Grade 8

Cluster 3: Fluids

Overview

In this cluster, students investigate the properties of fluids, including viscosity, density, and compressibility. Students identify products in which viscosity is an important characteristic, and plan and conduct experiments to determine factors that affect flow. Students illustrate effects of temperature on density, and they compare the effects of fluids with different densities on the buoyant force of an object. They use the particle theory of matter to explain the relationships among pressure, volume, and temperature. Investigations of the relative compressibility of fluids are related to the ability of liquids and gases to transmit forces in hydraulic and pneumatic devices. Students apply their understanding of fluids within a practical context through the design, construction, and testing of a prototype that utilizes a hydraulic or pneumatic system.

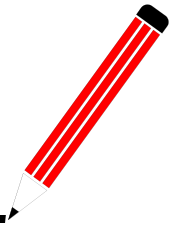
PRESCRIBED LEARNING OUTCOMES
Students will...
8-3-01 Use appropriate vocabulary related to their investigations of fluids. Include: fluid, viscosity, flow, density, particle theory of matter, buoyant force, pressure, compressibility, hydraulic, pneumatic. GLO: C6, D3, E1

SUGGESTIONS FOR INSTRUCTION

Teacher Notes

Prior Knowledge

Students have had previous experiences related to this cluster in Grade 7, Cluster 2: Particle Theory of Matter, and in Grade 6, Cluster 2: Flight.



➢ Introduce, explain, use, and reinforce vocabulary throughout this cluster.

➢ **Vocabulary Hopscotch**

Provide students with approximately 20 terms that are addressed in the cluster. Have students

- choose 10 of these terms
- print the term with every other letter missing, and then write a definition for the term beside it
- exchange hopscotch papers with a partner and solve the vocabulary puzzles

Example:

_ y _ r _ u _ i _ _ y _ t _ m: a device that uses a liquid to multiply a force to move something. (hydraulic system)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Measuring Matter (Video)

PRESCRIBED LEARNING OUTCOMES
Students will...
8-3-02 Distinguish between fluids and non-fluids. GLO: D3, E1
8-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2 **8-0-7f** ⊂ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

SUGGESTIONS FOR INSTRUCTION

➢ **Accessing Prior Knowledge: Fluids**

Have students list the characteristics of fluids and provide examples of both fluids and non-fluids.

Teacher Notes

Background Information

A *fluid* is any substance that flows, spreads out evenly when poured, and exerts pressure.

➢ **Demonstrating the Flow of Gases**

To demonstrate gases flowing, place a small piece of dry ice into a beaker of warm water and pour the carbon dioxide gas (given off as the dry ice sublimates) into another beaker.

Safety Precaution: Handle dry ice with mitts or tongs. Handling dry ice with bare hands can result in frostbite.

An alternative demonstration involves dissolving two antacid tablets in a flask of water and then pouring the gas over a burning candle. Have students explain what happened. (The flame went out because it is being smothered [not receiving the oxygen it needs to continue burning] due to the carbon dioxide produced by the tablets that is poured onto it.)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 8:
Fluids (Section 2.1)

Sciencepower 8 (Section 4.1)

Prescribed Learning Outcomes

Students will...

8-3-03 Explore and compare the viscosity of various liquids.

Examples: time the fall of a steel ball through various liquids; time the flow rate of different liquids on an incline...

GLO: C2, D3, E1

8-0-1a ⊂ Formulate specific questions that lead to investigations. Include: rephrase questions to a testable form; focus research questions. GLO: A1, C2 (ELA Grade 8, 3.1.2; Math: SP-I.1.8)

8-0-3a ⊂ Formulate a prediction/hypothesis that identifies a cause and effect relationship between the dependent and independent variables. GLO: A2, C2 (Math: SP-I.1.8)

8-0-3b Identify the independent and dependent variables in an experiment. GLO: A2, C2

8-0-3c ⊂ Create a written plan to answer a specific question. Include: apparatus, materials, safety considerations, steps to follow, and variables to control. GLO: C2 (ELA Grade 8, 3.1.4)

8-0-4a ⊂ Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability. GLO: C2

8-0-4e ⊂ Demonstrate work habits that ensure personal safety, the safety of others, and consideration for the environment. Include: keeping an uncluttered workspace; putting equipment away after use; handling glassware with care; wearing goggles when required; disposing of materials safely and responsibly. GLO: C1

8-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5e ⊂ Estimate and measure accurately using SI and other standard units. Include: determining volume by displacement of water. GLO: C2, C5 (Math: SS-IV.1.6, SS-III.1.5, Math: SS-III.1.6, SS-I.1.5)

8-0-5f ⊂ Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 8, 3.3.1; Math: SP-III.2.8)

8-0-6f ⊂ Identify how the original plan evolved and justify the changes. GLO: C2, C3 (ELA Grade 8, 3.3.4)

Suggestions for Instruction

Teacher Notes

Background Information

Viscosity, the opposite of fluidity, is the resistance of a fluid to a change in shape or movement. It is denoted by its opposition to flow or its opposition to have other matter flow through it. Viscosity is caused by the internal friction of a fluid's particles. Flow rate is determined by calculating the time a fluid requires to flow a certain distance.

➢ Comparing Viscosity

Use explicit instruction to introduce the concept of *viscosity* to students. Have students work in groups of two or three to plan and perform an experiment that compares the viscosity of several liquids (e.g., shampoo, hair cream rinse, cooking oil, liquid honey, molasses, water, vinegar, various types of engine oil). (Refer to the "examples" provided with the learning outcome 8-3-03 for suggestions.)

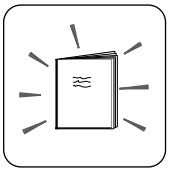
Students may record their work using the "Experiment Report" (BLM 8-R).

8-0-7a ⊂ Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 8, 3.3.4)

8-0-7c ⊂ Identify a new prediction/hypothesis based on investigation results. GLO: A1, C2 (ELA Grade 8, 3.3.4)

Suggestions for Assessment

Suggested Learning Resources



When assessing the Comparing Viscosity experiment, refer to "Experiment Report: Assessment" (BLM 8-S).

