
Senior 2

Cluster 3: In Motion

Overview

In order to develop an understanding of the physics of motion, the outcomes of this cluster are examined within the context of the automobile. The relationships among displacement, velocity, acceleration, and time are analyzed in conceptual, numerical, graphical, and symbolic modes. Students investigate the qualitative aspects of inertia, force, impulse, and momentum as they relate to automobile safety. The conservation of energy in car collisions and braking distance is explored. Using the knowledge they have gained, students use the decision-making process to address an STSE issue related to safe driving conditions.

In order to assist students in achieving the specific learning outcomes of this cluster, references to *In Motion: A Learning Resource for Students* are included in the Suggested Learning Resources column for this cluster. In addition, important teacher background information, helpful suggestions for implementation, and complete solutions to problem sets are found in Appendix 7—In Motion: Teacher Resource Guide. This resource material is also available online at the Curriculum Documents links of Manitoba Education and Youth's website at <http://www2.edu.gov.mb.ca/ks4/cur/science/default.asp>.

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p>S2-3-01 Analyze the relationship among displacement, time, and velocity for an object in uniform motion.</p> <p>Include: visual, numeric, graphical, symbolic (velocity = Dd/Dt)</p> <p>GLO: C5, C8, D4, E3</p>

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➤ **Notes for Instruction**

Encourage the discussion of everyday language relating to acts of motion, such as speeding up, getting faster, bashing, and cushioning. Use this as an opportunity to bridge words used in everyday language with scientific terms like *acceleration*, *momentum*, et cetera. A formal mathematical approach is not required in the course. However, there are many opportunities for teachers to make math connections with students' prior experiences in Senior 1 and Senior 2 mathematics, particularly, Applied Mathematics (20S). Equations derived from a graphical analysis should be modeled in terms of their behaviour with respect to their proportions (i.e., increasing and decreasing at constant or exponential rates).

Students will often mix up Position-Time graphs with Velocity-Time graphs, and velocity with acceleration. Care must be taken when interpreting graphs to differentiate between these terms.

➤ **Student Learning Activities**

Laboratory Activity S2-0-31, 3b, 4a, 4e

Students or student groups investigate position and velocity for uniform motion. Activities may include the use of

- a ticker-tape apparatus and an object such as a motorized toy that moves with a constant velocity. By attaching a ticker tape to the back of the vehicle, a series of dots can be recorded on a tape. The spacing of the dots is a visual representation of the motion and should be emphasized. The spacing of the dots can be referred to as a "picture" of the motion. See Appendix 3.1: A Visual Representation of Motion.
- a videotape to analyze motion. A toy car that is released down an inclined plane and then allowed to move across a horizontal surface can be videotaped and used to investigate constant motion. Play back the videotape on a VCR with frame-by-frame advance. Place an acetate sheet over the TV screen and mark the position of the car on the sheet every frame (or every few frames). Normally, the tape will be played back at 30 frames per second. Students can measure the distance between the dots and calculate the time by the number of frames advanced. For uniform motion, the dots will be evenly spaced.

(continued)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Pencil-and-Paper Tasks

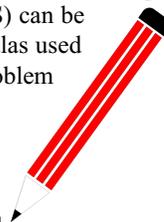
Students

- sketch a Position-Time graph from a description of motion (e.g., a walker and a runner leave the front door of the school at the same time; both move in the same direction at different constant velocities)
- differentiate between Position-Time graphs and Velocity-Time graphs
- describe how a record of motion is produced by a ticker-tape timer
- construct Distance-Time graphs, given data
- construct Velocity-Time graphs, given data
- discuss whether an odometer measures distance or displacement
- solve problems involving displacement, time, and velocity for an object in uniform motion
- calculate velocity, given data
- explain the difference between displacement and distance; velocity and speed

Teacher Background

It is important to note that only straight-line motion is examined and, in terms of defining vector quantities, it is only necessary to consider forward and backward motion. At this time, it is only necessary to examine situations where positive acceleration represents speeding up and negative acceleration represents slowing down. A more detailed analysis of motion in terms of vectors and direction in general will be left for Physics 30S/40S.

