Unit 2: Motion and its Applications
Specific Curriculum Outcomes

Suggested Time: 60 Hours

Unit Overview

Introduction

The concept of motion allows students to investigate and develop their interest in the sports that are part of their daily lives. Students will not only have opportunities to investigate the principles of kinematics, but will also be encouraged to apply its development into areas of individual interest. Whether they choose Olympic sports events or personal leisure activities such as snowmobiling or biking, students will develop their understanding of the concepts of displacement, velocity, and acceleration.

Focus and Context

The unit on motion should have two principal focuses- inquiry and problem solving. Students will be able to examine questions which inquire into the relationships between and among observable variables that affect motion. Once these relationships are understood, design investigations can begin to address the problems associated with those questions. By applying mathematical and conceptual models to qualitative and quantitative data collected, motion can be graphically represented. This will provide a visual representation of aspects of velocity and acceleration. Mathematics and graphical analysis allow us to see basic similarities in the motion of all objects. In addition, the unit provides opportunities to explore decision making as the students investigate the developments in design technology.

Science Curriculum Links

Prior to Level I, the study of motion receives little depth of treatment. Indirect connections are found with "Forces and Simple Machines" and "Flight" in elementary science. "Force and Motion" and "Machines and Work" in the intermediate grades have more direct, foundational connections. In high school, those students who pursue studies in Physics will develop further connections in "Force, Motion, Work, Energy, and Momentum." The study of motion will also develop a strong link to Mathematics in grades 9 and Level I where "Data Management" includes the collection, display, and analysis of data.

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 114-6 relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary studies 115-2 illustrate how science attempts to explain natural phenomena **Relationships Between Science and Technology** 116-1 identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology 116-5 describe the functioning of domestic and industrial technologies, using scientific principles 116-6 describe and evaluate the design of technological solutions and the way they function using principles of energy and momentum **Social and Environmental Contexts of Science and Technology** 117-1 compare examples of how society supports and influences science and technology 117-7 identify and describe science- and technology-based careers related to the science they are studying 118-2 analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology 118-6 construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives 118-9 propose a course of action on social issues related to science and technology, taking into account human and environmental needs 118-10 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability	**Initiating and Planning** 212-3 design an experiment identifying and controlling major variables 212-7 formulate operational definitions of major variables 212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making **Performing and Recording** 213-3 use instruments accurately for collecting data **Analysing and Interpreting** 214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots 214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables 214-8 evaluate the relevance, reliability, and adequacy of data and data collection methods 214-10 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty 215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results 215-5 develop, present, and defend a position or course of action, based on findings	325-1 describe quantitatively the relationship among displacement, time, and velocity 325-2 analyze graphically and mathematically the relationship among displacement, velocity, and time 325-3 distinguish between instantaneous and average velocity 325-4 describe quantitatively the relationship among velocity, time, and acceleration 325-5 use vectors to represent force, velocity, and acceleration NLS-2 describe the relationship among speed, distance and time

Distance and Speed

Outcomes

Students will be expected to

- describe the relationship among speed, distance and time (NLS-1)
  - define distance, time and speed qualitatively
  - demonstrate the proper use of SI units

Elaborations—Strategies for Learning and Teaching

Throughout this unit, it is important that the differences between speed-velocity, distance-displacement, and average velocity-constant velocity be recognized and the names consistently used. Also, if students are provided with various examples of motion to investigate, they will begin to develop a thorough understanding of the concepts of displacement and velocity.

Teachers could begin the unit by investigating students' prior knowledge on the concepts of distance and speed. Students could begin the unit by brainstorming a list of activities or content areas that are concerned with measuring distances and speeds. The list might include: automobiles and speed limits; various sports (swim distances, running speeds, throwing distances, pitching speeds); carpentry and construction; and the study of physics (measuring moving objects, speed of light and sound). It will likely become obvious through such a discussion that units and how objects are measured are key aspects of reporting any distance, speed or time measurement. For example; students might use the unit km to report the distance travelled in a car, the unit m to report the height of a building, and the unit mm to record the thickness or diameter of a coin. Likewise, the unit used to measure speed will depend on the rate of change. Fast moving objects, such as the speed of cars, may be measured in km/hr. Slow moving objects, such as the growth of plants, may be measured in cm/week.

Teachers could use the image of a speed limit sign (e.g., 60 km/hr) to help define speed and relate to the units used (see next elaboration). Using a photo or overhead of a speed limit sign, teachers can show students that speed is a unit of distance (e.g. 60 km) divided by a unit of time (1 hr). Teachers could refer to Figure 3 on page 138 if a speed limit sign is not available. Note the absence of units on this sign. In this case, since "everyone" knows the unit of speed for driving, the "km/hr" is normally omitted. Teachers could ask students whether they would always use these units (e.g. km and hr) to measure speed. This leads into the next outcome. (When addressing calculations of Speed, Distance, Time in a later section of this unit, teachers can come back to the example of a speed limit sign to help make the formula $s=d/t$ more relevant.

There are no set rules for choosing a unit to describe a distance or speed. Usually, society (newspapers, television, or everyday conversation) chooses a unit that keeps the magnitude of the distance or speed reasonable. For example, the distance between two towns may be reported as 36 km. This is reasonable since we know approximately what the distance of 1 km is, and can easily imagine 36 times that distance. Teachers could ask students how they would feel if someone told them that the distance between two towns is 36 000 000 mm.

Distance and Speed

Suggested Assessment Strategies

Performance

- Construct a chart to compare times required to travel a fixed distance, at various speeds. Students could crawl, walk, skip, jog, and sprint the fixed distance. What conclusions could be made about the students time and speed? (NLS-2, 214-10)

Journal

- Ask students to reflect on the previous assessment strategy and make a journal entry why it was important to maintain a fixed distance. (NSL-1)

Paper and Pencil

- Given a list of examples of chemical reactions, students identify the reaction type. (321-1)
- Students could suggest the proper SI units used to measure the following;
  - i) distance from St. John's to Corner Brook
  - ii) width of a hockey rink
  - iii) length of a popsicle stick
  - iv) width of a popsicle stick
  - v) time for a sports car to accelerate from rest to 60 km/h
  - vi) time to blink an eyelid
  - vii) mass of a moose
  - viii) mass of a bag of potato chips (NLS-2, 214-8)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 136-141

TR: 3.7-3.16

SRL: 198-207

Distance and Speed *(continued)*

Outcomes

Students will be expected to

- describe the relationship among speed, distance and time (NLS-1) **Cont'd**

  - measure distances accurately

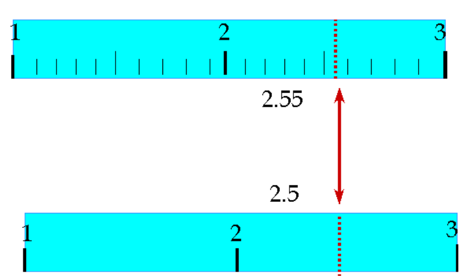
Elaborations—Strategies for Learning and Teaching

Scientists usually choose units based on easy conversion, relationship to other units (when used in calculations), and reasonable magnitude. SI units are recognized by the scientific community as the standard units of measurement. Students should choose the proper SI unit when measuring distances, volumes, temperatures, times and masses.

Teachers could relate this to the speed limit sign example. Note that the "standard" SI units for measuring speed (velocity) is metres and seconds not km and hr. Using km and hr is not wrong as it is more appropriate to use these units when discussing automobiles. It is more appropriate to use metres and seconds when working on a smaller scale (e.g., an experiment in a laboratory).

Teachers could use Diagnostic Assessment 1: Understanding Key Concepts to introduce the key concepts of distance, time, speed. Refer to page AT-12 of TR for details.

When performing any measurement properly, the last digit will be an estimated value which lies between the graduations (marks) on the measuring device. The number of digits reported in a measured value indicates the precision of a measurement. Students should realize that a measurement of 3.0 cm may not be the same as 3.00 cm. They were measured with instruments that have different degrees of precision. The measured value 3.0 cm could actually be 3.02 cm or 2.97 cm and the instrument would still read 3.0 cm. When measuring distances, estimating the last digit becomes more difficult the closer the graduations on the measuring device. For example; estimating between one millimeter divisions is much more difficult than centimeter divisions. Students should practise estimating between large divisions before attempting smaller ones.



Distance and Speed *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Provide an argument stating why it is important for recording devices to be very precise in various Olympic sports, such as down hill skiing and bobsleighing. (NLS-2, 214-8)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 136-141

TR: 3.7-3.16

SRL: 198-207

Distance and Speed *(continued)*

Outcomes

Students will be expected to

- relate personal activities to studying distance, speed and time (114-6)
  - defend a decision or judgment and demonstrate that relative arguments can arrive from different perspectives
- construct arguments to support a decision, using examples and evidence and recognizing various perspectives (118-6).
- propose courses of action on social issues related to science and technology, taking into account an array of perspectives (118-10).
- analyze the benefits to society of applying scientific knowledge on motion and introduction of a particular technology (118-2).

Elaborations—Strategies for Learning and Teaching

Teachers could ask students to complete the Try This Activity "Paper Airplane Exploration" page 137 of ST. Students get to apply the SI units discussed previously. When conducting this activity, teachers may want to ask the class to brainstorm about the variables that need to be controlled (independent/manipulated) so that an accurate measure of the distance travelled due to airplane design is obtained. For example, a uniform launching "mechanism" would need to be used to eliminate sources of error due to the height of launching, the speed of launching, angle of launching, etc. The actual testing of the airplanes could be done in a gymnasium or outside on a calm day. Ask students to launch by standing on a the third step of a step ladder and simply dropping the airplane rather than throwing will eliminate many variables. (Refer to page 3-9 of TR for more detail). The data collected in this activity can be used when discussing the differences between accuracy and precision as well as the adequacy of data and data collection.