Conducting a Fair Test

Provide students with the following self-assessment tool:

Self-Assessment: Conducting a Fair Test

1. One problem I had was _____
   _____
2. One thing I did well was _____
   _____
3. As a group member, I _____
   _____
4. I think our experiment _____
   _____

Nelson Science & Technology 8: *Fluids* (Section 2.3)

Sciencepower 8 (Section 4.2)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-3-04 Identify products in which viscosity is an important property, and evaluate different brands of the same product, using the design process.

Examples: sauces, lubricating oil, paint, hand lotion...

GLO: A5, B2, C1

8-0-1c Identify practical problems to solve. *Examples: How can I make water flow uphill? Which type of bottled water should I buy?…* GLO: C3

8-0-1d ⊂ Select and justify a method to be used in finding a solution to a practical problem. GLO: C3 (Math: SP-II.1.8)

8-0-3d ⊂ Develop criteria to evaluate a prototype or consumer product. Include: function, aesthetics, environmental considerations, cost, efficiency. GLO: C3

8-0-3e ⊂ Create a written plan to solve a problem. Include: materials, safety considerations, three-dimensional sketches, steps to follow. GLO: C3, C6

8-0-5b ⊂ Test a prototype or consumer product, using predetermined criteria. GLO: C3, C5

8-0-6e ⊂ Evaluate the strengths and weaknesses of a consumer product, based on predetermined criteria. GLO: C3, C4

8-0-7d ⊂ Propose and justify a solution to the initial problem. GLO: C3

8-0-7e ⊂ Identify new practical problems to solve. GLO: C3

8-0-7g ⊂ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 8, 4.4.1)

8-0-7h ⊂ Identify and evaluate potential applications of investigation results. GLO: C4

8-0-8a ⊂ Distinguish between science and technology. Include: purpose, procedures, products. GLO: A3

SUGGESTIONS FOR INSTRUCTION

➢ Useful Viscous Substances

Have students use the Think-Pair-Share strategy (Lyman and McTighe, 1992) to identify products in which viscosity is an important property.

Examples: ketchup, tomato sauce, vegetable oil, hand lotion, cream rinse, shampoo, paint, paint stripper, cough medicine, engine oil.

Have students use the design process to evaluate different brands of the same product, basing their evaluations on a class-created list of criteria.

Examples:

- Does the product have the correct viscosity to suit its specified function? (e.g., cough medicine: is it able to coat a sore throat and yet comes off a spoon easily?)
- Is the product cost effective? (e.g., does the product have a low viscosity and run off more quickly, thus causing you to use more?)

➢ Marketing a Product

Working in small groups, have students create a commercial that

- accentuates a product's viscosity or compares it to that of other brands
- illustrates/demonstrates why the product is the most desirable, based on its viscosity

Students may videotape their commercials or present them live to the class.

(For strategies and assessment suggestions to aid students in developing appropriate delivery skills for use in presentations, as well as public listening and viewing behaviours, refer to *5–8 ELA*, learning outcomes 4.4.2–4.4.3.)

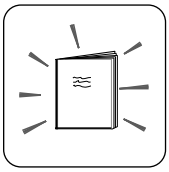
➢ Science or Technology?

Have students reflect on "Comparing Viscosity" (learning outcome 8-3-03) and "Useful Viscous Substances" (learning outcome 8-3-04) to determine which investigation was science-based and which was technology-based. Students should justify their categorization.

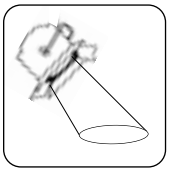
("Comparing Viscosity" is science-based, as it addresses a question and finds an answer. "Useful Viscous Substances" is technology-based, as it finds a solution to a practical problem. However, it also applies scientific understanding to the solving of a problem.)

Suggestions for Assessment

Suggested Learning Resources



When assessing the Useful Viscous Substances learning activity, refer to "Design Project Report: Assessment" (BLM 8-P).



Commercial Presentations

Provide students with the following tool for peer assessment of the Marketing a Product commercials:

Peer Assessment of Commercial					
Presenters:_____					
Topic: _____					
Peer assessor: _____					
Rating Scale					
Criteria	**Poor**		**Good**		**Excellent**
Speaking parts are clear and understandable	1	2	3	4	5
Commercial demonstrates why the product is most desirable based on its viscosity	1	2	3	4	5
Commercial shows a comparison with other brands	1	2	3	4	5
Good use of visuals	1	2	3	4	5
The commercial kept the interest of the group	1	2	3	4	5
Constructive comment:					

Nelson Science & Technology 8: *Fluids* (Sections 2.3, 2.5)

Sciencepower 8 (Section 4.2)

Prescribed Learning Outcomes

Students will...

8-3-05 Plan and conduct experiments to determine factors that affect flow within a given system.

Examples: temperature, pressure, tube diameter...

GLO: C1, C2, D3, E2

8-0-1a ⊂ Formulate specific questions that lead to investigations. Include: rephrase questions to a testable form; focus research questions. GLO: A1, C2 (ELA Grade 8, 3.1.2; Math: SP-I.1.8)

8-0-3a ⊂ Formulate a prediction/hypothesis that identifies a cause and effect relationship between the dependent and independent variables. GLO: A2, C2 (Math: SP-I.1.8)

8-0-3b Identify the independent and dependent variables in an experiment. GLO: A2, C2

8-0-3c ⊂ Create a written plan to answer a specific question. Include: apparatus, materials, safety considerations, steps to follow, and variables to control. GLO: C2 (ELA Grade 8, 3.1.4)

8-0-4a ⊂ Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability. GLO: C2

8-0-4e ⊂ Demonstrate work habits that ensure personal safety, the safety of others, and consideration for the environment. Include: keeping an uncluttered workspace; putting equipment away after use; handling glassware with care; wearing goggles when required; disposing of materials safely and responsibly. GLO: C1

