text{Pressure} = \frac{\text{Force}}{\text{Area}} \]
   \[ \text{Area} = \underline{\hspace{2cm}} \text{cm}^2 \]
   \[ \text{Pressure} = \underline{\hspace{2cm}} \text{N} \]
   \[ \text{Pressure} = \underline{\hspace{2cm}} \text{p} \]

8. Use the boat diagram and construct a boat. Make sure the boat’s dimensions match the dimensions of the diagram. When the boat is completely built, test the boat. Make any changes to will allow the boat to float. Show any changes on the boat diagram.

9. Test your boat. Carefully place the boat on the water. Carefully add the cargo, placing one penny in the boat at a time.

10. Count the total cargo. \underline{\hspace{2cm}} pennies

**Discussion Questions**

1. How does the changing the boat’s surface area affects the ability of the boat to increase the amount of cargo being transported?

2. Instead of using clay, what other materials could be used to build a boat?

3. Would a fully loaded boat float easier in the Atlantic Ocean or in the Great Lakes? Give the reason(s) for your answer.

4. Annually there is a cement canoe race on the Kalamazoo River. List the factors that are necessary to design a cement canoe that will float.
# Assessment Rubric

## Boat Design
- Will fit through the Sault Ste. Marie Locks (Sabin Locks) (4pts)
- Complete design (using metric measurements) (6pts)
  - Top View (2pts)
  - Side View (2pts)
  - Rear View (2pts)

## Boat Construction
- Built to design
  - Length (2pts)
  - Width (2pts)
  - Height (2pts)
- Floats empty (4pts)

## Carries Cargo
- Full cargo 50 pennies (10pts)
- 45 – 49 pennies (9pts)
- 40 – 44 pennies (8pts)
- 35 – 39 pennies (7pts)
- 30 – 34 pennies (6pts)
- less than 30 pennies (5pts)

## Questions
- Question #1 (2pts)
- Question #2 (2pts)
- Question #3 (2pts)
- Question #4 (4pts)

Total points: 40