Measurements of distance, time and speed accurately and precisely have very important implications to society. For example; successfully driving a car, flying a plane, producing maps and navigating a boat all depend on accurate measurements. Students could choose and argue one side of a debatable issue related to an activity that relies on accurate measurements of distance, speed or time. Students could examine issues such as determining speed limits, settling boundary disputes or Olympic games qualification guidelines for Canadians.

The CORE STSE component of this unit incorporates a broad range of Science 3200 outcomes. More specifically, it targets (in whole or in part) 114-6, 118-6, 118-10, 118-2, NLS-2 and their delineations. The STSE component, *School Bus Seatbelts?*, can be found in Appendix A.

Distance and Speed *(continued)*

Suggested Assessment Strategies

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 136-141

TR: 3.7-3.16

SRL: 198-207

Core STSE #7: *School Bus Seatbelts?,* **Appendix A**

Distance and Speed *(continued)*

Outcomes

Students will be expected to

- evaluate the relevance, reliability, and adequacy of data and data collection methods (214-8)
  - distinguish between accuracy and precision of data

Elaborations—Strategies for Learning and Teaching

There is no such thing as a perfect measurement. Each measurement contains a degree of uncertainty due to the limits of instruments and the people using them. Students should identify sources of error. They could reflect on the measurements they made previously. Initially students may produce a list of errors that depend on the experimenter's skill. It is important for teachers to emphasize that experimental errors are usually beyond the control of the experimenter. For example; when measuring mass, spilling some of the solid (poor technique) is not an experimental error. On the other hand, impurities in the solid or a faulty balance would be considered experimental error.

It is important to discuss the accuracy of measurement and techniques that minimize errors. This outcome, and any others dealing with measurements and data analysis, should be addressed throughout the unit, especially in dealing with activities involving measurements. Outside of the scientific world, the terms accuracy and precision are often used interchangeably. Strictly speaking, these terms describe different attributes of a measured value. Students may already have the conception that accurate and precise describe a "good" measured value, or how close it is to the actual value. Teachers can build on these naive concepts, to tease out the distinction between these terms. Accuracy is an indication of how close a measured value is to the accepted or actual value. Precision is the ability to measure in very small units, or the ability to reproduce a measurement many times.

Distance and Speed *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Ask students to suggest ways which a measuring instrument that is not accurate can be used accurately. For example, a broken meter stick, a slow clock, and so on. (214-8)

Presentation

- In a group, students could present suggestions on ways to improve the methods by which data is collected and recorded. Possible presentation formats may include video, role-playing, or demonstration. (214-8)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 136-141

TR: 3.7-3.16

SRL: 198-207

Distance and Speed *(continued)*

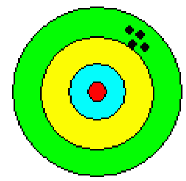
Outcomes

Students will be expected to

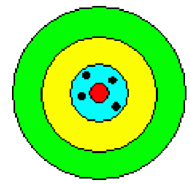
- evaluate the relevance, reliability, and adequacy of data and data collection methods (214-8) **Cont'd**

Elaborations—Strategies for Learning and Teaching

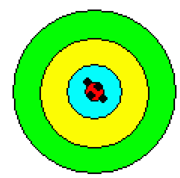
To understand the difference between accuracy and precision, teachers could use the analogy of the archer.



In this figure, we see that the archer's bow was quite precise, since his results were uniform possibly due to the use of a sighting scope. However, the bow did not provide accurate results. The fact that his results were precise, but not accurate, could be due to a misaligned sighting scope (analogous to an uncalibrated balance). Therefore, precision tells us something about the quality of the bow's (or measuring device's) operation.

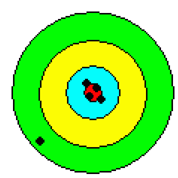


In this figure, the arrows are centered on the bull's eye but the results were not uniform, indicating that the archer's bow displayed good accuracy but poor precision. This could be the result of a poorly manufactured bow. In this case, the archer will never achieve both accuracy and precision, even if he very carefully uses the bow. If he is not satisfied with the results, he must change his equipment. Therefore accuracy tells us something about the quality or correctness of the result.



In this figure, the arrows are all uniform and centered on the bull's eye. The archer may have compensated for the poorly aligned sighting scope (or replaced the sight).

One benefit of taking many measurements of a single property is that errors are easily detected.



In this figure the results are both accurate and precise with the exception of an obvious error. Because several measurements were made, we can ignore the error as an obvious mistake, probably due to the archer's error. Teachers could ask students to draw dartboards or gun targets that indicate high accuracy and poor precision; high precision and low accuracy with one errant shot (caused by shooter's error) and so on.

Distance and Speed *(continued)*

Suggested Assessment Strategies

Presentation

- Ask students to produce a visual presentation (poster, slide show, etc.) to demonstrate the following conditions; (214-8)
  - (i) accurate and precise,
  - (ii) accurate and not precise,
  - (iii) precise and not accurate, and
  - (iv) neither precise nor accurate.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 136-141

TR: 3.7-3.16

SRL: 198-207

Distance and Speed *(continued)*

Outcomes

Students will be expected to

- evaluate the relevance, reliability, and adequacy of data and data collection methods (214-8) **Cont'd**
  - round measured or calculated values
  - convert measured or calculated values from one SI unit to another

Elaborations—Strategies for Learning and Teaching

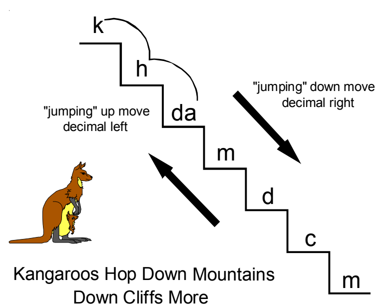
Teachers can refer to the "Teaching Suggestions" on pages 3-15 of TR for suggestions on how to approach this topic. Teachers can refer to the SRL (page 204-205) for additional practice problems to supplement the Understanding Concepts in the ST.

Teachers should be aware that rounding measured values has been covered extensively in previous mathematics courses. Teachers could connect this background with rounding their measured values.

There are numerous approaches which students could use to convert from one SI unit to another. Mathematically, students could use conversion factors. For example; the factor $^{1000m}/_{1km}$ could be used to convert 14.7 km to metres.

$$14.7km \times \frac{1000m}{1km} = 14700m$$

Alternatively, students could use a mnemonic to memorize the position of the decimal point and the prefix associated with it. For example: To remember the order of prefixes, memorize the sentence, "**K**angaroos **h**op **d**own **m**ountains **d**own **c**liffs **m**ore." Each letter (in bold type) stands for a prefix: k - kilo, h - hecto, da - deca, m - metre (or any base unit, like litre, etc.), and so on. To use this mnemonic, count the steps you "jump" when moving from one unit to another. If you "jump" down, move the decimal place right. If you "jump" up, move the decimal place left. For example; 34 212 dm is 3.4212 km. Decimal moved four places left, on the picture above you "jumped" four steps left.



Only one problem with this method - it only works for six different prefixes (but, these are the most common ones).

Distance and Speed *(continued)*

Suggested Assessment Strategies

Portfolio

- Students could enter into their portfolio a mnemonic (memory aid) to help in their conversion of SI units. (214-8)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 136-141

TR: 3.7-3.16

SRL: 198-207

Distance and Speed *(continued)*

Outcomes

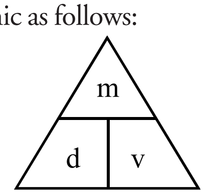
Students will be expected to

- evaluate the relevance, reliability, and adequacy of data and data collection methods (214-8) **Cont'd**
  - solve three-variable equations, given any two values

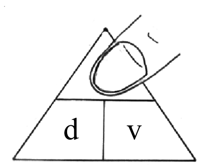
Elaborations—Strategies for Learning and Teaching

Teachers should be aware that rearranging three-variable equations has been covered in previous mathematics courses studied. It is important that teachers emphasize the manipulation of an equation does not create a new mathematical relationship. For example, the three equations v=d/t, d=vt, and t=d/v all represent the same relationship among distance (d), speed (v) and time (t). Preferably, students should apply their mathematical skills to manipulate the formula during problem solving.

Students, particularly if weak in mathematics, may be more comfortable using a "triangle technique" to manipulate three variable equations. For example, if students wanted to use the density formula (d=m/v) they could place it in a triangle graphic as follows:



By covering the variable you wish to solve, you will be able to see the formula required. Cover the "d" with your finger, then read the formula. It will read "m" over "v" or the mass divided by the volume. If you want to find the mass, cover the "m" with your finger and read. It says "d" times "v" or the density multiplied by the volume.



Finally, if you want to find volume, cover the "v" and read. It shows "m" over "d" or the mass divided by the density. The "triangle technique" could be setup for any three variable equation required for student manipulation.

Teachers should note, there are at least two potential problems with this method of problem solving: 1. Success hinges on reproducing the triangle correctly; and; 2. This approach is difficult to apply in more complex equations.

Distance and Speed *(continued)*

Suggested Assessment Strategies

Portfolio

- Students could enter into their portfolio a board game which requires players to solve three variable equations to move along the board. (214-8)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 136-141

TR: 3.7-3.16

SRL: 198-207

Distance and Speed *(continued)*

Outcomes

Students will be expected to

- identify and explain sources of errors and uncertainty in measurement (214-10)
  - calculate speed given distance traveled and time elapsed
  - predict the change in speed when altering distance traveled at constant time
  - predict the change in speed when altering time at constant distance traveled
- evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving and inquiring (212-8)
- compile and display evidence and information, by hand or computer, in a formal laboratory report (214-3)
- construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives (118-6)

Elaborations—Strategies for Learning and Teaching

The skills outcomes 214-10, 212-8 and 214-3 are addressed by completing *Your Speed*. CORE ACTIVITY #1.