8-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5c Select and use tools to observe, measure, and construct. Include: microscope, concave and convex mirrors and lenses, chemical indicators. GLO: C2, C3, C5

8-0-5e ⊂ Estimate and measure accurately using SI and other standard units. Include: determining volume by displacement of water. GLO: C2, C5 (Math: SS-IV.1.6, SS-III.1.5, Math: SS-III.1.6, SS-I.1.5)

8-0-5f ⊂ Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 8, 3.3.1; Math: SP-III.2.8)

8-0-6b ⊂ Interpret patterns and trends in data, and infer and explain relationships. GLO: A1, A2, C2, C5

8-0-6c ⊂ Identify strengths and weaknesses of different methods of collecting and displaying data, and potential sources of error. GLO: A1, A2, C2, C5 (ELA Grade 8, 3.3.3)

Suggestions for Instruction

➢ Investigating Factors That Affect Flow Rate

Have students brainstorm ways in which they could increase the flow rate of a liquid. Divide the class into groups and assign each group a factor to test.

Examples of variables to test:

- the effect of temperature (independent variable) on the flow rate of a fluid (dependent variable)
- the effect of different sizes of plastic straws (independent variable) on the flow rate of a fluid (dependent variable)
- the effect of adding pressure (squeezing a bottle) (independent variable) on the flow rate of a fluid (dependent variable)

Have students follow the scientific inquiry process to come to a conclusion regarding their testable question. Ask groups to present their findings to the class.

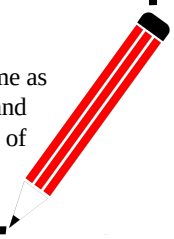
Teacher Notes

Background Information

Factors that can affect the *flow rate* of a fluid are

- the size of the fluid's particles
- the pressure exerted on the fluid
- the temperature of the fluid

Factors affecting the flow rate of fluid through a tube are the same as those listed above, as well as the surface material, straightness, and diameter of the tube and the difference in pressure from one end of the tube to the other.



8-0-6f ⊂ Identify how the original plan evolved and justify the changes. GLO: C2, C3 (ELA Grade 8, 3.3.4)

8-0-7a ⊂ Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 8, 3.3.4)

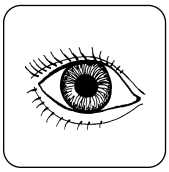
8-0-7b ⊂ Critically evaluate conclusions, basing arguments on fact rather than opinion. GLO: C2, C4

8-0-7c ⊂ Identify a new prediction/hypothesis based on investigation results. GLO: A1, C2 (ELA Grade 8, 3.3.4)

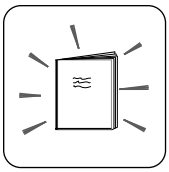
8-0-7f ⊂ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

Suggestions for Assessment

Refer to the following BLMs for assessment suggestions for the Investigating Factors that Affect Flow Rate learning activity:



"Conducting a Fair Test: Observation Checklist" (BLM 8-Q)



"Experiment Report: Assessment" (BLM 8-S)

Restricted Response

Provide students with the following:

Comparing Flow Rates

Which of the following would have a faster flow rate?

1. a straw with a narrow diameter or a straw with a larger diameter
2. a milkshake with a temperature of +5°C, or a milkshake with a temperature of –5°C
3. a milkshake with large chunks of ice cream or a milkshake that is smooth and has been thoroughly mixed

Look for:

1. larger diameter
2. +5°C
3. the one that is smooth and thoroughly mixed

Suggested Learning Resources

Nelson Science & Technology 8: *Fluids* (Sections 2.1, 2.4)

Sciencepower 8 (Section 4.2)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-3-06 Measure, calculate, and compare densities of solids, liquids, and gases.

Include: different amounts of the same substance, regularly and irregularly shaped objects.

GLO: C2, C5, D3

8-0-5c Select and use tools to observe, measure, and construct. Include: microscope, concave and convex mirrors and lenses, chemical indicators. GLO: C2, C3, C5

8-0-5d ⊂ Make conversions among commonly used SI units. GLO: C2, C5 (Math: SS-IV.3.7, SS-I.3.6, SS-III.3.7)

8-0-5e ⊂ Estimate and measure accurately using SI and other standard units. Include: determining volume by displacement of water. GLO: C2, C5 (Math: SS-IV.1.6, SS-III.1.5, Math: SS-III.1.6, SS-I.1.5)

8-0-9c ⊂ Demonstrate confidence in their ability to carry out investigations. GLO: C5

(continued)

SUGGESTIONS FOR INSTRUCTION

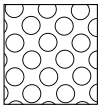
➢ Finding the Mass of a Solid and a Liquid

Provide students with a balance scale and various solid objects/substances. Have students determine the mass (in grams) of the objects/substances. To find the mass of a liquid, have students find the mass of the container, then the mass of both the container and the liquid, subtracting the mass of the container from the combined mass to obtain the mass of the liquid.

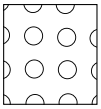
➢ Comparing Objects

Select three objects that have the same volume but a different mass and have students calculate the volume and measure the mass for each. (Commercial density block sets or specific gravity block sets can be used for this learning experience.) Ask students to explain, using the particle theory of matter, why it is that the three objects have the same volume but different masses. Have students record their answers in the science notebooks, using a diagram in their explanations. (The object that had a greater mass had more particles in the same space.)

Denser object



Less dense object



➢ Finding Density

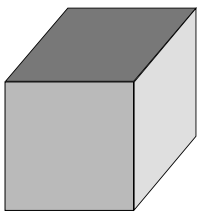
Have students calculate the densities of several regularly and irregularly shaped solids and liquids.

Part A: Regularly Shaped Solids

Have students use formulas to calculate the volume of regularly shaped objects. Have them use a balance scale to find the mass and then calculate the density using the formula m/v.

