Unit 2
Fluids
Specific Curriculum Outcomes
Suggested Time: 19 Hours

Unit Overview

Introduction

Fluids, including air and water, are essential in most industrial processes. They form the basis of hydraulic and pneumatic devices and machines. Students will explore the properties of fluids, including viscosity and density, and explain them using the particle theory. They will also have an opportunity to understand the buoyant forces acting on floating, submerged, and sunken objects. As students conduct their investigations, they will recognize the practical applications of the properties of fluids in the operation of simple machines.

Focus and Context

The focus of this unit is on the inquiry process. Students will also have the opportunity to design and carry out activities based on fluids. The context is the students' knowledge and use of fluids and buoyancy. Ocean-going vessels and oil rigs would provide a context to investigate why some things sink and some things float.

Science Curriculum Links

At the primary level, students have explored the properties of different liquids and observed objects that sink and float. In elementary, students were introduced to air as a fluid in the context of flight. At the high school level, students will have opportunity to further explore fluids and hydraulics in physics and technology courses.

Curriculum Outcomes

STSE	Skills	Knowledge
Students will be expected to	*Students will be expected to*	*Students will be expected to*
Nature of Science and Technology 109-10 relate personal activities in formal and informal settings to specific science disciplines **Relationships Between Science and Technology** 111-1 provide examples of scientific knowledge that have resulted in the development of technologies 111-5 describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems **Social and Environmental Contexts of Science and Technology** 112-7 provide examples of how science and technology affect their lives and their community	**Initiating and Planning** 208-1 rephrase questions in a testable form and clearly define practical problems 208-2 identify questions to investigate arising from practical problems and issues 208-8 select appropriate methods and tools for collecting data and information and for solving problems **Performing and Recording** 209-1 carry out procedures controlling the major variables 209-3 use instruments effectively and accurately for collecting data 209-6 use tools and apparatus safely **Analyzing and Interpreting** 210-2 compile and display data, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots 210-6 interpret patterns and trends in data, and infer and explain relationships among the variables 210-7 identify, and suggest explanations for, discrepancies in data 210-9 calculate theoretical values of a variable 210-12 identify and evaluate potential applications of findings	307-6 compare the viscosity of various liquids 307-7 describe factors that can modify the viscosity of a liquid 307-8 describe the relationship between the mass, volume, and density of solids, liquids, and gases using the particle theory of matter 307-9 explain the effects of changes in temperature on the density of solids, liquids, and gases and relate the results to the particle theory 307-10 describe situations in daily life where the density of substances naturally changes or is intentionally altered 307-11 analyse quantitatively the density of various substances 309-1 describe qualitatively the relationship between mass and weight 309-2 describe the movement of objects in terms of balanced and unbalanced forces 309-3 describe quantitatively the relationship between force, area, and pressure 309-4 explain qualitatively the relationship between pressure, volume, and temperature when liquid and gaseous fluids are compressed or heated

Fluids and Viscosity

Outcomes

Students will be expected to

- identify questions to investigate arising from practical problems and issues involving fluids (208-2)
  - define fluid.

Elaborations—Strategies for Learning and Teaching

Teachers could use a Word Wall to display the key terms of the unit. This could be used in one of two ways; the teacher could place all of the words on the wall prior to beginning the unit or add words to the list as they are introduced.

Teachers could ask students to create a K-W-L chart (see Appendix B) on students' understanding of fluids.

Teachers should define a fluid as any form of matter (substance) that flows. Since liquids and gases do not have a definite shape they are able to flow. Hence by definition, liquids and gases are fluids.

- compare solids, liquids and gases in terms of shape and volume, and using the particle theory of matter. Include:
  - (i) shape
  - (ii) volume
  - (iii) particle arrangement
  - (iv) particle movement

Students have already discussed the three states of matter in the grade 7 unit "Heat". Teachers should review the following characteristics:

Solids	Liquids	Gases
Definite shape	Indefinite shape	Indefinite shape
Definite volume	Definite volume	Indefinite volume
Particles close	Particles close	Particles distant
Particles vibrate in place	Particles free flowing	Particles demonstrate random movement

Teachers could have students create a foldable to outline the characteristics of solids, liquids, and gases.

Teachers could engage students in a Numbered Heads strategy (see Appendix B) to review the characteristics of solids, liquids, and gases.

Teachers could use some the BLM 7 Activity 8 (Particle Theory Bingo) as a review.

- identify examples of fluids in everyday life. Include:
  - (i) compressed air in tires
  - (ii) water
  - (iii) syrup

Teachers could have students brainstorm examples of fluids in everyday life. Several examples that could be used include:

- food fluids (syrup, honey, molasses, water, or oil.)
- cleaning fluids (shampoo, liquid detergents, gels, abrasive creams like Vim™)
- bodily fluids (blood, mucus)
- industrial fluids (oils as lubricant, compressed air in tires)

Students may have difficulty with the concept of gases being fluids. Teachers can use this as an opportunity to address the fact that many terms have a different and often more precise meaning in science.