This activity provides students with an opportunity to bring meaning to distance, time, and in particular, speed values. Students may not be familiar with some of the units for measuring speed. For example; is travelling 15 m/s fast? Is it slow? Most students will be familiar with speed values measured in km/hr. They can appreciate that an automobile travelling 10 km/hr is considered slow, however, while travelling at 90 km/hr it is considered fast. When discussing this, teachers might want to use the following examples to help get the point across. 100 km/hr is 28 m/s (i.e., highway speed). 40 km/h (driving around town speed) is 11 m/s. Teachers may wish to make the point about the importance of "keeping your eyes on the road" when driving because you are actually travelling great distances in very short periods of time. For example, in the time it takes you to turn your head to talk to someone in the backseat, (1 to 2 seconds) your vehicle (if you are traveling 100 km/hr) has travelled between 28 and 56 metres! That will be at least the length of your school. Consider what could happen in that short time (i.e., a moose jumping in front of you). While completing Core Activity #1, students could use units that produce km/hr speeds, a unit they can appreciate. This could lead to discussions pertaining to unit selection. Students measuring walking speed or skateboarding speed should realize that using km/hr produces very low values and may not be the best unit of choice. Students should use different measuring devices (for time or distance) to produce different units for speed. Teachers could question students regarding their opinion on the different units produced and the motion they measured. For example; is a person travelling 8.3 m/s on a bike travelling fast or slow? Is a skater, travelling 22.1 m/min, going fast? Is reporting a walkers speed as 10 000 cm/min the most appropriate unit? Students should also use the terms "faster" or "slower" while predicting speed changes when altering one of distance or time. Possible extensions of this activity could include students mathematically converting speed units. They could also create their own units for measuring time and distance. For example; students could use a water clock or hourglass to measure time; or they could use their own feet or create their own ruler to measure distances. Note: teachers could link this activity with proper use of SI units completed previously.

The Inquiry Rubric (page AT-6 and AT-7 of TR) could be used to grade work on this investigation. Teachers can ask students to use pages 208 – 211 to record their data and answer related questions.

Distance and Speed *(continued)*

Suggested Assessment Strategies

Performance

- While collecting and recording data in a chart, students could write all values in a form that recognizes the precision of the measurements. (214-8, 214-10)

Paper and Pencil

- Ask students to create a list of technologies or equipment that might be used to measure distance, time, and speed. Demonstrate how these instruments and technologies are used. (214-10)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 142-145

TR: 3.17-3.20

BLM: 3.5-3.6

SRL: 208-215

Distance and Speed *(continued)*

Outcomes

Students will be expected to

- list the factors to be considered when purchasing an automobile. Include:
  - (i) owner needs
  - (ii) engine size and efficiency
  - (iii) vehicle size
  - (iv) fuel type and consumption
  - (v) cost
  - (vi) safety
  - (vii) durability/reliability
  - (viii) style

- propose courses of action on social issues related to science and technology, taking into account an array of perspectives (118-10)
- propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)
- list factors which affect the speed of an object (NLS-2)
- relate hybrid electric vehicles to studying distance, speed and time (114-6)
- analyze the benefits of applying scientific knowledge on motion and introduction of hybrid electric vehicle technology (118-2)

Elaborations—Strategies for Learning and Teaching

Purchasing an automobile usually requires consideration of many factors. A group brainstorming session could produce a lengthy list of factors that should influence a vehicle purchase. Teachers could remind students to think beyond a vehicle's ability and appearance, and consider its impact on the community and the environment. One method of simplifying the considerations for analysis is to categorize them into subgroups. The list could be divided into "opinions" and "facts". For example; "The car is comfortable" is an opinion, while "The car consumes 10.6 L/100km" would be a fact. Alternatively, the list could be divided into "needs" and "options". For example; "passenger capacity" may be a need, while "colour" would be an option. Teachers could assign students particular criteria. For example; student A could be assigned rural farmer with a family of 5; student B could be assigned single, urban business-person. Other classmates could be instructed to "sell" these students a car. The "sales-people" should highlight positive attributes of their cars and down-play any deficiencies. "Sales-people" and "customers" should research their automobiles and requirements respectively.

Teachers could provide a list of several automobiles (representing different models, capabilities and so on) and ask students to rank them in order of preference. Once ranked, students should justify their order and list their top three considerations. Teachers could ask, "Based on their subgroups, what type of considerations dominated their ranking? What do you think the average car buyer considers when purchasing a vehicle?"

Teachers could ask students to work in pairs to complete the Take a Stand activity (page 145 of ST). Students could use the Internet to access specific information about different makes and models of automobiles. Students could use pages 212 – 215 of the SRL to record their work.

The CORE STSE component of this unit incorporates a broad range of Science 3200 outcomes. More specifically, it targets (in whole or in part) NLS-2, 114-6, 118-2, 118-9, 118-10, 118-6 and their delineations. The STSE component, *The Physics of Hybrid Electric Cars*, can be found in Appendix A.

Distance and Speed *(continued)*

Suggested Assessment Strategies

Portfolio

Part 1

- Ask students to research automobile manufacturing sites and choose one vehicle to collect the following information:
  - (i) engine size and efficiency
  - (ii) vehicle size
  - (iii) fuel type and consumption
  - (iv) cost
  - (v) safety
  - (vi) reliability
  - (vii) style (118-6)
- Ask students to refer to table 1 and table 2, page 144-45 in student text and use recent gas prices to determine the fuel consumption per year for their vehicle. (118-6)

Part 2

- Ask students to compare their information collected and construct arguments for which vehicle is 'best'. Be sure to consider the impact on the environment, fuel consumption, owner needs, and operational costs in your reasoning. (118-6, 118-9)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 142-145

TR: 3.21-3.23

SRL: 208-215

Core STSE #8: *The Physics of Hybrid Electric Cars,* **Appendix A**

Displacement and Velocity

Outcomes

Students will be expected to

- describe quantitatively, and analyze mathematically, the relationship among distance, time, and average speed of an object's linear motion (212-7, 325-1, 325-2)
  - define average speed

Elaborations—Strategies for Learning and Teaching

An effective method of illustrating average speed is to use examples of people walking to a store and making several stops along the way, or people driving across a city with several stoplights along the chosen route. Students could perform calculations to investigate average speed and factors which influence its magnitude. For example, Grace, a Science 3200 student, travels nonstop from her home to the local convenience store (a distance of 300 m) in 4 minutes. She remains at the store chatting with her friend for 10 minutes, and then proceeds to school, nonstop for 15 minutes (a distance of 1500 m). Calculate her average speed from home to the store. Calculate her average speed from the store to the school. Calculate her average speed for home to the school. Students should explain why the overall average speed (home to school) is different than the average speeds for the two shorter trips (home to store, and, store to school). Teachers should note a common misconception is that the average speed of an entire trip is the mathematical average of the average speeds of the shorter trips. Students can practise problems of this nature involving trips with more than two parts.

Teachers may want to introduce instantaneous speed (covered later) and differentiate it from average speed.

- calculate any one of average speed, distance or time, given the two other variables

Because calculating average speed involves a three-variable relationship, teachers can extend and reinforce concepts covered previously. A useful technique to mathematical problem solving is to list the given information and the unknown, and then apply the necessary formula. Recall, if necessary, the triangle method can be employed once again, as with any three-variable formula.

If teachers decide to use the Try This Activity on pages 148-149 they should be aware that a ball dropping from a height of 2m will hit the ground in less than 1 second. Thus, recording the time with a stopwatch will be problematic. It is preferable to use a computer probe set up such as Vernier or to increase the height (e.g., drop in a stairwell or from a second story window). The stopwatch should be digital.

Teachers could use worksheet 15 (Appendix B) to provide students with extra practice with these calculations.

- relate thunder and lightning to studying distance, speed and time (114-6)

The CORE STSE component of this unit incorporates a broad range of Science 3200 outcomes. More specifically, it targets (in whole or in part) 114-6, NLS-1, 212-7, 325-1, 325-2 and their delineations. The STSE component, *The Physics of Thunder and Lightning*, can be found in Appendix A.

Displacement and Velocity

Suggested Assessment Strategies

Journal

- Students could enter into their portfolio an operational definition of average speed. They could provide examples that affect their daily lives. (212-7, 325-1, 325-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 146-151

TR: 3.24-3.32

BLM: 3.6-3.7; 3.11

SRL: 216-224

Core STSE #9: *The Physics of Thunder and Lightning,* **Appendix A**

Displacement and Velocity *(continued)*

Outcomes

Students will be expected to

- describe quantitatively, and analyze mathematically, the relationship among distance, time, and average speed of an object's linear motion (212-7, 325-1, 325-2) **Cont'd**
  - compare the average speed of freely falling objects with different masses

Elaborations—Strategies for Learning and Teaching

A common misconception, based on real life observations, is that more massive objects fall to earth faster than less massive objects. In completing the activity *Measuring the Average Speed of Falling Objects,* students will calculate the average speed of three different objects (with different masses but with approximately the same size). Within experimental error, the average speed of the falling objects is identical. This, however, may not convince students who believe more massive objects will fall faster. To help students overcome this naive conception, teachers could avail of the video of the experiment conducted by the astronaut David Scott on the moon (available at http://vesuvius.jsc.nasa.gov/er/seh/feather.html). In this famous experiment the astronaut drops a feather and a hammer from the same height at the same time. In the absence of air, and under the influence of the moon's gravity, both objects land at the same time. To further reinforce this concept and illustrate the effect of air resistance on a falling object, teachers may use the following demonstration. The point that teachers should make is that the physics concept we are trying to get across is that all falling objects have the same acceleration **in the absence of air resistance.** First, drop a book and a sheet of paper independently. As students may have predicted, the book strikes the floor first. But, they are forgetting the effects of air resistance. Secondly, place the sheet of paper on top of the book and then drop both the book and paper together. If done properly, the paper should remain on top of the book as it falls and strikes the floor with the book. This should help students realize that when the effect of air resistance is removed from the paper (the book "pushes" the air away from the paper), it will fall in an equivalent manner as the book. Later in this unit the concept of acceleration is covered. Teachers may want to redo this demonstration to explain the constant acceleration due to gravity.