Example:

length x width (base) x height = volume
3 cm x 2 cm x 2 cm = 12 cm^3



mass = 24 g

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{24\text{ g}}{12\text{ cm}^3} = 2\text{ g/cm}^3$$

(continued)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 8: *Fluids* (Sections 2.8-2.9, 2.13)

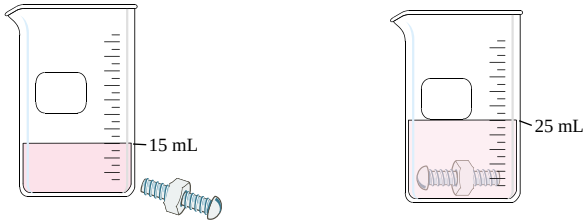
Sciencepower 8 (Section 5.2)

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
8-3-06 *(continued)*	*(continued)*

Part B: Irregularly Shaped Solids

Have students use displacement (placing the solid in a graduated cylinder of water, subtracting the water's initial volume from the new combined volume) to find the volume of an irregularly shaped solid. Have students use a balance scale to find the mass and then calculate density using the formula m/v.

Example:



volume = 25 mL – 15 mL = 10 mL

mass = 20 g

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{mass}}{\text{volume}} = 2 \text{ g/mL}$$

Part C: Liquids

To calculate the density of a liquid, have students

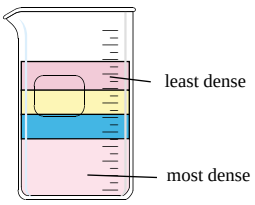
- use a balance scale to find the mass of a beaker
- pour 100 mL of a liquid into the beaker and find the combined mass of the beaker and the liquid
- determine the mass of the liquid by subtracting the mass of the container from the total mass of the liquid and container
- calculate the density of the liquid using the formula m/v

Example:

- Mass of empty container = 15 g
- Mass of container with 100 mL of liquid = 25 g
- Mass of liquid = 25 g – 15 g = 10 g

➢ **Comparing Densities**

Have students construct a density tower composed of the liquids and solids whose densities were previously calculated. The substances with the greatest density will be on the bottom, the substance with the least density will be on the top, with the range of densities in between.



SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Restricted Response

Provide students with the following:

Density

Calculate the densities and solve the following problems. Show your work.

1. A gas has a mass of .05 g and fills a 100 mL container. What is its density?
2. Object B is a solid that has a mass of 20 g and a volume of 10 cm^3. What is its density?
3. Object C is a solid that has a volume of 15 cm^3 and a mass of 6 g. What is its density?
4. If objects B and C were placed in pure water, which has a density of 1.0 g/mL, what would happen? Why?
5. Objects D and E have the same volume. Object D has a greater mass. Identify which has a greater density and explain your reasoning.

Look for:

1. $m/v = \frac{.05\ g}{100\ mL} = .0005\ g/mL$
2. $m/v = \frac{20\ g}{10\ cm^3} = 2\ g/cm^3$
3. $m/v = \frac{6\ g}{15\ cm^3} = .5\ g/\ cm^3$
4. Object B would sink because it has a greater density than water. Object C would float because it is less dense than water. The water is denser than object C and its particles are closer together and therefore are able to support object C.
5. Object D has a greater density. Although its volume is the same as object E, its mass is greater; therefore, its particles are packed closer together and there are more of them in the same space.

PRESCRIBED LEARNING OUTCOMES

Students will...

8-3-07 Illustrate, using the particle theory of matter, the effects of temperature change on the density of solids, liquids, and gases.

GLO: A2, C6, D3, E4

8-0-7f ⊂ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts.
GLO: A2, C4 (ELA Grade 8, 1.2.1)

SUGGESTIONS FOR INSTRUCTION

Teacher Notes

Background Information

The *particle theory of matter* states that there is an attraction between particles within a state of matter. When heat energy is added, the attraction between the particles weakens and the particles move more freely. As particles vibrate more freely, they move apart, and a change of state can occur if enough heat is added.

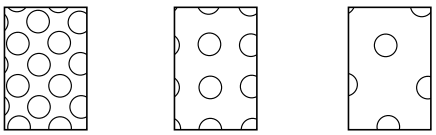
Solids have their particles most densely packed. Liquids are less densely packed (they have more space between particles), and gases are the least dense (they have large spaces between particles). Adding heat causes particles to be less tightly packed and less dense. Removing heat causes particles to be more tightly packed and denser.

Note: Water is an exception to the rule that solids are denser than the liquid state of the same type of matter. Water becomes less dense when it freezes. This allows ice to float on lakes in winter and organisms to live below.

➢ Activating Prior Knowledge: Particle Theory of Matter

Have students draw particle diagrams of the three states of matter.

Example:



solid liquid gas

Ask students to describe what happens to the particles when heat energy is applied to them. (When heat energy is applied to matter it causes the particles to vibrate faster and spread farther apart.)

➢ Illustrating Density

Have students draw diagrams representing the effects of temperature changes on the density of particles within a solid, a liquid, and a gas. Have them describe the relationship between heat and the density of matter. (Applying heat to an object changes its density.)

Suggestions for Assessment

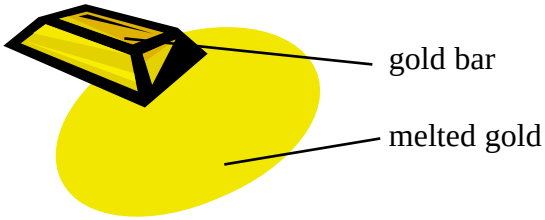
Suggested Learning Resources

Restricted Response

Provide students with the following:

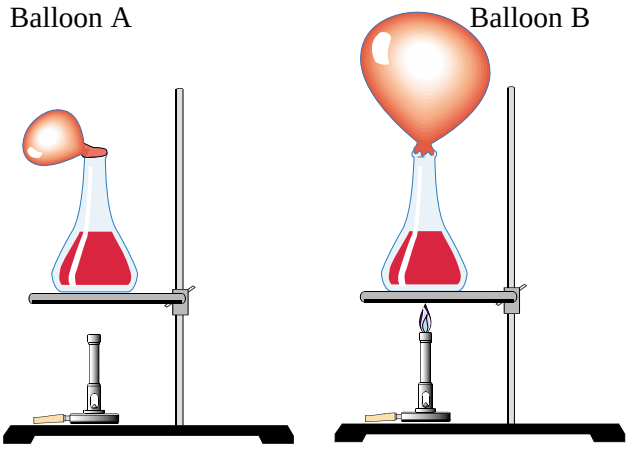
Density and the Particle Theory

1. Draw the particles in the diagram below.



   a. What two states of matter are seen in the above diagram?
   b. What type of energy was added to cause the change of state to occur?
   c. Which is less dense, the gold bar or the melted gold?