An understanding of *position*, *velocity*, and *acceleration* is developed conceptually (in this case visually), numerically (by measuring and collecting data), graphically, and symbolically (formula). The emphasis is intended to be on the conceptual understanding of the terms. Connections with Senior 2 Applied Mathematics (20S) can be made in the numerical and graphical modes. The only formulas used in this cluster will be to define velocity and acceleration. Problem solving using mathematical relationships is not emphasized; however, teachers could develop mathematical solutions to problems as an extension for advanced students.

*(continued)***In Motion**

- Ch. 1 Introduction
- Ch. 2 Analyzing Motion—Position and Displacement
 Instants and Intervals of Time
 Investigation 1—Vehicles in Motion
 Uniform Motion—Slope
 Instantaneous Velocity

Science 10

- 9.4 Investigation: Your Speed
- 9.5 Relating Speed to Distance and Time
- 9.6 Distance-Time Graphs
- 9.9 Activity: Simulation: Average Speed on an Air Table
- 9.10 Investigation: Determining an Average Speed
- 11.7 Velocity
- 12.1 Position-Time Graphs
- 12.2 Velocity-Time Graphs
- BLM 12.1a Position-Time Graphs
- ABLM 9.7a Distance-Time Graphs
- ABLM 12.1 Position-Time Graphs I
- ABLM 12.1a Position-Time Graphs II
- ABLM 12.2 Velocity-Time Graphs I

Science Power 10

- 9.1 Getting Into Motion
- 9.2 The Language of Motion
- 9.3 Measuring Motion
- Investigation 9-D: Slow but Sure
- 10.1 Position, Time, and Velocity
- 10.3 Velocity-Time Graphs

(continued)

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p><i>(continued)</i></p> <p>S2-3-01 Analyze the relationship among displacement, time, and velocity for an object in uniform motion.</p> <p>Include: visual, numeric, graphical, symbolic (velocity = Dd/Dt)</p> <p>GLO: C5, C8, D4, E3</p>

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

- a motion detector with a microcomputer or a graphing calculator to investigate uniform and accelerated motion. Students stand in front of the detector and try to make graphs that correspond to different types of motion. See Appendix 3.1 for more information on this activity.

Collaborative Teamwork S2-0-3b, 4e, 4f, 4g

Student groups solve problems involving displacement, time, and velocity for an object in uniform motion.

Journal Writing S2-0-8b

Students “tell a story,” given a Position-Time graph. Students can exchange stories, draw the corresponding Position-Time graph, and compare to the original. A RAFTS format could be used (see *SYSTH* 13.23). For sample graphs, see Appendix 3.2: Graphical Analysis.

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Laboratory Report S2-0-5b, 5c, 6a, 6b

Students interpret their laboratory results, and prepare a report describing their investigation findings (see *SYSTH* 14.12 for a lab report format). Word-processing, graphing, and spreadsheet software can be used for report writing.

Journal Writing S2-0-8b

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

BLM 10-1 Describing Position-Time Graphs

BLM 10-2 The Helicopter Challenge

BLM 10-7 Once Upon a Time

BLM 10-12 Car in Motion

SYSTH

13.21 Journal Evaluation

13.23 RAFTS

14.12 Lab Report Format
Concept Map

Appendices

3.1 A Visual Representation of Motion

3.2 Graphical Analysis

6.4 Lab Report Assessment

Teacher Background

Erratum: Page 5, In Motion Collision Scenario.