Fluids and Viscosity

Suggested Assessment Strategies

Paper and Pencil

- Create a foldable, or a window pane, to represent the arrangement and movement of particles in solids, liquids and gases. (208-2)
- Describe what happens to water particles as water changes from solid (ice) to liquid to gas (steam). Be sure to include the following words in your description:
  - (i) shape
  - (ii) volume
  - (iii) particle arrangement
  - (iv) particle movement (208-2)

Performance

- Design and perform a role play or a dance which shows the difference in behavior of the particles in the different states of matter. Students should focus on arrangement and movement of particles. (208-2)
- List examples of different types of fluids found in your home and specify whether these are liquids (L) or gases (G). Group them into categories using the table below:

Food Fluids	Cleaning Fluids	Bodily Fluids	Mechanical Fluids

(208-2)

- Interview 3 people who work in three different environments to determine what fluids are used, or found, in their workplace. (208-2)

Conventions used in Resources column

ST = Student Text

TR = Teacher Resource

TR AC = Assessment Checklist

TR PS = Process Skills Rubric

TR AR = Assessment Rubric

BLM = Black Line Master

BLM 8 Activity # = Additional BLMs for each grade level

Resources

ST p. 268

TR AC 24

ST pp. 269- 272
BLM 3-7

BLM 3-6

Fluids and Viscosity (continued)

Outcomes

Students will be expected to

- compare the viscosity of various liquids (307-6)
  - define viscosity
  - relate the viscosity of a liquid to the amount of friction between particles
  - identify examples of viscosity in everyday life.

Elaborations—Strategies for Learning and Teaching

Teachers should emphasize that viscosity is a measure of a liquid's resistance to flow. Many students will have had first hand experience with the viscosity of a variety of liquids. An informal discussion of various common liquids such as shampoo, juice, honey, pancake syrup or dish washing liquid will help the teacher determine how familiar students are with this concept.

Viscosity	Flow Rate	Description
High	Slow	Thick
Low	Fast	Runny

Teachers should review the idea of friction as a force that resists movement. Students have already defined friction and have explored how to increase or decrease its effects in the unit on forces and simple machines in grade five. The greater the friction or rubbing of particles in any fluid, the higher the viscosity. This can result from the size and shape of the liquid particles as well as the attraction between particles. Further discussion about the attraction between particles will take place later in this unit.

Using a variety of examples, such as motor oil, paint, various foods, teachers should help students identify the variety of examples of fluids in everyday life and to clarify that different fluids have different flow rates or viscosities. Teachers should also make students aware that many substances require the proper degree of viscosity to perform their intended function. For example, in order for motor oils to be effective lubricants, they need to have the proper viscosity. Paints require an appropriate degree of viscosity in order to spread properly. Peanut butter kept in the fridge is often too viscous to spread.

Students should be familiar with the correct way to describe the viscosity of fluids. Fluids that have a high viscosity, or fluids that are more viscous, flow slowly. Whereas fluids that have a low viscosity, or fluids that are less viscous, flow freely or faster.

Teachers could have students begin creating a mind map, using fluids as the central term.

Fluids and Viscosity (continued)

Suggested Assessment Strategies

Paper and Pencil

- Create a comic strip depicting the relationship between the viscosity and the friction between particles in a fluid. (208-2, 307-6)
- Find examples of different types of oils found in your home. For each type of oil, explain what it is used for and relate its viscosity to its uses. (109-10, 307-6)
- Rank the following liquids in order from lowest to highest viscosity: molasses, shampoo, water, cooking oil, tomato juice and dish washing liquid. (307-6)
- Choose any two liquids and describe the difference in terms of viscosity. (307-6)

Performance

- Create a poem, rap or song to help you distinguish between fluids that have a high viscosity and those that have a low viscosity. (307-6)

Journal

- Explain why some foods such as peanut butter are not kept in the refrigerator, while others, such as, margarine are. (208-2)

Resources

ST p. 278

ST p. 278

ST pp. 279-280
BLM 3-10, 3-12, 3-14

Comparing Viscosity

Outcomes

Students will be expected to

- identify and relate personal activities and potential applications to fluid dynamics (109-10, 210-12). Include:
  - (i) pancake batter
  - (ii) motor oil

Elaborations—Strategies for Learning and Teaching

Teachers should encourage students to generate a list of fluids used in everyday life. Teachers should lead students in a discussion relating the viscosity of liquids to their use. For example, the temperature of engine oil would dictate how quickly it would drain from an engine during an oil change, or why different types of motor oil are used for different engines and different seasons.

Teachers could work with the Home Economics teacher to have students investigate the viscosity of pancake batter. Teachers could ask students to determine why you are able to pour some batters and yet must spoon others. Teachers could have students investigate the preparation of various types of maple syrup and honey products that have various viscosities.

- define flow rate.
- identify examples of liquids with different flow rates. Include:
  - (i) water
  - (ii) dish washing liquid
  - (iii) corn syrup

Teachers should define flow rate as the speed at which a fluid flows from one point to another. This is often used to compare the viscosity of fluids since viscosity itself is a difficult property to measure directly.

Teachers should choose examples to show obvious differences in flow rates. The liquids chosen should include examples of fast (water), medium (dish washing liquid) and slow (corn syrup) flow rates. Other liquids that could be discussed and investigated include molasses, pancake syrup, honey, body lotion, liquid hand soap, cooking oil, shampoo, water, pop, milk and juice. Flow rate sensors could be used to investigate and measure viscosity.

- rephrase questions in a testable form and clearly define practical problems (208-1)
- identify and suggest explanation for discrepancies in data (210-7)
- compile and display data using a bar graph (210-2)
- carry out procedures controlling the major variables (209-1)
- interpret patterns and trends in data and infer and explain relationships among the variables (210-6)

Core Laboratory Activity: The Flow Rate of Liquids.

The laboratory outcomes 208-1, 209-1, 210-2, 210-6, 210-7 and, in part 307-6 are addressed by completing CORE LAB 7-2B “The Flow Rate of Liquids”.

Teachers could challenge students to design another method for testing the viscosity of liquids other than that outlined in the textbook. Some examples of other types of testing include: using a syringe and a constant pressure (weight) on the syringe to determine which liquid empties first; a splatter test, whereby students determine how far a particular liquid travels under constant pressure; and a spread test, whereby students draw a small circle (about 1/2 cm) in diameter on a white sheet of paper on which they place one drop of a particular liquid to see how far the liquid spreads in a given amount of time.

Students should discuss practical applications related to the viscosity of liquids.