2. Draw the particles in Balloon B and describe the density of the air in Balloon B in comparison to Balloon A.



Look for:

1. a. solid and liquid b. heat energy c. melted gold (liquid)
2. Particles should be spread further apart in Balloon B. The air in Balloon B is less dense than the air in Balloon A.

Nelson Science & Technology 8: *Fluids* (Sections 2.16, 2.4)

Sciencepower 8 (Section 5.2)

Measuring Matter (Video)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-3-08 Compare fluids of different densities to determine how they alter the buoyant force on an object.

GLO: C2, D3

8-0-5c Select and use tools to observe, measure, and construct. Include: microscope, concave and convex mirrors and lenses, chemical indicators. GLO: C2, C3, C5

8-0-7f ↻ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

SUGGESTIONS FOR INSTRUCTION

➢ Using a Hydrometer to Measure Densities

Have students use a hydrometer to measure the densities of various liquids, following these steps:

- Build a hydrometer by cutting a drinking straw in half and attaching a ball of modelling clay to one end.
- Mark a scale along the length of the hydrometer (with increments of 5 mm).
- Place the hydrometer in a glass of tap water and record the reading on the hydrometer according to the straw scale.
- Place the hydrometer in the following liquids and record the reading on the hydrometer for each: a glass of water with two tablespoons of salt dissolved in it, vegetable oil, and shampoo.

Have students answer the following questions in their science notebooks:

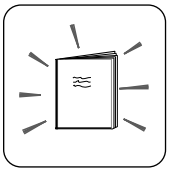
1. Did the hydrometer float higher in the salt water or in the fresh water? (The hydrometer floated higher in the salt water.)
2. Density refers to how closely packed particles of a substance are in relation to its volume. Dense liquids are able to support the mass of other, less dense materials. Based on this knowledge, which of the liquids do you think is more dense and what in the above investigation indicated this? (The salt water is denser. The salt water's closely packed particles were able to support the hydrometer and allow it to float higher up out of the water.)
3. What is the relationship between the buoyant force of a liquid and its density? (The denser the liquid is, the more buoyant force it has.)

➢ The Science of the Sinking Titanic

Have students use the Think-Pair-Share strategy (McTighe and Lyman, 1992) to identify the reasons why a large boat is able to float, considering that steel is denser than water. (Boats are hollow and there is air in the compartments. The average density of the boat is less than that of the water, and this allows the boat to float.)

Have students read "The Titanic" (BLM 8-C), and explain, in their science notebooks, why the Titanic was no longer able to float, using the term *density* in their explanation.

Suggestions for Assessment



Titanic Newspaper Article

When assessing students' newspaper articles, look for indications of the following:

Rating Scale					
Criteria	**Poor**		**Good**		**Excellent**
The student					
• identifies scientific flaws of the Titanic's specially made compartments	1	2	3	4	5
• suggests design modifications to improve the effectiveness of the compartments	1	2	3	4	5
• uses a format/ approach suited to a newspaper article	1	2	3	4	5

Teacher Notes

A *hydrometer* is an instrument that measures the density of a liquid and its subsequent buoyant force. Buoyant force is the fluid's ability to exert an upward-pushing force.

An instructional strategy suggested for learning outcome 8-4-03 asks students to make a hydrometer to compare the densities of fresh water and salt water.

Suggested Learning Resources

Nelson Science & Technology 8: *Fluids* (Sections 2.10-2.13)

Sciencepower 8 (Section 5.2)

Measuring Matter (Video)

Prescribed Learning Outcomes

Students will...

8-3-09 Recognize that pressure is the relationship between force and area, and describe situations in which pressure can be increased or decreased by altering surface area.

Examples: wearing snowshoes instead of boots to decrease pressure, increase surface area, and stay on top of snow...

GLO: B1, B2, D4

8-0-1a ⊂ Formulate specific questions that lead to investigations. Include: rephrase questions to a testable form; focus research questions. GLO: A1, C2 (ELA Grade 8, 3.1.2; Math: SP-I.1.8)

8-0-3a ⊂ Formulate a prediction/hypothesis that identifies a cause and effect relationship between the dependent and independent variables. GLO: A2, C2 (Math: SP-I.1.8)

8-0-3b Identify the independent and dependent variables in an experiment. GLO: A2, C2

8-0-3c ⊂ Create a written plan to answer a specific question. Include: apparatus, materials, safety considerations, steps to follow, and variables to control. GLO: C2 (ELA Grade 8, 3.1.4)

8-0-4a ⊂ Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability. GLO: C2

8-0-4e ⊂ Demonstrate work habits that ensure personal safety, the safety of others, and consideration for the environment. Include: keeping an uncluttered workspace; putting equipment away after use; handling glassware with care; wearing goggles when required; disposing of materials safely and responsibly. GLO: C1

8-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5f ⊂ Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 8, 3.3.1; Math: SP-III.2.8)

8-0-6b ⊂ Interpret patterns and trends in data, and infer and explain relationships. GLO: A1, A2, C2, C5

8-0-6c ⊂ Identify strengths and weaknesses of different methods of collecting and displaying data, and potential sources of error. GLO: A1, A2, C2, C5 (ELA Grade 8, 3.3.3)

8-0-6f ⊂ Identify how the original plan evolved and justify the changes. GLO: C2, C3 (ELA Grade 8, 3.3.4)

Suggestions for Instruction

➢ The Race

Have students race across a deep snowy field, with some students wearing snowshoes, some wearing skis, and some wearing boots. At the end of the race, ask students to explain what happened. (The people wearing boots sank, whereas the people wearing skis and snowshoes were able to go across the snow. Their footwear spread out their weight and reduced the amount of pressure in one spot.)