The fact that falling objects have the same acceleration in the absence of air resistance can also be demonstrated in the following activity in which the air resistance on the two falling objects is identical. Take two juice cans with the top removed. Fill one can ¾ full with sand. Leave the second can empty. Release both cans simultaneously from a 2nd floor window. Ask pairs of students to observe which of the cans hit the ground first. Repeat several times to help account for human error in releasing the cans. For ease of visibility, the two cans could be coloured differently.

Displacement and Velocity *(continued)*

Suggested Assessment Strategies

Journal

- Students could reflect and enter into their portfolio what they think would happen when objects of varying masses, such as a bowling ball and a marble, are dropped from a fixed height. Ask students to investigate the free fall of objects with different masses and shapes. Also ask students to reflect upon and record in their journals what would happen if this was investigated on the moon. (212-7, 325-1, 325-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 146-151

TR: 3.24-3.32

SRL: 216-224

Displacement and Velocity *(continued)*

Outcomes

Students will be expected to

- describe and evaluate the design of a technological device and the way it functions, using scientific principles (116-6)
  - list the factors that affect the performance of the student-designed vehicle. Include:
    - (i) mass of vehicle
    - (ii) amount of propellant
    - (iii) friction
    - (iv) aerodynamics
- evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making (212-8)
- develop, present, and defend a position or course of action, based on findings (215-5)

Elaborations—Strategies for Learning and Teaching

The skills outcomes 116-6, 212-8 and 215-5 are addressed by completing *Balloon Car Contest*. CORE ACTIVITY #2.

Core Activity #2 involves students in a problem-solving approach with a heavy emphasis on creativity. Teachers may choose to have limited input into the design of the balloon car. Students should explore ideas and modify them when necessary. Teachers could generate a list of the factors that affect the car performance as students discover new ways to make their cars faster. For example, early designs should indicate that larger cars (more massive) are much slower than smaller ones. Teachers could ask students to explain the difference in performance. Student explanations could lead to a class list of factors affecting car speed or performance. Students should be given the opportunity to re-design their cars based on the developing list.

Teacher's could approach Core Activity #2 from a Science Olympics perspective. Student groups could be given a limited set of materials, a limited time frame, and be expected to produce the fastest car. This cooperative learning exercise enhances the teamwork approach to problem solving. Once completed, students could reflect on what affected their car's performance.

This activity could also be modified to include other types of propellants such as, mouse traps, carbon dioxide cylinders, elastic bands and so on. Many kits are available from science supply companies and the Internet provides access to instructions for class contests.

Teachers should coordinate with the school's Technology Education teacher who may be able to provide appropriate materials or who may be able to provide sources of materials.

Displacement and Velocity *(continued)*

Suggested Assessment Strategies

Paper and pencil

- Ask students to research the structural evolution of formula 1 race cars. Use this research to help design their balloon car for core activity #2. (116-6)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 146-151

TR: 3.24-3.32

SRL: 216-224

Displacement, Velocity and Acceleration

Outcomes

Students will be expected to

- describe quantitatively, and analyze both graphically and mathematically, the relationship among distance, time, and speed of an object's linear motion (212-7, 325-1, 325-2)
  - explain what is meant by uniform motion (constant speed)
  - explain what is meant by instantaneous speed

Elaborations—Strategies for Learning and Teaching

Real-life examples of uniform motion are difficult to find. Air resistance, friction and variations in force cause many moving objects to experience non-uniform motion. Objects such as an automobile on cruise control, travel in space, and motion on air tracks or air tables (that approach uniform motion) can be used as demonstrations or examples.

Teachers should distinguish among uniform motion (constant speed), average speed, and instantaneous speed. Teachers could revisit the problems covered in the average speed section and re-examine them in terms of instantaneous speed and uniform motion (constant speed). Recall the problem covered previously; that is, Grace, a Science 3200 student, travels nonstop from her home to the local convenience store (a distance of 300 m) in 4 minutes. She remains at the store chatting with her friend for 10 minutes, and then proceeds to school, nonstop for 15 minutes (a distance of 1500 m). Grace's average speed from her home to the store is 75 m/min. However, this information tells us little about her instantaneous speed at any time from her home to the store and it may never be 75 m/min. If she were travelling with uniform motion during this period, actually quite unlikely, we would know that her instantaneous speed at all times over the 4 minutes is 75 m/min. But, instantaneous speed would probably vary greatly during her trip. Hence, it is often much easier to analyze problems in terms of average speed.

Students could reflect on what factors may cause her instantaneous speed to vary during the trip. For example, as she encounters a hill, or as she tires near the end of her journey, her instantaneous speed may drop. Teachers could choose to analyze the remainder of Grace's trip in terms of instantaneous speed and uniform motion (constant speed). By comparing the two parts of the entire trip, students could suggest why differences exist in average speeds. For example, perhaps her average speed from the store to the school may be greater because over this portion of the trip she may be walking downhill.

Displacement, Velocity and Acceleration

Suggested Assessment Strategies

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 152-153

TR: 3.33-3.36

SRL: 225-227

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- describe quantitatively, and analyze both graphically and mathematically, the relationship among distance, time, and speed of an object's linear motion (212-7, 325-1, 325-2)
  - calculate any one of constant speed, distance or time, given the two other values
- compile and display evidence and information, by hand or computer, in graphical format (214-3)
  - given distance-time data, draw and label a proper distance vs. time graph
  - determine that a straight-line distance vs. time graph represents a constant speed (uniform motion)

Elaborations—Strategies for Learning and Teaching

Because calculating constant speed involves a three-variable relationship, teachers can extend and reinforce mathematical skills covered previously. Students should be able to connect these calculations and those involving average speed covered previously. As before, a useful technique to mathematical problem solving is to list the given information and the unknown, and then apply the necessary formula. Recall, if necessary, the triangle method can be employed once again, as with any three-variable formula. Performing another type of three variable calculation will reinforce these techniques.

Teachers could ask students to complete the Try This Activity, "Instantaneous and Constant Speed", page 153 of ST. Page 226 of SRL provides structure for students to record their observations. Other teaching suggestions can be found on page 3-35 of the TR. Teachers could use the Extension Activity, page 225 of SRL to further refine students' understanding of this concept.

Students may be deficient in the skills required to produce the accurate graph (i.e., scale selection and plotting). Teachers need to be aware that basic graphing skills have been covered in previous courses studied, including intermediate and high school mathematics. Teachers may want to consult with these math teachers and/or curriculum resources to best develop their instructional plan. Teachers should refer to the *Skills Handbook* (p.290-292) to review graphing skills with their students.

Students often have misconceptions about what the graph represents, i.e., they interpret a motion graph with rises, plateaus and drops as a picture of an object that moves uphill, along a flat and downhill. This misconception may be reinforced if a graph is defined as a "representation" or "picture" of the motion of an object. Teachers should stress that a graph is a representation of the mathematical relationship of the motion, i.e., a distance-time graph represents the relationship that describes the speed (the change in distance over time) - for Science 3200, $v=d/t$.

To help students understand graphing, they could plot a distance-time graph using data collected from a motion involving themselves or their classmates. If computer interfaces and sonic motion detectors are available, students could be asked to "trace" a graph. In this activity, students are given distance-time graphs with different shapes. Using a sonic motion detector and themselves as the object, they move to try and produce a graph on the computer monitor identical to the one provided. Students should experiment and use trial-and-error to determine how to create different attributes of their graph, i.e., a horizontal line indicates that the object has stopped and the length of the line indicates how long it was stopped.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Presentation

- Students could illustrate graphically the motion sequence for an object. This should include stop (no motion), motion forward and away from the original starting point. (325-2)
- Students could use data to construct distance-time (d-t) graph from which two methods may be used to determine quantitatively, the average speed of a student's or object's motion. (214-3)
- Students could research and present examples and non-examples of instantaneous vs. constant speed. (212-7, 325-1, 325-2)

Interview

- Students could analyze graphically and mathematically the relationships among distance, time and speed of a motion sequence. What assumptions have to be made? (214-3)

Paper and Pencil

- Students could create a collage that shows the difference between constant speed and instantaneous speed. (212-7, 325-1, 325-2)
- Given the distances to selected towns, students could calculate the driving time required (based on their estimated travel speed). (212-7, 325-1, 325-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 154-157

TR: 3.37-3.43

BLM: 3.8-3.11; 3.28

SRL: 228-240

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- compile and display evidence and information, by hand or computer, in graphical format (214-3) **Cont'd**
  - define independent and dependent variables
  - identify independent and dependent variables when collecting data necessary to determine an object's speed
  - relate the slope of a distance vs. time graph to an object's speed
  - calculate an object's speed (slope) using a distance vs. time graph

Elaborations—Strategies for Learning and Teaching

In previous courses studied, students may have used the terms responding and manipulated variables instead of dependent and independent variables, respectively. Students often confuse these variables. Teachers should use the terms that students find most comfortable. To help distinguish them, teachers could emphasize that the dependent variable/responding variable is the variable which the experimenter does not change or alter. It depends on/ responds to changes in another variable. For example, in a motion experiment, the distance (dependent, "responding" variable) which an object travels, depends on the time (independent, "manipulated" variable) for which it has been travelling.