Legend

- Car B
- Car A
- Skateboarder
- Motorcycle
- Motorcyclist
- ▲ Helmet

FIGURE 3

Car Crash After

Legend

- Car B
- Car A
- Skateboarder
- Motorcycle
- Motorcyclist
- ▲ Helmet
- Oil Drops
- ~ Skid Marks

FIGURE 4

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
S2-3-02 Collect displacement data to calculate and graph velocity versus time for an object that is accelerating at a constant rate. GLO: C5, C8, D4, E3
S2-3-03 Analyze the relationships among velocity, time, and acceleration for an object that is accelerating at a constant rate. Include: visual, numeric, graphical, symbolic GLO: C5, C8, D4, E3

SUGGESTIONS FOR INSTRUCTION

(1 HOUR) & (2 HOURS)

➤ **Notes for Instruction**

Learning outcomes S2-3-02 and S2-3-03 can be addressed together. Students should first collect displacement data (S2-3-02) through experimentation, and then analyze their data (S2-3-03). Students often confuse velocity and acceleration. Reinforce the point that these are related, but distinct, concepts. A ticker tape, video analysis, or motion detector can be used to collect data for an object that is accelerating at a constant rate. Calculate the average velocity for each interval and graph at the midpoint of the interval. (Note: The average velocity for an interval closely approximates the instantaneous velocity at the midpoint of the interval.) For a straight-line graph, the rate of change of velocity is proportional to the change of time, and acceleration is defined as Dv/Dt .

➤ **Student Learning Activities**

Laboratory Activity S2-0-3c, 4e, 5a, 5b

Students or student groups collect displacement data to calculate and graph velocity versus time for an object that is accelerating at a constant rate. For example:

- a toy car is released down an inclined plane surface and videotaped. For accelerated motion, the spaces between the dots will increase (or decrease if the acceleration is negative).
- a cart with a ticker-tape timer is released down a ramp. The tape is examined to calculate the distance traveled and the speed for each time interval.

Collaborative Teamwork S2-0-4f, 4g, 9b, 9c

Student groups analyze their data collected during the laboratory activity to determine the relationships among velocity, time, and acceleration for an object that is accelerating at a constant rate.

Student groups solve problems involving velocity, time, and acceleration for an object that is accelerating at a constant rate.

Journal Writing S2-0-2c, 8b

Students prepare a glossary of new words for quick reference. A Three-Point Approach could be used (see *SYSTH* 10.22).

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Laboratory Report S2-0-5c, 6c, 7a, 7b

Students interpret their laboratory results, and prepare a report describing their investigation findings (see *SYSTH* 14.12 for a lab report format). Word-processing, graphing, and spreadsheet software can be used for report writing.

Journal Writing S2-0-2c, 8b

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Pencil-and-Paper Tasks

Students

- construct graphs of velocity versus time when provided with data
- contrast velocity with acceleration
- match written descriptions of objects in motion with their graphical representations
- predict which has the greater acceleration: a bike that increases its speed from 0–10 km/h, or a car that goes from 50–60 km/h in the same time
- explain what is meant by *negative acceleration*
- solve problems involving velocity, time, and acceleration for an object that is accelerating at a constant rate

SUGGESTED LEARNING RESOURCES

In Motion

Ch. 2 Analyzing Motion
Accelerated Motion
Real-life Motion

Science 10

10.2 Activity: Speed Comparisons
10.3 Defining Acceleration
10.4 Speed-Time Graphs for Acceleration
10.5 Investigation: Graphing Distances During Acceleration
10.9 Investigation: Constant Acceleration
10.10 Investigation: Acceleration of Different Vehicles
12.2 Velocity-Time Graphs
12.4 Investigation: Speeding Up and Slowing Down

ABLM 10.2 Speed Comparisons
ABLM 10.4 Speed-Time Graphs for Acceleration
ABLM 10.5 Graphing Distances During Acceleration
ABLM 10.9 Constant Acceleration

Science Power 10

9.1 Getting Into Motion
9.2 The Language of Motion
9.3 Measuring Motion
Investigation 10-C: Pick Up the Pace
11.1 Describing and Measuring Acceleration
11.2 Using and Picturing Acceleration
Investigation 11-A: The Definite Difference
BLM 9-11 The Bug Race
BLM 10-13 Pick Up the Pace
BLM 11-2 Recognizing Accelerated Motion
BLM 11-20 Stunt Driving

SYSTH

10.22 Three-Point Approach
13.21 Journal Evaluation
14.12 Lab Report Format

Appendix

6.4 Lab Report Assessment

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p>S2-3-04 Outline the historical development of the concepts of force and “natural” motion.</p> <p>Include: Aristotle, Galileo, Newton’s First Law</p> <p>GLO: A2, A4, B1</p>

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

➤ **Entry-Level Knowledge**

In Grades 5 and Senior 1, students gained some familiarity with the work of Aristotle, Galileo, and Newton. The stories of Newton’s apple and Galileo’s Tower of Pisa experiment are well known.