Alternatively, have students walk through sand or mud, with some wearing sneakers and others high heels.

➢ Penny Boats

Have students plan and conduct an experiment to determine whether the surface area of a boat affects the number of pennies it can hold before sinking. Students may use "Experiment Report" (BLM 8-R) to record their work. Ensure that students include potential applications of their findings related to surface area and pressure.

Examples:

- *Inventions:* The width of snowshoes allows users to spread out their weight and reduce pressure on one spot, which helps prevent them from breaking through the surface of snow.
- *Nature:* Snowshoe hares and polar bears have wide furry feet, allowing them to walk across snow without breaking through the surface.
- *Life-saving techniques:* When rescuers attempt to cross thin ice to rescue someone, they lie down and spread out their bodies. By increasing the surface area, they reduce pressure on the ice.

8-0-7a ⊂ Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 8, 3.3.4)

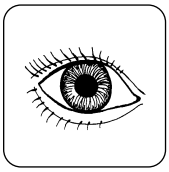
8-0-7b ⊂ Critically evaluate conclusions, basing arguments on fact rather than opinion. GLO: C2, C4

8-0-7c ⊂ Identify a new prediction/hypothesis based on investigation results. GLO: A1, C2 (ELA Grade 8, 3.3.4)

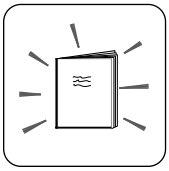
8-0-7h ⊂ Identify and evaluate potential applications of investigation results. GLO: C4

Suggestions for Assessment

Refer to the following BLMs for assessment suggestions:



"Conducting a Fair Test: Observation Checklist" (BLM 8-Q)



"Experiment Report: Assessment" (BLM 8-S)

Suggested Learning Resources

Nelson Science & Technology 8: *Fluids* (Section 2.14)

Sciencepower 8 (Section 6.1)

PRESCRIBED LEARNING OUTCOMES
Students will...
8-3-10 Explain, using the particle theory of matter, the relationships among pressure, volume, and temperature of liquid and gaseous fluids. GLO: A2, D4
8-0-7f ↻ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

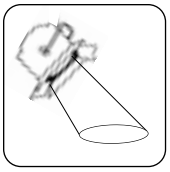
SUGGESTIONS FOR INSTRUCTION

➢ **Pressure Problem**

Distribute copies of "A Tiring Story" (BLM 8-D). Have students read the story and identify what is causing the tire problem, describing it in terms of the particle theory of matter.

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES



Analyzing "A Tiring Story"

Provide students with the following:

1. Given the information in "A Tiring Story," are you able to identify specifically which of Sam's tires "blew out" on Sam? Why or why not?
2. What are the relationships among air pressure, volume, and temperature?
3. What recommendations would you make with regard to maintaining proper air pressure in automobile tires throughout the year?

Look for:

1. Yes. The back left tire blew out, because that was the one in which Sam probably put too much air when he was adding air without using a tire gauge. When it became hot, the tire expanded, and when Sam drove a lot, the friction from the road added to the increase in temperature and volume and caused the tire to burst.
2. The higher the temperature, the greater the air pressure and, subsequently, the greater the volume.
3. Check a tire's air pressure regularly with a gauge. In particular, check a tire's air pressure when there is a change in outdoor temperature.

Nelson Science & Technology 8: *Fluids* (Section 2.19)

Sciencepower 8 (Section 6.1)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-3-11 Compare the relative compressibility of water and air, and relate this property to their ability to transmit force in hydraulic and pneumatic systems.

GLO: A5, C1, D4, E1

8-0-4c ⊂ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 8, 5.2.2)

8-0-4d Identify and assume various roles to achieve group goals. GLO: C7 (ELA Grade 8, 5.2.2)

8-0-4e ⊂ Demonstrate work habits that ensure personal safety, the safety of others, and consideration for the environment. Include: keeping an uncluttered workspace; putting equipment away after use; handling glassware with care; wearing goggles when required; disposing of materials safely and responsibly. GLO: C1

8-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5c Select and use tools to observe, measure, and construct. Include: microscope, concave and convex mirrors and lenses, chemical indicators. GLO: C2, C3, C5

8-0-7h ⊂ Identify and evaluate potential applications of investigation results. GLO: C4

8-0-9c ⊂ Demonstrate confidence in their ability to carry out investigations. GLO: C5

8-0-9d ⊂ Value skepticism, accuracy, precision, and open-mindedness as scientific and technological habits of mind. GLO: C3

(continued)

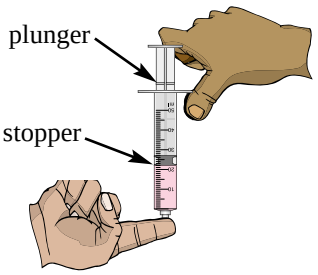
SUGGESTIONS FOR INSTRUCTION

➢ Fluid Compressibility Comparison

Part A: Comparing Compressibility

Have students use a syringe to compare the compressibility of several different fluids, including air, following these steps:

- Draw back the plunger and fill the syringe with specific fluid.
- Plug the hole and push in the plunger.
- Observe what happens. The change in volume represents the level of compressibility.
- Record your data in your science notebook and indicate whether the fluid is compressible or incompressible.