Teachers should emphasize that slope is determined by dividing the change in the rise by the change in the run.

$$slope = \frac{change\,in\,rise}{change\,in\,run} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

When a graph begins at the origin (0,0) students may simply divide the y-coordinate of a point by the x-coordinate of a point. However, teachers need to emphasize that this method does not work for the majority of distance-time graphs which do not start at the origin. If students have difficulty with mathematics, teachers could limit the examples to those that start at the origin. If students have a good grasp of slope, doing examples that do not start at the origin will provide excellent support to what students have learned in their math program.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Using a distance-time (d-t) graph student must realize that the slope of the graph represents speed. Students use the formula slope = change in rise/change in run to calculate speed. (214-3)
- Using distance-time (d-t) graphs with different slopes, students could compare the relative speeds of the different graphs. (214-3)

Interview

- In a group, students could investigate different relationships among variables and identify the independent and dependent variables. A member of each group would present his/her findings to the class. (214-3)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 154-157

TR: 3.37-3.43

BLM: 3.8-3.11

SRL: 228-240

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- interpret patterns and trends in data, and infer or calculate linear relationships among variables (214-5)
  - list the factors that affect the speed of a moving object on an inclined plane. Include:
    - (i) angle of the inclined plane
    - (ii) friction
    - (iii) aerodynamics

Elaborations—Strategies for Learning and Teaching

The skills outcomes 214-5, 214-3 and 213-3 are addressed by completing *Determining an Average Speed Contest*. CORE ACTIVITY #3.

Core Activity #3 involves the use of calculator interfaces to collect data. Microcomputer interfaces, if available, could easily be substituted and may offer some advantages (visibility, familiarity and ease of use). If interfacing technology is not available, teachers could refer to the alternate activity cited in the Student Record of Learning (p. 238). The use of the Ticker Tape to collect data adds complexity to the activity. Teachers should note that using this method of analysis may cause students to lose focus of the main purpose of the activity - to measure the average speed of a non-uniform motion. Students will have to analyze Ticker Tapes to collect distance-time data and then plot a distance vs. time graph to produce a curve. To determine the average speed, students would be required to draw a line of best fit on the curve and calculate its slope. Teachers, not employing technology, could ask students to produce their Ticker Tapes individually (or in small groups), then analyze them together as a class project. The teacher could first demonstrate each step of the analysis to the class, then student groups should complete each step of their analysis on their own Ticker Tapes. Alternatively, teachers could ask students to produce their own Ticker Tapes, demonstrate the analysis, however, then provide students with their own speed-time data to analyze (data that would have been collected by a computer).

Students should be aware that the factors affecting the motion of the dynamics cart are very similar to the balloon car (Core Activity #2). In fact, friction, areodynamics and propulsion force have an impact, to different degrees, on any moving object on Earth.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Performance

- Ask students to roll toy cars down an incline plane (ramp) from rest and record in a chart, the time it takes to reach the bottom. Investigate the effect the following factors would have on time: (214-5)
  (i) angle of incline plane
  (ii) aerodynamics
  (iii) friction
  (iv) mass
  (v) others

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 154-156

BLM: 3.27

SRL: 228-240

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

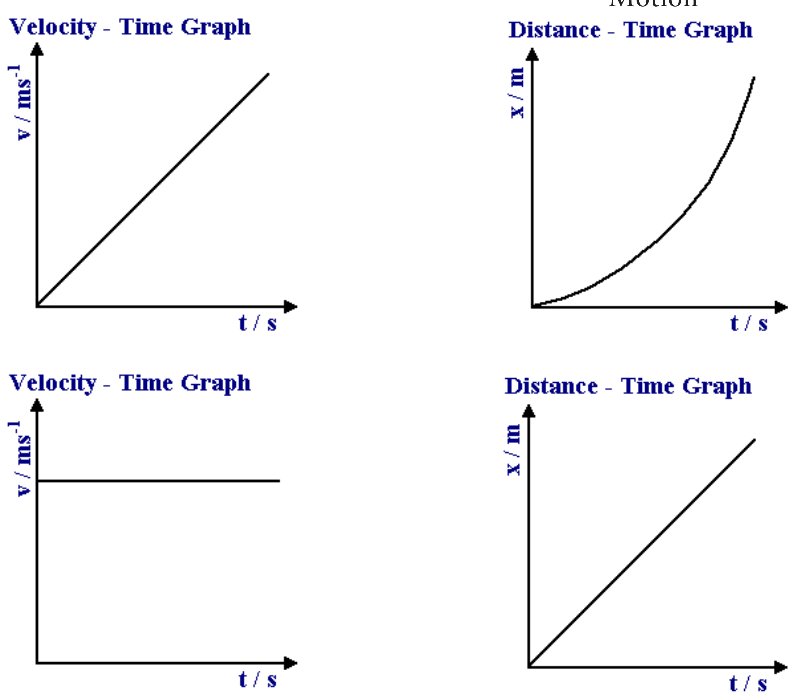
- compile and display evidence and information, by hand or computer, in a variety of formats, including tables and graphs (214-3)
    - distinguish between the speed-time graph for uniform motion versus an object moving down an inclined plane (non-uniform motion)
    - determine that a curve-line distance vs. time graph represents a non-uniform motion
- use instruments effectively and accurately for collecting data (213-3)
- relate the Olympics to studying distance, speed and time (114-6)
- explain what is meant by uniform motion (214-3)

Elaborations—Strategies for Learning and Teaching

Students should be able to identify, from the shape of a d-t graph, the type of motion (and vice versa). Students should also be able to identify, from the shape of a v/t graph, the type of motion (and vice versa). Teachers, manually or by using the technology, should show students the distance-time graph for Core Activity #3. For purposes of Science 3200, the following chart could be produced by students to highlight the differences between graphs.

Uniform Motion

Non-uniform Motion



Graphs for uniform motion could be re-examined from the previous section.

Teachers could use worksheet 16 (Appendix B) to assess students' understanding of this topic.

The CORE STSE component of this unit incorporates a broad range of Science 3200 outcomes. More specifically, it targets (in whole or in part) 114-6, 214-3, 118-2, 118-10, 118-6, NLS-2 and their delineations. The STSE component, *The Physics of the Olympics*, can be found in Appendix A.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Journal

- Students could draw graphs in their portfolios to show that they understand the relationship between uniform and non-uniform motion. (214-3)
- Students could create a visual presentation to differentiate between uniform and non-uniform motion. (214-3, 325-2)

Paper and Pencil

- Students could create a collage of uniform and non-uniform motion. (214-3, 325-1, 325-2)

Performance

- Students could role play situations where uniform and non-uniform motions are involved. (214-3, 325-2)
- Students could create a poem, song, or rap, that shows the difference between uniform and non-uniform motion. (214-3, 325-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 154-156

BLM: 3.27

SRL: 228-240

Core STSE #10: *The Physics of the Olympics,* **Appendix A**

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- describe quantitatively, and analyze mathematically, the relationship among displacement and time of an object's uniform motion (212-7, 325-1, 325-2)
  - distinguish between scalar and vector quantities, using distance and displacement as an example
  - define a vector

Elaborations—Strategies for Learning and Teaching

Teachers could introduce this section by asking students thought-provoking questions such as: "If Lynn leaves school and walks 3 km, do you know where she will be located?" Students may reply with answers which do not consider the importance of the direction in which the person has travelled. Of course there are an infinite number of final locations where the person may be. Teachers could continue this line of questioning and lead students into considering there may be more than one stage to the 3 km trip. For example, Lynn may have first walked 2 km North and then 1 km South. In actual fact she may be found at the school, if, for example she walked 1.5 km North and then 1.5 km South. This type of questioning should highlight the importance of Lynn's direction of motion and the need for a method of indicating direction. The designation of quantities involving direction are called vectors. Students can begin to re-examine many of the quantities that they have encountered previously, and consider whether or not the inclusion of a direction in the quantity is reasonable. For example, velocity, acceleration or force (Acceleration and force are not covered in Science 3200, however, students may have some concept of these). The quantity time, conversely, does not involve direction and is designated as a scalar quantity. Likewise, mass and rate of pay are scalar quantities.

Teachers could also use the following physical example to help students distinguish between scalar and vector quantities. Mark a spot on the floor at the front of the classroom. Give a student a list of instructions (e.g., take one step forward, turn 90 degrees to your right, take 3 steps forward, turn 45 degrees to your left, take 1 step forward, etc.). Mark the spot where the student lands. Measure the total distance in steps the student covered while following the instructions (this is a scalar quantity). Then measure the straight line distance (in steps) from where the student started to where the student lands. This is displacement (i.e., the difference between where they started and where they ended up). If you add a direction to the displacement (e.g., 5 steps North West) then you have a vector quantity. Adding the direction helps you pinpoint where the person is located. Games that make use of this concept (distance and direction) include chess, battleship, checkers, and snakes & ladders.