Comparing Viscosity

Suggested Assessment Strategies

Performance

- Using a variety of pancake batter thicknesses, students will cook, share and compare their results. (109-10,112-7, 210-12)
- Create your own controlled experiment to compare the viscosities of a variety of liquids using the following materials:
  - (i) Inclined plane (example: a plank of wood)
  - (ii) Masking tape and straws (to create lanes)
  - (iii) Stopwatch
  - (iv) A variety of liquids (motor oil, paint, molasses, water, orange juice, ketchup) (307-6)
- Teachers could use an observational checklist to assess whether students can identify the dependent, independent and control variables in this activity.
- Interview a mechanic or another adult to determine why there are so many different types of motor oils; for example, why there are different oils for different engines as well as for different seasons. (109-10, 112-7, 210-12)

Resources

ST pp. 278-280

ST pp. 281-284
BLM 3-13

Core Lab # 3: "The flow Rate of Liquid", p. 282
TR pp. 3.14-3.16
TR AC 18, 19
TR PS 8, 10
TR AR 3
BLM 3-11
BLM 8 Activity 3

Comparing Viscosity (continued)

Outcomes

Students will be expected to

- provide examples of products that have been developed because of our understanding of viscosity (111-1)
- provide examples of how science and technology affect our lives and community (112-7)
- describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems (111-5)
- relate personal activities in formal and informal settings to specific science disciplines (109-10)

Elaborations—Strategies for Learning and Teaching

The **CORE STSE** component of this unit incorporates a broad range of grade 8 science outcomes. More specifically, it targets 109-10, 111-1, 111-5 and 112-7. The STSE component “Cleaning Fluids: Soaps and Detergents” can be found in Appendix A.

Comparing Viscosity (continued)

Suggested Assessment Strategies

Performance

- Design an activity to test the hypothesis "cleaning fluids with higher viscosities will clean substances better than fluids with lower viscosities". (109-10, 208-1)
- Create a comic strip that describes the actions of soaps and detergents on various types of dirt. (111-5)

Resources

Core STSE:
"Cleaning Fluids - Soaps & Detergents", Appendix A

Factors that Affect Viscosity

Outcomes

Students will be expected to

- describe factors that can modify the viscosity of a liquid (307-7)
  - explain a liquid's resistance to flow in terms of the particle theory of matter. Include:
    - (i) temperature
    - (ii) concentration
    - (iii) strength of attraction between particles

Elaborations—Strategies for Learning and Teaching

The Particle Theory of Matter, which students studied in grade 7, helps explain how these three factors affect viscosity:

(1) Particles are constantly in motion. As they acquire more energy, they move faster. As liquids are heated the particles move faster and farther apart. As a result, the space between the particles increases and thus the viscosity decreases because there is less friction and the attractive force between particles is reduced. For example, when honey or wax is heated it flows faster (viscosity decreases).

(2) There is empty space between the particles. Concentration refers to the amount of substance dissolved in a given volume. If a liquid is concentrated, it means that in general there are more particles in a given space. For example, skim milk, 1% milk, 2% milk, whole milk and cream.

(3) There is a force of attraction between particles that can be either strong or weak. The discussion with respect to viscosity should include the following two ideas: 1) there is an attraction of particles within the liquid itself; 2) there is an attraction between the particles of the liquid and the particles of the object on which it is flowing (i.e., "stick" to each other and "stick" to the container). Essentially these are the ideas of cohesion and adhesion. Students are not responsible for knowing these two terms, however, teachers should ensure that students could identify the two situations in which the attraction of particles takes place. Consider the droplets of rain that appear on a clothesline after a rainfall; the fact that water particles remain together to form droplets is an example of cohesion and the fact that the droplets remain on the clothesline is an example of adhesion.

The student textbook includes size as a factor that affects viscosity. While this is not core to the curriculum, teachers may choose to include this factor. The impact of "size" of a particle on viscosity is complex. Viscosity is impacted by the complexity of the particle's shape. Usually, the larger a particle is, the more complex its shape. As particles (molecules) get larger they generally have a more complex shape with numerous branched structures. It is the interaction of these shapes and branches that actually causes the increased viscosity as molecules "hook up" with each another. Consider the difference between pouring marbles or Jacks from a beaker. The marbles will "flow" much more easily than the Jacks. The tips (branches) of the Jacks will hook together, reducing "flow", and resulting in "clumps" of Jacks coming from the beaker.

Teachers could have students complete Investigations 7-3C and 7-3E as a means of covering this outcome and to provide students with the opportunity to observe the impact of temperature and concentration on viscosity of liquids in an experimental setting.

Factors that Affect Viscosity

Suggested Assessment Strategies

Journal

- Explain the following statement using the term viscosity:
  It is better to store molasses in the cupboard rather than the refrigerator when we are using it for pancakes. (307-7)
- Explain the scientific basis of the expression "slow as cold molasses." (307-7)

Paper and Pencil

- Explain how the viscosity of Purity Syrup (concentrated) changes when you mix it with water (dilute). (307-7)

Resources

ST pp. 286-288, 291-296
BLM 3-15, 3-16, 3-17
BLM 8 Activity 9
BLM 8 Activity 10

Defining Density

Outcomes

Students will be expected to

- describe the relationship among the mass, volume, and density of solids, liquids and gases using the Particle Theory (307-8)
  - define mass
  - define volume
  - define density
  - describe the relationship between state of matter (solid, liquid or gas) and density using the Particle Theory
  - describe the relationship between mass, volume and density

Elaborations—Strategies for Learning and Teaching

Teachers could have students construct regular solids from uniform building blocks and measure the volume of liquids by pouring them into a calibrated beaker. While the differentiation between mass and weight is done a bit later in this unit, teachers could choose to address this topic at this time.