Part B: Observing Decompression

Some systems use the rebound of compressed fluids to move parts. Have students compress a fluid (used in Part A) as much as possible and then release the plunger and observe the distance the stopper rebounds. Ask them to record in their science notebooks which fluid rebounded more after decompression.

➢ Pneumatic Versus Hydraulic Systems

Have students, working in groups, set up and conduct the following experiments to compare how a pneumatic system, as compared to a hydraulic system, transmits force. Ensure that students work over a sink or plastic tub when filling their syringes with water. Glycerine may have to be added around the rubber stopper to ensure a complete seal and allow the plunger to move back and forth smoothly and easily.

Part A: Pneumatic System

- Push in the plunger completely on syringe A and then attach syringe A with rubber tubing to syringe B, whose stopper is at the last measurement indicator.
- Push in the plunger on syringe B.
- Record the distance the plunger on syringe B is moved and the distance syringe A's plunger moves.

(continued)

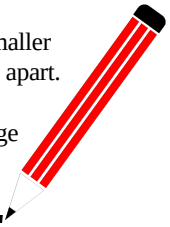
Suggestions for Assessment

Suggested Learning Resources

Teacher Notes

Background Information

Compressibility is the ability of fluids to be squeezed into a smaller volume. Gases are compressible because their particles are far apart. Liquids are considered almost incompressible because their particles are much closer together and there is no visible change in volume when they are being compressed.



Nelson Science & Technology 8: *Fluids* (Section 2.18)

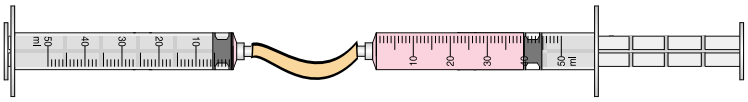
Sciencepower 8 (Section 6.1)

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
8-3-11 *(continued)*	*(continued)*

Part B: Hydraulic System

- Attach rubber tubing to syringe B and then, by pulling on the stopper of syringe B, fill the syringe and the tubing with water.
- Push in the plunger completely on syringe A and then attach it to the rubber tubing that is connected to syringe B, which is filled with water.
- Push in the plunger on syringe B.
- Record the distance the plunger on syringe B is moved and the distance syringe A's plunger moves.

syringe A **syringe B**



Have students answer the following questions in their science notebooks:

1. A system that transfers force efficiently would have the resulting movement of the load be equal or near equal to the distance the effort force travelled. An example of an efficient transfer of force would occur if the plunger on syringe A (providing the effort force) travelled five centimetres and the plunger on syringe B (load) travelled an equal distance. Based on this information, which fluid in your experiment transferred force more efficiently? (water)
2. A *hydraulic* system uses liquids for the transmission of force and a *pneumatic system* uses air for the same purpose. Based on the results you observed in your experiment involving pneumatic and hydraulic systems, which system would be more efficient to use if you were lifting a large load but did not have much force in the form of person power to lift the load? Why?

   (The hydraulic system would be more efficient because liquid transmits force more efficiently. You do not have to push as much with a hydraulic system as you do with a pneumatic system to have the object move an equal distance.)
3. What is the relationship between a fluid's compressibility and its ability to transmit force?

   (If a substance compresses little or not at all, it transmits force more efficiently.)

Suggestions for Assessment

Provide students with "How We Worked Together" (BLM 8-E) for self-assessment purposes.

Suggested Learning Resources

PRESCRIBED LEARNING OUTCOMES

Students will...

8-3-12 Identify a variety of natural and constructed hydraulic and pneumatic systems and describe how they function.

Examples: heart, lungs, eyedropper, misting bottle, fuel pump, hydraulic lift...

GLO: D4, E2

8-3-13 Compare hydraulic and pneumatic systems, and identify advantages and disadvantages of each.

GLO: B1, D4, E1, E2

8-0-2a ⊂ Access information, using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 8, 3.2.2)

8-0-2b Develop and use criteria for evaluating information sources. Include: distinguish between fact and opinion. GLO: C6, C8 (ELA Grade 8, 3.2.2, 3.2.3; TFS 2.2.2)

8-0-2c Make notes in point form, summarizing major ideas and supporting details and referencing sources. GLO: C6 (ELA Grade 8, 3.3.2)

8-0-7g ⊂ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 8, 4.4.1)

SUGGESTIONS FOR INSTRUCTION

➢ How Do They Compare?

Have students use a Compare and Contrast Frame (Matchullis and Mueller, 1994) to compare pneumatic and hydraulic systems. Provide students with numerous examples of hydraulic and pneumatic systems and have them research the topic using resources such as CD-ROMs, printed text, and/or the Internet.

(For strategies to aid students in using a variety of information sources, determining the usefulness of information, constructing meaning, recording information, referencing and evaluating sources, refer to *5–8 ELA*, learning outcomes 3.2.2–3.2.5 and 3.3.2–3.3.3.)

Teacher Notes

Background Information

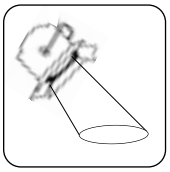
Both *hydraulic systems* and *pneumatic systems* can multiply a force, are based on the transformation of energy, deal with pressure in fluids, and have many technological applications.

Characteristics of Hydraulic and Pneumatic Systems

Hydraulic systems are	*Pneumatic systems* are
• operated by liquid, which becomes more viscous in cold temperatures, thus causing the device to "stiffen" (and the liquid may freeze)	• operated by gas or air, which contracts but does not become more viscous in cold temperatures
• used to transmit force by compression	• used to transmit force by decompression (like a spring)
• self-lubricating	• not self-lubricating
• not self-cooling	• self-cooling
• less commonly found than pneumatic systems	• more commonly found than hydraulic systems
• used to transport fluids in pipes, which requires pumps to create pressure to keep fluid flowing, as well as valves to regulate direction of flow	
• both natural and constructed (examples: the heart and circulatory system, oil pipeline, water pipes, hair salon or dentists' chairs, Jaws of Life, car hoists)	• both natural and constructed (examples: the lungs and respiratory system, air brakes, large tampers, dentists' drills, air bags, tires)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES



Engineering Challenge

Provide students with the following:

Engineering Challenge

An engineer is designing a machine to lift heavy pipes that are to be used for new sewer and water services in northern communities. Winter roads (frozen lakes and marshes) are the least expensive method of hauling equipment to these isolated communities. Workers often work in –30°C conditions. Should the engineer design a pneumatic or hydraulic system to lift loads at these sites? Explain your reasoning.