Teachers could use worksheet 17 (Appendix B) to assess students' understanding of this topic.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Journal

- Students could enter into their portfolio an operational definition for a vector. They could provide examples of vector quantities in real life. (212-7, 325-1, 325-2)

Presentation

- Students could research and present on how vectors are important in search and rescue situations. (212-7, 325-1, 325-2)
- Students could research and present on the various occupations that use vector quantities in their everyday work. (212-7, 325-1, 325-2)

Interview

- Students could interview a search and rescue technician (or research using the Internet) about how they use vectors in their everyday work. (212-7, 325-1, 325-2)

Paper and Pencil

- Students could list all the things they can that are vector quantities. (212-7, 325-1, 325-2)
- Students could create a diagram that indicates compass headings and degrees. (212-7, 325-1, 325-2)
- Students could create a "treasure map" in which the instructions use vector quantities. (212-7, 325-1, 325-2)
- Students could create an "advertisement" that promotes the use of vector quantities. (212-7, 325-1, 325-2)

Performance

- Students could create a mnemonic device to help them remember the points on the compass. (212-7, 325-1, 325-2)
- Students could develop and act out a skit that utilizes vector quantities. (212-7, 325-1, 325-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 160-167

TR: 3.47-3.57

BLM: 3.12-3.18

SRL: 246-261

Displacement, Velocity and Acceleration *(continued)*

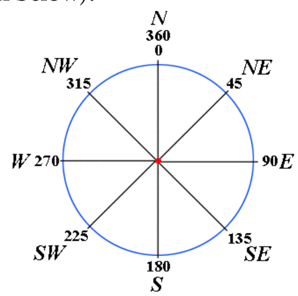
Outcomes

Students will be expected to

- describe quantitatively, and analyze mathematically, the relationship among displacement and time of an object's uniform motion (212-7, 325-1, 325-2) **Cont'd**
  - use an appropriate measurement (unit) to indicate the direction of a vector using:
    - (i) compass method
    - (ii) degree method
  - draw an appropriate vector to represent a given displacement
  - use appropriate symbols to distinguish between distance and displacement ($\Delta d \; vs. \Delta \vec{d}$)

Elaborations—Strategies for Learning and Teaching

There are many different units of direction and methods of indicating direction. For example; there are compass directions, degrees on a circle or azimuths. Vectors could be written like: 3 km [30° North of East], 2 m/s [E 25° N], 23 m [243°]or 5 m [N]. For the purposes of the compass method in Science 3200, all vectors should be limited to eight points on the compass (see diagram below).



This limitation allows students, using the compass method, to indicate vector direction without indicating degrees. For example 350 m [NW]. In simplified cases (i.e., when only N, S, E and W are used) the direction may be indicated by a positive or negative sign. This greatly simplifies some vector addition (later in the unit).

The degree method of indicating direction utilizes the 360° within a circle. Students, when measuring a scale diagram vector, should use a protractor to determine the angle of the vector from its reference point (defined to be due East, i.e., a vector straight towards East would have a 0° angle). See diagram above. For example, the vector d = 3 cm can be represented below where the length of the vector is 3 cm. In order to accurately measure the angle as 252°, students can first be reminded that a straight line constitutes 180°. Secondly, the angle between the x-axis and the vector is measured using a protractor to be 72°. Finally, adding 180° and 72° provides the value 252°.

Teachers could use worksheet 18 and 19 (Appendix B) to assess students' understanding of this topic.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Journal

- Students could describe examples of how displacement vectors can be used in real life situations. (325-1, 325-2)

Presentation

- Students could prepare a presentation that explains how displacement vectors can be used to determine location. (212-7, 325-1, 325-2)

Performance

- Using tiles on the classroom floor (or a grid created with masking tape), 3 displacement vectors, and a starting point, ask students to move through the "grid" by following the displacement vectors in various orders. [Students will discover that the end point remains the same regardless of the order.] (212-7, 325-1, 325-2)

Presentation

- Using the Internet, students could prepare a report or presentation on how the sport of orienteering relies heavily on vector quantities. (212-7, 325-1, 325-2)

Observation

- Teachers could observe students as they identify points on a compass (using direction and degrees). (212-7)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 160-167

TR: 3.47-3.57

BLM: 3.12-3.18

SRL: 246-261

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- describe quantitatively, and analyze mathematically, the relationship among displacement and time of an object's uniform motion (212-7, 325-1, 325-2)
  Cont'd
  - draw an appropriate vector diagram
  - use an appropriate sign convention to indicate the direction of a vector
  - determine the resultant displacement using the math method
  - determine the resultant displacement using the scale diagram method

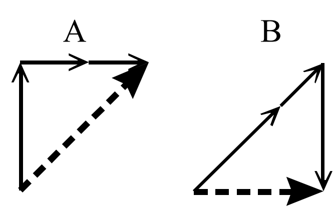
Elaborations—Strategies for Learning and Teaching

Teachers should ensure that when students are practising drawing and measuring vectors, they should interchange the different methods of indicating direction.

Teachers could emphasize that vector addition will provide students with some of the skills necessary to solve real-life motion problems. Students are expected to be able to solve 3 different types of vector addition problems.

First, one dimensional vector addition (the simplest type of vector addition). Within each problem, direction will be limited to two compass points (South/North or East/West). The direction of these vectors can be further simplified into positive and negative values, i.e., East is positive and West is negative or North is positive and South is negative. It is this type of vector addition which the text thoroughly covers on p. 162-165.

Second, two-dimensional vector addition problems limited to the eight point compass. In these problems, it is expected that students draw accurate scaled vector diagrams. Graph or grid paper would be very helpful for students to apply a scale and determine the magnitudes. The resultant vector will be determined by drawing an arrow from the tail of the first vector to the head of the last vector. In this type of addition problem, the resultant vector should be limited to a direction of one of the 8 points on the compass. For example, diagram A could be drawn, using a scale, to represent an object travelling 3.0 m [N], then 1.5 m [E] and finally another 1.5 m [E]. The dashed vector represents the sketched resultant vector (the final displacement of the object) which would measure 4.2 m and be in the Northeast direction. Students should represent this vector as 4.2 m [NE]. Diagram B could be drawn, using a scale, to represent an object travelling 2.8 km [NE], then 1.4 km [NE] and finally 3.0 km [S]. The resultant vector would be 3.0 km [E].



Teachers could use worksheet 20 and 21 (Appendix B) to assess students' understanding of this topic.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could complete the Extension Activity (page 246 of SRL). (212-7, 325-1, 325-2)
- Students could create displacement problems, with answer key, to challenge their peers to solve. (212-7, 325-1, 325-2)
- Given at least 3 displacement vectors (e.g. 2 blocks [N], 3 blocks [W], 1 block [S]), ask students to add them in all possible orders to determine the possible end point when beginning at a set start point. Teachers could use any grid or use Figure 2, page 167 of ST or any town/city map. (212-7, 325-1, 325-2)

Presentation

- Students could develop a set of instructions that describes how to add vectors. (212-7, 325-1, 325-2)

Performance

- Students could create a rap, song, or poem, that describes how to add vectors and/or how displacement vectors are a reliable way to find locations. (212-7, 325-1, 325-2)
- Students could complete the Try This Activity on page 165 of ST and include the completed report (page 250 of SRL) in their portfolio. (212-7, 325-1, 325-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 160-167

SRL: 246-261

Displacement, Velocity and Acceleration *(continued)*

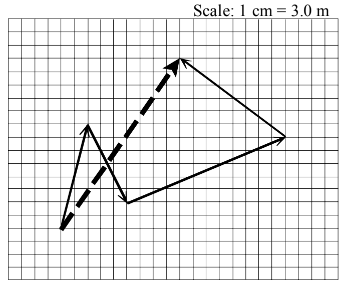
Outcomes

Students will be expected to

- describe quantitatively, and analyze mathematically, the relationship among displacement and time of an object's uniform motion (212-7, 325-1, 325-2) **Cont'd**
  - compare the scale diagram method to the math method of vector addition. Include:
    - (i) ease of use
    - (ii) accuracy
    - (iii) types of problems

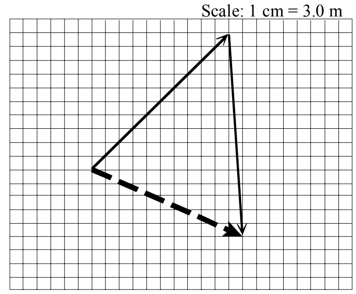
Elaborations—Strategies for Learning and Teaching

Third, two dimensional vector addition problems in unlimited directions. Teachers could begin by completing problems in which the vectors are already drawn head-to-tail on a scale diagram. Students should be able to draw the resultant vector and measure its magnitude and direction from any combination of vectors. For example, the following scaled vector diagram represents the motion of an object over a city block. Draw the vector representing the resultant displacement of the object and determine its magnitude and direction.



Resultant:

Once students have become comfortable with problems at this level, they should move on to vector addition using vector notation. In this type of problem, students would be expected to create their own scale diagram. These problems should be restricted to the addition of two vectors, each with unlimited magnitude and direction. For example, an person in a field moves 20 m [30°] and then 25 m [290°]. Determine the final displacement of the person.