In general, the following relationship exists between the states of matter and density:

	Solid	Liquid	Gas
Particles	Very close to each other	Close to each other	Distant from each other
Density	High	Moderate	Low

Teachers should ensure students understand the concepts of mass and volume prior to defining density. Teachers should emphasize that the mass-to-volume ratio of a material is a constant value.

Teachers could use lead and aluminum density blocks to help students gain an understanding of the relationships among the mass, volume and density of solids.

Students could investigate how various liquids (e.g. oil, salt water, distilled water) float on one another. Hydrometers could be used to investigate the densities of a variety of liquids.

Teachers could have students investigate the difference in density of gases by comparing an air-filled balloon to a helium-filled balloon of equal volumes.

Defining Density

Suggested Assessment Strategies

Performance

- Given a variety of liquids, groups of students can be challenged to place them in a test tube in an order that will produce the greatest number of layers. Remember that food coloring can be used for visual separation, depending on the liquid. Students will share their best combination with other groups. (307-8)

Journal

- Explain scientifically why it is easier to float in the ocean, rather than in a pond. (307-8)

Resources

ST pp. 302, 310

ST pp. 302-306
BLM 3-20

ST p. 311

Determining Density

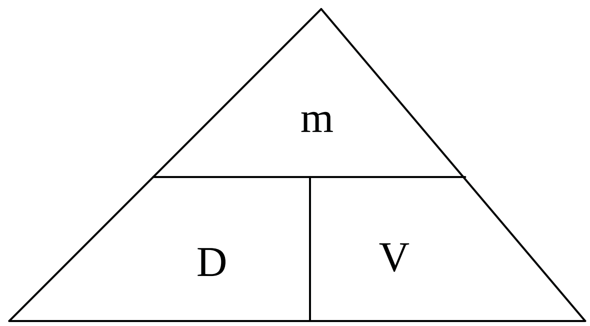
Outcomes

Students will be expected to

- analyze quantitatively the density of various substances (307-11)
  - calculate the density of a material, given mass and volume
  - calculate the mass of a material, given density and volume
  - calculate the volume of a material, given density and mass

Elaborations—Strategies for Learning and Teaching

The formula for density is D = m/V. Some students may be able to manipulate the equation algebraically. For students who struggle with the algebra, teachers could teach the three forms of the equation to calculate mass, volume and density (V = m/D and m = D x V), or use a formula triangle such as the following:



Teachers should note that Table 8.1 gives the approximate densities of various fluids and solids that can be used for calculations.

Teachers could use a data table, like the one below, to record observations and calculations as they address this outcome.

Substance	Mass (g)	Volume (cm^3 or mL)	Density (g/cm^3 or g/mL)
A			
B			
C			

Teachers should ensure that students understand that the density of a fluid (liquid and gas) is expressed in g/mL while the density of a solid is expressed in g/cm^3 since 1 mL is equal to 1 cm^3.

Teachers could reinforce the concept of density by using a dimensional diagram or regular shaped objects. For example, the density of brick can be calculated measuring the mass of a brick and determining its volume using l x w x h.

Determining Density

Suggested Assessment Strategies

Portfolio

- Students will complete the following table to calculate mass, volume and density of common items. Calculations for each are required.

Substance	Mass(g)	Volume (cm^3 or mL)	Density (g/cm^3 or g/mL)
Salt	20.00	9.26	
Gold	0.72		19.32
Wood (birch)		8.00	0.66

(307-11)

Resources

ST pp. 311-315
BLM 3-21, 3-22, 3-23, 3-24, 3-26

Determining Density (continued)

Outcomes

Students will be expected to

- use instruments effectively and accurately for collecting data (209-3)
- select appropriate methods and tools, and use them safely, in order to determine the volume of irregular shaped objects by water displacement (208-8, 209-6)
- identify, and suggest explanations for, discrepancies in data (210-7)
- interpret patterns and trends in data and infer and explain relationships among the variables (210-6)
- calculate the density of various objects. (210-9) Include:
  - (i) irregular shaped objects
  - (ii) liquids
  - (iii) granular objects
  - (iv) regular shaped objects

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity "Determining Density".

The laboratory outcomes 208-8, 209-3, 209-6, 210-7, 210-9 and, in part 307-11 are addressed by completing CORE LAB 8-2B "Determining Density".

NOTE: The instruction in Part 2 of this lab activity instructs students to create a line graph of the class results. However, for these results, a histogram (bar graph) is a more appropriate way to display the results graphically. It is recommended that teachers make the following changes to the instructions/ procedure:

Part 1:

- Procedure step 9 (ST p. 318). Replace the class results table with the following table:

Substance	Mass-to-Volume ratio (g/mL)
Water	
Oil	
Glycerol	
Molasses	
Sand	

Part 2:

- Replace instructions for line graph to instruct students to create a bar graph
- Adjust the questions that follow (e.g., Analyze #1, Conclude & Apply #5, #7, and #8) to reflect the graph change
- BLM 2-25, if used, will need to be modified to reflect these changes.

In order to determine density, teachers should probe the idea of how to determine the volume of irregular shaped objects. Teachers should ensure that students are aware that they can determine the volume of irregular solids by immersing them into a beaker of water and measuring the volume of the displaced fluid. Teachers could use Activity 8.2A to demonstrate this concept.

Teachers should note that the volume of the substance used could be adjusted to smaller amounts, e.g., 50 mL, 100 mL, 150 mL, etc.

Variations in readings of the various instruments will help students understand the need for accurate measurement and how some errors can be explained when compared to a norm.

Teachers could initiate a discussion of the Nature of Science. This discussion could include how science has advanced with the introduction of various tools and the fact that observations made are only as good as the tool used, as well as the person using it. Teachers could raise the question of whether scientists would ignore results that are not consistent with what they expected and discuss why this may happen.