Look for:

The engineer should design a pneumatic system because air does not become more viscous in colder weather; however, a pneumatic system does not transfer energy as well as a hydraulic system does. A hydraulic system would work only if the engineer could find a liquid that did not become very viscous at low temperatures or a way to keep the liquid warm. Liquid transfers energy better than air does and a hydraulic system would be useful for lifting heavy pipes.

Scoring Rubric	
Score	**Criteria**
4	The student expresses an opinion, logically justifies the answer, and elaborates. The response includes evidence of higher order thinking.
3	The student expresses an opinion, logically justifies the answer, and elaborates.
2	The student expresses an opinion and justifies the answer, but the answer may contain minor errors. The response contains elaboration to support answer.
1	The answer is incorrect and/or contains major erors. The answer is not elaborated.

Nelson Science & Technology 8: *Fluids* (Sections 2.19-2.23)

Sciencepower 8 (Sections 6.2-6.3)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-3-14 Use the design process to construct a prototype that uses a pneumatic or hydraulic system to perform a given task.

Examples: a prototype that can lift a load a specified distance...

GLO: C3, D4

8-0-1c Identify practical problems to solve. *Examples: How can I make water flow uphill? Which type of bottled water should I buy?…* GLO: C3

8-0-1d ⊂ Select and justify a method to be used in finding a solution to a practical problem. GLO: C3 (Math: SP-II.1.8)

8-0-3d ⊂ Develop criteria to evaluate a prototype or consumer product. Include: function, aesthetics, environmental considerations, cost, efficiency. GLO: C3

8-0-3e ⊂ Create a written plan to solve a problem. Include: materials, safety considerations, three-dimensional sketches, steps to follow. GLO: C3, C6

8-0-4b ⊂ Construct a prototype. GLO: C3

8-0-5b ⊂ Test a prototype or consumer product, using predetermined criteria. GLO: C3, C5

8-0-6d ⊂ Identify and make improvements to a prototype, and explain the rationale for the changes. GLO: C3, C4

8-0-7d ⊂ Propose and justify a solution to the initial problem. GLO: C3

8-0-7e ⊂ Identify new practical problems to solve. GLO: C3

SUGGESTIONS FOR INSTRUCTION

➢ **Design Project: Toy**

Present students with the following scenario:

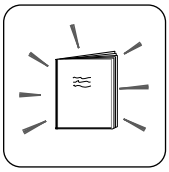
You are a designer at a toy company and your team specializes in designing the pneumatic and hydraulic components for toys. The list below indicates toys that need to be fitted with a hydraulic or a pneumatic system. Each toy has a part that requires movement, a load to be lifted, and/or a switch to be opened or closed.

Criteria should make reference to function, aesthetics, environmental considerations, cost and efficiency. Be prepared to present your design, test data and prototype to the toy company's board of directors (the class).

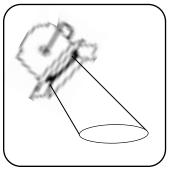
Design of Pneumatic/Hydraulic Devices for Toys

Possible toys:	**Design a pneumatic/hydraulic system or device that**
• jack-in-the-box	causes the doll to pop up. The toy can have a seasonal theme—a ghost pops up for Halloween, a chick pops out of an egg for Easter
• elevator in garage	lifts up a toy car from the ground floor to the second floor of a garage or car parkade. (Extension: Have the elevator platform tilt to send the car down a ramp and back down to the first floor.)
• dump truck	tilts the box to dump the load
• hairdresser's chair	lifts a salon chair that can hold a plastic doll
• fire-engine ladder	causes an extension ladder to lengthen

Suggestions for Assessment



When assessing the design of the pneumatic/hydraulic device, refer to "Design Project Report: Assessment" (BLM 8-P).



Design Presentation

Provide students with the following tool for peer assessment of the pneumatic/hydraulic device presentation.

Presenter: _____

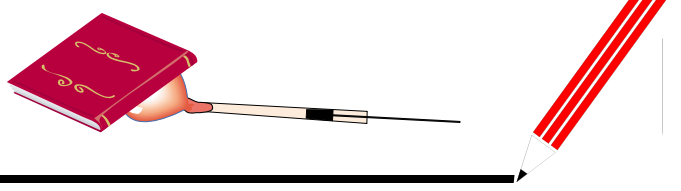
Peer assessor: _____

The speaker	Yes	No
• spoke so all could hear		
• used visual aids or props		
• identified whether the device was a pneumatic or a hydraulic system		
• clearly explained how the device worked		
Constructive comment:		

Teacher Notes

Prototypes may be made from a variety of materials such as cardboard, shoeboxes, straws, and small or large syringes, depending on the size of the load and the distance it will be lifted.

If sufficient quantities of syringes are difficult to obtain, construct working models using a balloon, large hosing or rubber tubing, a cork stopper, and a knitting needle or other similar object. Connect a piece of hosing to a balloon and place some water in the hose and balloon. Insert a stopper plunger into the opposite end of the hose. (See diagram below.) Pushing the plunger causes the water to fill the balloon, which increases in size and is able to lift the load.



Suggested Learning Resources

Nelson Science & Technology 8: *Fluids* (Section 2.2, Design Challenge)

Sciencepower 8 (Section 6.2, Unit 2, Chapter 6 project)

By Design: Technology Exploration & Integration (Design Process Reference and Tools)

Design and Technology System (Design Process Reference and Tools)

Mathematics, Science, & Technology Connections (Design Process Reference and Tools)

Notes