Resultant :

Student success at vector addition will be contingent on their grasp and mastery of the previous section, i.e., their ability to draw scale diagrams. In fact, this is one of the major differences between the math and scale diagram method. Students should realize that the types of problems which can be solved using the math method (for the purposes of Science 3200) are much more limited than those that can be solved using the scale diagram method. However, it may be very difficult to obtain accurate results using the scale diagram method. Teachers should reinforce this fact by comparing the class results of a particular problem and highlight the range in results possible.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- When provided with a map of their town (or any town) with a grid overlaid, students could: (212-7, 214-3, 325-1, 325-2)
  - (i) Provide the displacement vectors needed to travel from their home to the school or any two points
  - (ii) Find the resultant displacement when they travel from one point to another when following a predetermined route
  - (iii) When given a desired location on the map, students could determine the displacement vectors of the fastest route to get there from a particular starting point (following the streets)
  - (iv) Students could provide a displacement vector description that a stranger can use to successfully navigate between two points on the map

Performance

- If the classroom floor has tiles (or tape can be used to create a grid), use these to create a scale model of your town (i.e., each tile is equivalent to the scale of the grid that was overlaid on the map). (214-3, 325-1, 325-2)

Portfolio

- Students could include their completed worksheets in their unit portfolio. (325-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 160-167

SRL: 246-261

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- analyze graphically the relationship among displacements (325-2)
  – determine that the resultant displacement is independent of the order in which vectors are added
- display and analyze information, by hand or computer, in diagrams (214-3)
- analyze the benefits to society of applying scientific knowledge on motion and introduction of animal tracking technology (118-2)
- relate animal tracking to studying distance, speed and time (114-6)
- describe quantitatively, and analyze mathematically, the relationship among displacement, time, and velocity of an object's uniform motion (212-7, 325-1, 325-2)
  - distinguish between speed and velocity
  - use appropriate symbols to represent speed and velocity (v vs. $\vec{v}$)

Elaborations—Strategies for Learning and Teaching

Teachers could reinforce the associative property of vector addition, as well as increase student interest by having students complete several "real-life" problems. For example, a student takes a trip and reports his three displacements as : 4 km [N], 5 km [E], and 2 km [W]. (A) Determine the student's final displacement. (B) If the student started his/her trip at school, using the map provided (by the teacher), determine his/her final location. (C) During his/her trip, did the student pass by the store (a location on the map in between the start and the final location)? Explain your answer.

Teachers could use worksheet 22 (Appendix B) to assess students' understanding of this topic.

The CORE STSE component of this unit incorporates a broad range of Science 3200 outcomes. More specifically, it targets (in whole or in part) 114-6, 214-3, 118-2, 212-7, 325-1, 325-2, NLS-2 and their delineations. The STSE component, *The Physics of Animal Tracking*, can be found in Appendix A.

Students should recognize the similarities between velocity and speed, including similar mathematical relationships and similar units. This could lead to possible confusions between these two values. Teachers could use a similar approach to introduce velocity as they did with displacement. Questioning techniques that emphasize the role of direction will help students reflect on the importance of vectors. For example; teachers could pose questions similar to: If a car travels at 75 km/hr for 4.0 hr, will you know where the car would be located at the end of its trip? The total distance which the car has travelled can easily be calculated, however, the omission of a direction leads to an infinite number of final locations for the car.

Students should understand that velocity is a measure of speed in a particular direction, i.e., the difference between speed and velocity is that measurements of speed do not include any reference to direction, e.g., 85 km/h represents a speed whereas 85 km/h [N] represents a velocity.

Speed is represented by the variable " v " and velocity is represented by " ". The arrow used in the symbol for velocity indicates that it is a vector quantity. For example; v = 85 km/h while $\vec{v}$ = 85 km/h [N].

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Presentation

- Students could present on the following: (212-7, 214-7, 325-3)
  - (i) What is the relative velocity of Centipedes vs. Millipedes?
  - (ii) What is the fastest non-winged insect?
  - (iii) Assuming it travels in a straight line, what is the maximum velocity of a mosquito?
  - (iv) When you compensate for their body size, do ants have a greater or lesser velocity than a cheetah?
- Using the Internet, students could find examples of graphs showing velocity-time graphs which do not have uniform acceleration and present them to the class (e.g., automobiles). (214-3, 325-1, 325-3)

Paper and Pencil

- Using the Internet, students could create a Timeline/Interval Graph (page TSM 6 of TR) to chart the migration of Monarch butterflies. (115-2, 116-1, 325-5)

Performance

- Using an outline map, students could chart wind velocity for a week. (116-1, 325-3)
- Students could create a song, poem, or rap, that summarizes the concept of velocity. (212-7, 325-1, 325-2)

Portfolio

- Students could keep a record of the velocity of winds in their area as a storm approaches and then passes. (325-5)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 160-167

SRL: 258-261

Core STSE #11: *The Physics of Animal Tracking,* **Appendix A**

ST: 168-171

TR: 3.58-3.60

BLM: 3.19-3.22

SRL: 262-263

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- distinguish between instantaneous and average velocity (325-3)
  - determine that a straight-line displacement vs. time graph represents a constant velocity
  - determine that a curve-line displacement vs. time graph represents a changing velocity
  - calculate any one of velocity, displacement or time given the two other values
- use vectors to represent velocity (325-5)

Elaborations—Strategies for Learning and Teaching

Teachers should emphasize that knowing the average velocity of an object does not provide any information regarding the motion of an object at a specific point in time. In order to know such information, the instantaneous velocity of the object, at that point, is required. For example; if a car travels with an average velocity of 35 km/hr [E] for 3.5 hours, the characteristics of its motion at any point during the 3.5 hours are unknown. At 2.0 hr it could be travelling at 100 km/hr in the opposite direction, i.e., West. From this information we can simply calculate the final displacement of the car. If we knew its starting point, we could determine, since it is a vector quantity, its final location.

Once students have become comfortable with velocity and how it is different from speed, teachers should revisit graphing and calculations involved with a three-variable relationship. At this point, to differentiate constant and changing velocity, the displacement vs. time graph should be introduced. With graphing and calculations involved with velocity, teachers could highlight the similarities to their studies on distance, speed and time. For example, similar shape graphs, similar formula, similar units, and so on.

Students are expected to be able to draw scale diagrams and use appropriate notation to represent velocity vectors. There is no expectation for students to manipulate them in any vector addition. Note: simply adding velocity vectors has no physical meaning in terms of final location. For example, if you add two velocity vectors (3 km/hr [E] and 3 km/hr [N]) this does not mean your displacement is 4.2 km [NE].

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Observation

- Teachers could use a rubric to assess students' graphing skills. (214-3)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 168-171

BLM: 3.27-3.28

SRL: 262-263

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- illustrate how science attempts to understand the migration of birds (115-2)
- identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-1)

Elaborations—Strategies for Learning and Teaching

Teachers could complete Case Study 3.15 as a whole class project. The case study could be read aloud or individually by students. Prior to a discussion of the questions, teachers could help clarify how this tracking process works and why it is important/useful. After (or during) the class discussion, students, working individually or in groups, could refer to pages 266-268 of the SRL to complete a report on this case study. Teachers should remind students of the differences between distance, displacement, speed, and velocity as well as the associated formulas.

BLM 3.15 can be used as either an overhead to lead students through this case study or copied for students to draw the displacement vectors on the map and then calculate the resultant displacement.

Teachers could include some discussion of Global Positioning Systems (GPS). A GPS could be brought into the class and its operation demonstrated. Teachers could use the Extension Activity "Tracking and Position" on pages 264-265 in the SRL to further explore how GPS works.

- display and analyze position and time information, by hand or computer in a properly labeled position-time graph (214-3, 325-2)
  - given displacement-time data, draw and label a proper position vs. time graph

Teachers should remind students of what they have already learned about distance-time graphs (earlier section) as this information can be directly transferred to position-time graphs. Figures 1 and 2 (page 174 of ST) provide a good comparison of the differences between these two types of graphs. Distance-time graphs show the total distance the object travels during a period of time (i.e., during a trip). A position-time graph indicates the object's location from the starting point at any period in time during the trip.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Journal

- Students could record their thoughts and reflections on the importance of tracking the migration patterns of various animals. (115-2, 116-1)

Presentation

- Students could present their opinions on GPS after completing Case Study 3.15 in SRL. (116-1)
- Students could demonstrate how a GPS operates. (116-1)

Portfolio

- Students could include a detailed description of how a GPS works as well as a detailed description of how to use a GPS. (116-1)

Paper and Pencil

- When given displacement-time data for different situations (e.g. walking up a steep hill, a child riding a tricycle, a tennis ball rolling down hill, etc.) ask students to create a properly labelled position vs. time graph. (214-3, 325-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 172-177

TR: 3.61-3.68

BLM: 3.26-3.29

SRL: 264-275

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- display and analyze position and time information, by hand or computer in a properly labeled position-time graph (214-3, 325-2) **Cont'd**
  - relate the slope of a position vs. time graph to an object's velocity
  - calculate an object's velocity using a position vs. time graph
  - compare, in terms of information conveyed, distance vs. time and position vs. time graphs
- identify and describe science- and technology-based careers related to the study of motion (117-7)
- analyze the benefits to society of applying scientific knowledge on motion and introduction of a particular technology (118-2)

Elaborations—Strategies for Learning and Teaching

Teachers should ensure students understand that with position-time graphs, a positive slope value is the direction that is given on the positive y-axis of the graph. A very common student misconception is to associate a negative value with the object "slowing down". The negative slope value indicates a direction opposite to that given on the positive y-axis (i.e. opposite to the initial direction). For example, if the positive y-axis indicates a north direction, a value of 8.5 m/s indicates the direction is north. A value of -8.5 m/s indicates that the object is moving at a constant velocity and that the direction is south (i.e., opposite to the initial direction which was north).

BLM 3.16a can be used to review the different types of graphical representations that could be presented using a position-time graph. BLM 3.16b provides worked out examples that show the difference between constant velocity and instantaneous velocity (calculated using graphical data). While students are not expected to calculate instantaneous velocity, they should understand it as a sample of the object's velocity at a specific point in time. BLM 3.16c can be used by students when they complete question #4 of the "understanding concepts" (page 176 of ST and 272 of SRL).