Determining Density (continued)

Suggested Assessment Strategies

Journal

- Identify when you would use the water displacement method for determining the volume of irregularly shaped objects. (208-8, 209-6)

Performance

- Given a graduated cylinder, water, a ruler and a catch tray, measure the volume of a rock and a rectangular pencil eraser. Describe how to measure the volume of each object. (208-8, 209-6)

Paper and Pencil

- Using the water displacement method, you determined that the volume of a marble was 10.5 cm^3. Your lab partner also measured the volume but used a formula for their calculations and found the volume to be slightly less than yours. Explain. (210-7)
- Using the concepts of volume, density and mass describe how Archimedes proved that the King's crown was not made of pure gold (refer to Discovering Science 7 text for the Archimedes story). (208-8, 209-6)

Resources

Core Lab # 4: "Determining Density", p. 316
BLM 3-25
TR pp. 3.36-3.38
TR AC 4
TR PS 7, 10
TR AR 3
BLM 8 Activity 3

Changes in Density

Outcomes

Students will be expected to

- explain the effects of changes in temperature on the density of solids, liquids, and gases and relate the results to the Particle Theory (307-9)

  - identify examples of density changes (resulting from a temperature change) in everyday life. Include:
    - (i) hot air balloons
    - (ii) warm vs. cool tire pressure
    - (iii) water in its three states

- describe situations in life where the density of substances naturally changes or is intentionally changed. (307-10) Include:
  - (i) drying of wood (seasoning of wood)
  - (ii) hot air balloons
  - (iii) salt water being easier to float in

Elaborations—Strategies for Learning and Teaching

Students should be familiar with the effect of temperature on the three states of matter.

The example of density being influenced by temperature change could be demonstrated using a balloon, a measuring tape and the freezer compartment of a refrigerator. Teachers could fill a balloon with air and tie it off. Measure the circumference of the balloon. Place the balloon in the freezer and again measure the circumference of the balloon – it should be less. As density is a measure of the ratio of mass and volume, density should increase when the air in the balloon is cooled. This could be observed by measuring the circumference of the balloon.

Most substances are denser in their solid state than in their liquid state; water is an exception. When water freezes, it expands due to its molecular structure (i.e., its volume increases) and its density decreases because there is more space between the molecules . This is why ice floats.

Hot air balloons, submarines and scuba gear are a few examples of situations that teachers could use to describe how the density of some substances changes or is changed. Teachers could have students investigate situations in nature where the density of substances changes naturally such as in the air bladder of a fish and ice.

Teachers could use examples of floating offshore drilling rigs and how sunken ships, such as fishing boats or the Titanic, could be raised from the sea floor.

Changes in Density

Suggested Assessment Strategies

Portfolio

- Using knowledge of how temperature change affects volume and density, explain the following situations:
    - (i) A helium-filled balloon shrinks when exposed to cold temperatures
    - (ii) Alcohol, in a thermometer, rises when heated
    - (iii) Vinyl siding installed during cold weather must have spaces between each piece
    - (iv) Power lines sag in the summer (307-9)

Journal

- Explain why you should not over-inflate your car tires during the hot, summer months. (307-9)

Performance

- Research the use of nitrogen to inflate car tires. (307-9)

Interview

- Interview any person associated with the building or use of wooden watercraft. Investigate:
    1. Why certain types of wood are used more commonly?
    2. Why the wood is dried before using? (309-2, 307-10)

Resources

ST pp. 324-326
BLM 3-40

ST pp. 324-326
BLM 3-27
BLM 8 Activity 4
BLM 8 Activity 5

Balanced and Unbalanced Forces

Outcomes

Students will be expected to

- describe the movement of objects in terms of balanced and unbalanced forces (309-2)

  - define:
    - (i) force
    - (ii) newton
    - (iii) balanced and unbalanced forces
    - (iv) weight
    - (v) mass

Elaborations—Strategies for Learning and Teaching

Teachers should provide students with examples of balanced and unbalanced forces. Balanced forces are equal and opposite forces such as those that prevent a wagon from rolling down a hill. Unbalanced forces are unequal such as those that cause an object to fall.

While the terms “weight” and “mass” are often used interchangeably they do not mean the same thing in science. Teachers may have to spend some time clarifying the difference between mass and weight as this topic progresses. Weight is a measure of the force (pull) of gravity on an object while mass refers to the amount of matter in a substance. The weight of an object will change if the gravitational force changes (e.g., if you leave Earth and go to the Moon). However, the amount of matter in the object will remain the same. Likewise, a brick will weigh less when submerged in water but its mass is unchanged. Teachers should define newton as the unit of measure of force. In practical terms, on Earth 1 newton is equal to approximately 100 grams.

Teachers could engage students in a Quiz-Quiz Trade activity (see Appendix B), with balanced and unbalanced forces, using the Inside-Outside Circle (see Appendix B). The inside circle would rotate clockwise and the outside circle would rotate counter-clockwise. As in Quiz-Quiz Trade, students should exchange cards after each question.

- describe qualitatively the difference between mass and weight (309-1)

Teachers should ensure that students recognize that the mass of an object does not change, but its weight changes depending on the local gravitational force.

Teachers could have students compare units of mass (grams, kilograms) with the forces (newtons) they exert on Earth by using spring scales and various balances.

Teachers could have students take part in a Think-Pair Share activity (see Appendix B) dealing with situations involving mass and weight. An extension of this could involve students correcting false statements related to these concepts.

As enrichment, teachers could have students complete BLM 3-31.

Balanced and Unbalanced Forces

Suggested Assessment Strategies

Paper and Pencil

- Draw a diagram of each of the following three situations:
  - (i) rock sinking in water
  - (ii) helium balloon rising
  - (iii) boat floating on water

  In each diagram, use arrows to demonstrate the forces of buoyancy and weight. Longer arrows will represent the greater force, shorter arrows will represent the smaller force, and arrows of the same size will represent equal forces. (309-2)
- Describe the difference between mass and weight using the terms force meter, balance scale, and gravity. (309-1)

Journal

- You have just accepted a new position with NASA and your first mission involves a two-month stay at their space station on the Moon. Because of mass restrictions on the spacecraft, your suitcase cannot exceed 20 kilograms. NASA also requires that the weight of your suitcase be measured. Upon arrival at the space station, you notice that your suitcase weighs less. Explain. (309-1)

Portfolio

- Given the following data, explain why the weight of an object varies from planet to planet. Which planet has the least amount of gravity? Explain.

Planet	Weight (newtons)
Earth	680
Mercury	240
Venus	572
Mars	266

(309-1)

Resources

ST pp. 334-335, 346
TR AR 3

ST p. 335

Buoyancy and Buoyant Forces

Outcomes

Students will be expected to

- describe the connection between weight, buoyancy, and sinking or floating (309-2)

Elaborations—Strategies for Learning and Teaching

Teachers should provide students with the opportunity to discuss weight, buoyancy, sinking or floating by relating their personal observations when swimming and/or lifting objects in the water. Students may already have had the experience of trying to immerse a beach ball in water, but have not been able to explain it scientifically.

Teachers could introduce students to simple force vectors when investigating and representing the various forces in play when an object floats or sinks.

- define buoyancy
- apply the concept of balanced and unbalanced forces to the buoyancy and weight of an object to explain why it sinks or floats

Teachers should ensure that students understand that an object will float if its buoyant force, when fully immersed, is greater than its weight (gravitational force); and it will sink if its weight is greater than the buoyant force. To illustrate this, teachers could use objects of different masses and place them in water.

Buoyancy and Buoyant Forces

Suggested Assessment Strategies

Performance

- Using a variety of common materials cut into equally sized blocks, investigate mass, volume and density. For example, styrofoam, wood, cheese, modeling clay and floral foam. Measure their masses, predict and determine whether or not they will sink or float in water. Results can be recorded in a table, as follows:

Type of Material	Mass of Block (g)	Prediction (Sink or Float)	Observation (Sink or Float)

(309-2)

- Investigate and describe the interaction between buoyant forces and weight of different objects. For example, three different balls, made of materials such as Styrofoam, rubber and metal, can be immersed and released in water. After the balls have come to rest, explain your observations in terms of buoyant forces in relation to the object's weight. Results can be summarized in a table as below:

Object	Mass (g)	Weight (N)	Sink or Float?	Greater Force; buoyancy or gravity?
Styrofoam ball				
Metal ball				
Rubber ball				

Note: This can be modified by providing students with objects of different shapes to show the role shape and surface area play in buoyancy. (309-2)

Journal

- Your younger brother loves piggy back rides. You discover that it is much easier to give him a piggy back ride in your swimming pool than it is in your living room. Explain, using buoyant forces. (309-2)
- An ice cube in the bottom of an empty glass will float as water is poured into the glass. Why doesn't the ice cube stay on the bottom of the glass or float into the air like a balloon? (309-2)

Resources

ST p. 336
BLM 3-29, 3-32

ST pp. 336-339
BLM 3-32

Applications of Buoyancy

Outcomes

Students will be expected to

- provide examples of technologies that have been developed because of our understanding of density and buoyancy (111-1) Include:
  - (i) personal flotation devices (ex. life jackets)
  - (ii) submarines
  - (iii) hot air balloons

Elaborations—Strategies for Learning and Teaching

Personal flotation devices (PFD) generally operate because they are made of materials that have a very low density. When a person wears a life jacket, the average density of the person and life jacket is less than the density of the water. As a result, the person floats.

Teachers could introduce the relationship between weight of the person and the size of the PFD. Teachers could also discuss why a PFD loses its buoyancy after a period of years (i.e., as the materials start to break down they compress and they become more dense).

Teachers should provide students with opportunities to relate various technologies, such as personal flotation devices, research submersibles and diving equipment, based on the principles of density and buoyancy.

- define average density

Teachers should clarify that average density results in objects that would normally sink being able to float (e.g., metal ships). Students should be able to:

- indicate that an object will float if its average density is less than the fluid in which it is immersed
- indicate that an object will sink if its average density is denser than the fluid in which it is immersed

Teachers could have students complete Activity 9-1C and/or Activity 9-1D to reinforce an understanding of density and buoyancy.

- list examples of materials that may sink or float, depending on the application. Include:
  - (i) wooden boats vs. a water logged stick
  - (ii) metal block vs. metal boats
  - (iii) a sealed, empty plastic bottle vs. a plastic bottle full of water

Teachers could encourage student thinking about questions to investigate using the following to start discussion:

- Why do metal boats float when metal is more dense than water?
- When swimming, why do you sink when you roll yourself into a ball, but you float when you lie flat on your back or stomach?

Teachers could use an Anticipation /Reaction Guide strategy (see Appendix B) using examples of different materials.