Research into careers related to motion or measuring motion could provide excellent motivation and bring relevance to the topic. Teachers could choose to begin this unit by briefly examining such careers and the importance of applying knowledge on motion. For example; crime investigators collect accurate and precise data on car movement, tire marks and vehicle damage. They analyze this data, both graphically and mathematically, to determine causes and effects of motor vehicle accidents.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Presentation

- Students could develop and present a skit that reveals the misconceptions that people have about how radar guns work and how to beat them. (117-7, 118-2)
- Students could conduct a mock trial in which one student attempts to prove that the "police officer" was wrong to give them a speeding ticket. (116-5, 118-2)

Interview

- Students could interview a police officer to learn how the officer uses the concepts of motion when investigating a traffic accident. (116-5, 118-2, 325-2)

Paper and Pencil

- Students could be provided with a list of occupations that require a knowledge of how to apply a knowledge of various concepts of motion. In groups or pairs, they could research the post-secondary training required to enter these occupations. (117-7, 118-2)
- Students could research how a radar gun works to determine the instantaneous speed of a moving automobile. (117-7, 118-2, 214-3)

Portfolio

- Students could include examples of occupations that require a knowledge of the various concepts of motion and the post-secondary training required. (118-2)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 172-177

TR: 3.61-3.68

BLM: 3.26-3.29

SRL: 264-275

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- describe quantitatively the relationship among velocity, time, and acceleration (212-7, 214-5, 325-4)
  - distinguish between acceleration and deceleration
  - explain what is meant by constant or uniform acceleration
  - recognize how different units can be used to express acceleration. Include:

    (i) $\frac{m/s}{s}$ or m/s^2

    (ii) $\frac{km/hr}{s}$

Elaborations—Strategies for Learning and Teaching

Teachers should consider student's prior experience as they introduce acceleration. For example, many students will be familiar with terms such as "a car can go from 0 to 100 in 5 seconds." This is a common expression that describes the car's acceleration many people would be able to understand. However, students will unlikely be as familiar with the concept of acceleration as they would be with speed. Teachers should be careful to avoid developing student misconceptions such as equating the meaning of speed (or velocity) to acceleration. For example given the speed of an object, Science 3200 students can easily determine the distance travelled by the object (over a given period of time). Given the acceleration of the object, however, it is much more difficult to determine the distance the object travelled (such calculations are beyond the scope of Science 3200).

In order to distinguish uniform acceleration from non-uniform acceleration, teachers could choose to present students with data representing a "real-life" situation. For example, the following data could represent the changes in a car's velocity.

From 0.0 s to 4.0 s, the car's acceleration is uniform, i.e., 10 m/s^2. However, after 4.0 s the car continues to accelerate, since its velocity is increasing, but not uniformly. From 4.0 s to 5.0 s, its acceleration is 8.0 m/s^2. From 6.0 s to 7.0 s, its acceleration is 12 m/s^2.

Acceleration units may pose problems for students. Often when describing acceleration such as, "0 to 100 in 5 seconds" the velocity units (km/hr) are omitted. The previous statement describes a changing velocity over time. More correctly, it should be said, "the car travelled 20 km/hr/s", a much more complex unit. Understanding the different units for acceleration, however, helps students to apply the appropriate units to particular circumstances. For example, when discussing the short acceleration of a car, the unit km/hr/s is preferred over m/s^2. A car's speed is often measured in km/hr and the time of acceleration is brief. In any data analysis or calculation, teachers should attempt to keep the time units the same.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Journal

- Students could record their impressions of the costs of various cars relative to how important they feel big acceleration is. (212-7)

Presentation

- Students could develop a cost-benefit analysis of acceleration data of various automobiles, and present their analysis and views to the class. (116-6, 212-7, 214-3)

Paper and Pencil

- Students could use the Internet to compile acceleration data (0 – 100 km/hr) on various cars (e.g. sports car, family car, dragster, etc.). This could be displayed in a chart, velocity – time graph, etc. (212-7, 214-5, 325-4)
- Students could use the Agree/Disagree graphic organizer (page TSM 8 of TR) as they research acceleration rates of various cars (i.e., make predictions before they conduct the research). (212-7, 214-5, 325-4)

Portfolio

- Students could make a poster, of various automobiles, that indicates the pros and cons of their respective acceleration rates. (212-7, 214-5, 325-4)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 178-185

TR: 3.71-3.81

BLM: 3.30-3.50

SRL: 276-295

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- describe quantitatively the relationship among velocity, time, and acceleration (212-7, 214-5, 325-4) **Cont'd**
  - calculate any one of acceleration, final speed, initial speed or time given the three other values
  - apply and interpret sign conventions when solving acceleration problems

- describe the motion of domestic and industrial technologies, using scientific principles (116-5)
  - classify the motion of an object, given its velocity data in terms of:
    - (i) constant velocity
    - (ii) instantaneous velocity
    - (iii) acceleration
    - (iv) deceleration

Elaborations—Strategies for Learning and Teaching

The textbook indicates that a negative (-) acceleration is equivalent to deceleration or slowing down. This may not always be true. For example, consider an object speeding up from 2.0 m/s [W] (or -2.0 m/s if the West direction is designated as negative) to 6.0 m/s [W] (or - 6.0 m/s) over a time interval of 3.0 s. Its acceleration would be :

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

$$\vec{a} = \frac{-6.0\,{}^{m}\!/\!_{s} - (-2.0\,{}^{m}\!/\!_{s})}{3.0s}$$

$$\vec{a} = \frac{-4.0\,{}^{m}\!/\!_{s}}{3.0s}$$

$$\vec{a} = -1.3\,{}^{m}\!/\!_{s^2}$$

The negative value for acceleration indicates that the object is accelerating in the negative direction (i.e., West). Since the object is also moving in the negative direction, the object is speeding up. If the object were moving in the positive direction (i.e., East) and accelerating in the negative direction (i.e. West) the object would be slowing down. It is the treatment of the latter situation to which the text is limited to.

Student should be provided with the equations :

$$t = \frac{\vec{v}_2 - \vec{v}_1}{\vec{a}} \qquad \vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{t}$$

$$\vec{v}_2 = \vec{v}_1 + \vec{a}t \qquad \vec{v}_1 = \vec{v}_2 - \vec{a}t$$

They would not be expected to derive one equation from another. Students must be able to appropriately use and interpret sign conventions during such problem solving.

Teachers should use activity 3.19 to reinforce what students have learned concerning velocity, acceleration and time. Teachers may decide to extend the activity and expect students to be able to provide a pictorial representation of an object undergoing given changes in motion. If the treatment is to be purely qualitative, the distance between the objects in the representation would only have to be approximate values. If the treatment is to be more quantitative (likely much more difficult) the distances between the objects in the representation would also have to be appropriately indicated through the use of a scale.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Journal

- Students could record their thoughts about how they would improve the acceleration of their family vehicle. (214-5, 325-4)

Presentation

- Students could present the data they collected in Investigation 3.20 to the class. (212-7)

Portfolio

- Students could include samples of the various types of accelerometers (including a description of the similarities and differences) in their portfolio. (116-5, 325-7)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST: 178-185

TR: 3.71-3.81

BLM: 3.30-3.50

SRL: 276-295

Displacement, Velocity and Acceleration *(continued)*

Outcomes

Students will be expected to

- propose a course of action on social issues related to the Space Shuttle taking into account human and environmental needs (118-9)
- propose courses of action on social issues related to the Space Shuttle taking into account an array of perspectives (118-10)
- describe graphically the relationship among velocity, time and acceleration (212-7, 214-5, 325-1)
- use appropriate graphical modes of representation to communicate results (215-2)
- design an experiment identifying and controlling major variables (212-3)
- interpret patterns and trends in data, and infer linear relationships among variables (214-5)

Elaborations—Strategies for Learning and Teaching

The CORE STSE component of this unit incorporates a broad range of Science 3200 outcomes. More specifically, it targets (in whole or in part) 118-2, 118-9, 118-10, 118-6 and their delineations. The STSE component, *The Physics of Space Shuttle Launch*, can be found in Appendix A.

The focus of this investigation is for students to match the slope of a velocity-time graph to the acceleration of the object. Teachers should link what has already been covered on graphing in this unit to this activity. For example, students should be able to sketch appropriate distance-time graphs and velocity-time graphs for their experimental cars.

In the experiment, the vehicle which completes the track first, will have the steepest slope. Students should reflect on what features of the car affect its acceleration. Students will likely generate a list very similar to that developed in Core Activity #2, including mass of vehicle, nature of propellant, aerodynamics and friction.

Students should understand why only sketches of the velocity-time graphs are generated; that is, the difficulties in accurately measuring the velocity of the car over the length of the track. This will help students to link what was covered in Core Activity #3 to this activity.

Teachers could decide to modify the experimental design to incorporate technology.

Displacement, Velocity and Acceleration *(continued)*

Suggested Assessment Strategies

Presentation

- After completing the "Work the Web" (page 185 of ST), students could prepare a presentation that describes each type of accelerometer and, as a member of a group, present this to the class. (116-5, 325-7)

Observation

- Using a rubric, teachers could observe students as they carry out Investigation 3.20, make observations, record data, identify trends, and infer relationships, to assess their process skills in these areas. (212-3, 214-5)

Paper and Pencil

- Students could create a display (poster, digital presentation, web page) that describes the results of the their Investigation on constant acceleration. (212-7, 214-5, 325-1)

Resources

www.gov.nl.ca/edu/science_ref/main.htm

Core STSE #12: *The Physics of Space Shuttle Launch,* **Appendix A**

ST: 178-185

BLM: 3.30-3.50

SRL: 276-295

Summary

ST: 186-191

TR: 3.82-3.87

SRL: 296-298