Applications of Buoyancy

Suggested Assessment Strategies

Performance

- In groups, investigate the relationship between mass to volume, by designing a variety of vessels using modelling clay or tin foil. Each group is responsible for designing and conducting a fair test to determine which design holds the most mass. (111-1, 309-2)
- Choose from a variety of materials, such as tinfoil, cardboard, modelling clay, and plastic to design and construct a boat. Test the designs to determine which boat can hold the most mass and stay afloat. (111-1, 309-2)

Paper and pencil

- You have decided to purchase some new canoe paddles for the summer season. At the sporting goods store, you see several types; some made of wood and some made of metal, but they have equal mass. Given that wooden paddles are less dense than water and the metal paddles are more dense, which would you buy? Explain (309-2)
- Your younger brother has recently received some bath tub toys and asks you to explain why some of the objects float, while others sink. Write a response to his question using your knowledge of density. (309-2)

Journal

- Your teacher has just presented the class with a glass of water containing one ice cube. Explain why most of the ice cube is below the surface of the water, yet the ice cube is still floating. (309-2)

Presentation

- Research a variety of technologies that use the principles of density and buoyancy in their function. Some examples are: life jackets, submarines, hot air balloons, research submersibles, and diving equipment. Create a visual display that demonstrates how these devices take advantage of our knowledge of density and buoyancy. (111-1)
- Material, the shape and size of the vessel are all important factors in boat and ship construction. Investigate how these factors affect how well a boat or ship floats. Create a visual display of your findings. (111-1, 208-2)

Resources

ST p. 340
BLM 3-33

ST pp. 339-343
BLM 3-30, 3-34

Pressure, Hydraulics and Pneumatics

Outcomes

Students will be expected to

- describe quantitatively the relationship between force, area, and pressure (309-3)

Elaborations—Strategies for Learning and Teaching

A study of unbalanced forces could also lead to an investigation of pressure in fluids (liquid and gas) and solids. Teachers should ensure that students have a qualitative understanding of the relationship between force, area and pressure before teaching the quantitative relationships. Using the example of flat-heeled shoes and high-heeled shoes, teachers could lead a discussion on the relationship of weight (gravitational force) and pressure.

Teachers could provide opportunities for designing experiments and identifying major variables related to relationships among force, area, and pressure.

Teachers could demonstrate the relationships between fluid depth and pressure, using bottles or cans with holes at varying depths to illustrate how the water will leak out when put in the cans.

- define pressure

Teachers could use activity 9-2A to introduce the concept of pressure.

- define the pascal (Pa) unit

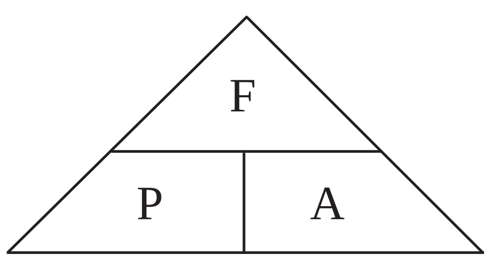
Teachers should introduce students to the term pascal when doing investigations involving pressure. One pascal is a very small amount of pressure, $1 \text{ Pa}=1\text{N/m}^2$. Teachers could further explain to students that this is the equivalent of 100 grams of force spread over a 1 metre by 1 metre surface.

- define atmospheric pressure

Atmospheric pressure is the amount of force that is exerted by the weight of the atmosphere. Students may have difficulty accepting the concept that gases such as the air around us has “weight”. To demonstrate that gases have weight place a paper bag or beaker on an electronic scale and zero. Produce carbon dioxide gas by combining vinegar and baking soda. Pour the invisible carbon dioxide gas into the bag/beaker on the electronic scale and notice the change in mass/weight.

- calculate the pressure, given force and area
- calculate the force, given pressure and area
- calculate the area, given pressure and force

Some students may be able to manipulate the equation algebraically. For students who struggle with the algebra, teachers could also teach the three forms of the equation to calculate pressure, force and area ($P = F/A$, $F = P \times A$, and $A = F/P$), or use a formula triangle such as the following:



Pressure, Hydraulics and Pneumatics

Suggested Assessment Strategies

Journal

- Explain how force, area and pressure interact to make the following events possible:
  - (i) A person wearing snowshoes can walk across a section of deep, soft snow without sinking
  - (ii) The nozzle on a garden hose can be used to create a faster or slower flow of water (309-3)

Paper and Pencil

- Students will complete the table below:

Force (N)	Area (m^2)	Pressure (N/m^2 or Pa)
10	2	
	5	1000
50		150

(309-3)

Performance

- Pour hot water into a plastic pop bottle. Rinse it around and pour out the water. Screw the cap on tightly, observe what happens. Using what you have learned about atmospheric pressure, explain your observations. (309-3)

Resources

ST pp. 350-353

ST p. 349, 351

ST p. 355

ST pp. 350-353
BLM 3-35, 3-36

Pressure, Hydraulics and Pneumatics (continued)

Outcomes

Students will be expected to

- describe the science underlying hydraulic technologies (111-5)
  - define hydraulic system
  - identify a liquid as an incompressible fluid (i.e. definite volume)
  - define pneumatic system
  - identify a gas as a compressible fluid (i.e. indefinite volume)

Elaborations—Strategies for Learning and Teaching

Investigation of hydraulic systems and pipeline systems would enable the students to better understand the relationship among force, area, and pressure. Teachers could invite professionals working in the oil industry to speak to the class.

Teachers could use the following table to compare a hydraulic system with a pneumatic system.

Property	Hydraulic System	Pneumatic System
State	Liquid	Gas
Volume	Definite	Indefinite
Pressure	Not Compressible	Compressible

- state Pascal's Law

Teachers should provide students with an opportunity to explore Pascal's Law. Teachers could use water-filled balloons, plastic bottles or syringes to illustrate a simple hydraulic system.

- identify examples of applications of Pascal's Law. Include:
  - (i) car lift or hoist
  - (ii) hydraulic jack
  - (iii) automobile braking system
  - (iv) air compressors
  - (v) automobile/bicycle tires

There are numerous examples of technology that use Pascal's Law in their functioning. For example, students may have observed the automobile lift pump seen in service stations, which is a common example and application of Pascal's Law. Where feasible, teachers could arrange a field trip to a local service centre to see a variety of technologies based on Pascal's Law. Other examples of Pascal's Law that students could explore include hydraulic chairs (dentist, hairdresser, and office), water guns, farm machinery, heavy construction equipment, hydraulic jacks, automobile braking systems, artesian wells, water towers, and dams. While it is not expected that students study all these examples, teachers could opt to examine one of these devices in detail or to assign teams of students to analyze and describe how Pascal's Law applies to a selected technology.

Teachers should clarify that Pascal's Law applies to both hydraulics and pneumatics.

Pressure, Hydraulics and Pneumatics (continued)

Suggested Assessment Strategies

Interview

- Interview a mechanic regarding the importance of having hydraulic technologies in a garage. These technologies can include a car lift, hydraulic jacks, and automobile brake systems. (111-5)

Portfolio

- Using Pascal's Law, explain how a water gun works. (111-5)

Resources

ST p. 354-359

ST p. 356

ST pp. 356-362

Physical Properties of Gases

Outcomes

Students will be expected to

- explain qualitatively the relationship among pressure, volume, and temperature when liquid and gaseous fluids are compressed or heated (309-4)
  - indicate that increasing the pressure on a gas results in a decrease in volume when temperature is held constant
  - indicate that increasing the temperature of a gas results in an increase in volume when pressure is held constant

Elaborations—Strategies for Learning and Teaching

Teachers could use an Anticipation /Reaction Guide strategy (see Appendix B) to introduce these relationships and to activate students' prior knowledge of this topic.

Teachers could use pressure sensors along with computer interface technology to explore, illustrate and demonstrate pressure changes. These sensors can easily measure changes in gas pressure, and can help students make an abstract concept more concrete and measurable. Computer simulations can be used to demonstrate the relationship among pressure, volume and temperature.

Teachers should provide students with examples of how increasing pressure decreases volume. This could include propane tanks, carbon dioxide cartridges used in paint ball guns, spray paint, whipped cream in an aerosol can, compressed air toys (Air Hogs™ and Nerf ™ guns) and aerosol hair spray.

Other pressure-volume examples that students may be familiar with include: hot air balloons, compressor for tools, hyperbaric chamber, automobile tires, football, soccer ball and basketball.

Teachers should provide students with examples of how increasing temperature increases volume. This could include hot air balloons or gasoline cans on a hot day. Teachers could use the Particle Theory to explain how temperature affects volume. For example, increasing temperature provides more kinetic energy to the particles of gas. These particles then move further apart which increases their volume.

Teachers could have students carry out Activity 9-3A, "Hot and Cold Gases" to demonstrate how temperature affects the volume of a gas.

- indicate that increasing temperature of a gas results in an increase in pressure when volume is held constant

Teachers could also use the Particle Theory when they address this outcome. Heating a closed container provides more kinetic energy to the gas particles. This causes them to increase their movement. Since there is nowhere to go in a closed container, those particles bang into the walls of the container. Eventually, if enough energy (heat) is applied, the particles will hit the walls with sufficient force (which we call pressure) to break the container open. When the container breaks open, all the contents exit through the break in rapid order. This results in what we refer to as an explosion. A common example would be heating canned food without opening the can.

Teachers could have students complete Activity 9-3C, "The Pressure is Rising" to reinforce the effect of temperature on a closed gas.

If time permits, teachers could have students complete Activity 9-3D (BLM 3-44) to examine the effects of pressure on a liquid and to further reinforce their laboratory and graphing skills.

Physical Properties of Gases

Suggested Assessment Strategies

Portfolio

- Use a concept map to show the relationship between pressure, volume and temperature when liquids and gases are compressed or heated. (309-4)

Paper and Pencil

- Draw a sketch or cartoon to show how gas volumes change at different temperatures. Be sure to include the Particle Theory of Matter. (309-4)
- Describe how an increase in temperature affects the volume of an inflated balloon. (309-4)

Performance

- Create a storybook that can be used by an elementary-aged child to understand the relationship between temperature, volume, and pressure of gases. (309-4)

Resources

ST pp. 364-372

ST pp. 364-372

Physical Properties of Gases (continued)

Outcomes

Students will be expected to

- explain qualitatively the relationship among pressure, volume, and temperature when liquid and gaseous fluids are compressed or heated (309-4)

  (continued)

  - provide examples illustrating the relationship among pressure, volume and temperature when gaseous fluids are compressed or heated. Include:
    (i) propane cylinders (increase in pressure with a decrease in volume at constant temperature)
    (ii) heating an aerosol can result in an explosion (increase in temperature resulting in an increase in pressure, at constant volume)

Elaborations—Strategies for Learning and Teaching

Teachers could ask students to consider why aerosol cans have a symbol on them warning that they should not be placed near heat/ flame. Using the Particle Theory to explain this would be helpful. Teachers could use WHMIS or consumer safety symbols relating to items under pressure to make a link between these concepts and safe practices when using compressed gases.

Teachers could use BLM 3-38 which engages students in an activity to consider the safety of various household liquids.

Physical Properties of Gases (continued)

Suggested Assessment Strategies

Paper and Pencil

- Prepare a graph to show that at a constant temperature, an increase in pressure will result in a decrease in volume. (210-6, 309-4)
- Prepare a graph to show that at a constant volume, an increase in pressure will result in an increase in temperature. (210-6, 309-4)
- Prepare a graph to show that at a constant pressure, an increase in temperature will result in an increase in volume. (210-6, 309-4)

  Note: These graphs do not need to be numeric.

Performance

- Create a poster or collage that demonstrates the relationship between pressure, volume, and temperature of gases you encounter each day. (309-4)
- Create a brochure that explains the dangers associated with storing gases under pressure (i.e., explain the relationships between pressure, volume, and temperature). (309-4)

Resources

ST pp. 368-370
BLM 3-43

ST pp. 366-372
BLM 8 Activity 9