➤ **Notes for Instruction**

Develop the principles of Newton’s laws qualitatively with the intention of using these principles of force and motion in later discussion about car collisions. A historical discussion can introduce the idea of inertia.

Use a KWL frame to activate students’ prior knowledge of concepts related to this learning outcome (see *SYSTH* 9.24). Discuss student misconceptions, such as the idea that heavier objects fall faster than lighter ones. The use of demonstrations and hands-on activities will aid in student understanding of this learning outcome.

➤ **Student Learning Activities**

Class Discussion S2-0-8e, 8d, 8g, 9a

Galileo’s Thought Experiment can be imitated using toy cars. See Appendix 3.3: Force and Natural Motion. Relate Galileo’s story while demonstrating that the toy car will rise to almost the same height from where it was released. Discuss the limitations of the demonstration (friction) and tell students that Galileo’s contribution to the way we practise science was his ability to idealize a situation.

Teacher Demonstration S2-0-9b

There are several demonstrations of inertia, the most popular of which is pulling a tablecloth rapidly from under a set table. The dishes should stay behind. Other examples:

- Place a penny on a card that is resting on your finger. Using your other hand, flick the card quickly, leaving the penny on your finger.
- Cut a ring from a large PVC pipe and place the ring on top of a pop bottle or an open-mouthed flask. On top of the ring, place a peanut or small marble. If you pull the ring rapidly, the peanut will fall into the bottle.

These demonstrations can also be attempted by students.

(continued)

SUGGESTIONS FOR ASSESSMENT

Pencil-and-Paper Tasks

Students

- explain why the dishes stay behind when a tablecloth is rapidly pulled from under a set table
- contrast Aristotle’s view of motion with that of Galileo’s
- define *inertia*
- predict which of two objects of similar size but different masses, dropped from the same height, will reach the ground first
- draw a timeline outlining the historical development of the concepts of force and “natural” motion
- summarize Galileo’s contribution to our knowledge of motion
- state, in their own words, Newton’s First Law of Motion
- explain why a person has to push harder on the pedals of a single-speed bicycle to start it moving than to keep it moving at a constant velocity
- predict what will happen to the passengers in a car as it moves along a curve
- describe how Newton’s First Law applies when a billiard ball rolls toward and collides with an unmoving ball

Journal Writing S2-0-8c, 8e, 8g, 9a

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Teacher Background

Initially, Aristotle proposed that every terrestrial object had a natural motion toward the centre of the universe (Earth). To move otherwise, an object would be in violent motion under the influence of an external force. Two thousand years later, Galileo challenged Aristotle’s views in his *Two New Sciences*. Students can read Galileo’s words and draw their own conclusions about Galileo’s view of inertia.

It is not well understood whether Galileo thought that inertial motion was circular (i.e., an object free to move on the surface of the Earth would circumnavigate the Earth). See Appendix 3.4 for a discussion of Galileo’s Thought Experiment.

SUGGESTED LEARNING RESOURCES

In Motion

Ch. 3 Inertia

Natural Motion—Aristotle
 Natural Motion—Galileo
 Newton’s First Law and the
 “Second Collision”

Science 10

12.7 Acceleration Due to Gravity

12.10 Explore an Issue: “Nothing by Authority”

Unit 3 Challenge: Scientific Perspectives on Motion: Testing of Motion

Science Power 10

Investigation 9-A: Be Specific

BLM 9-2 Arguing with Aristotle

BLM 9-3 Be Specific

BLM 9-4 The Parachute Drop

BLM 9-5 Galileo’s Experiments

SYSTH

3.20 Jigsaw

9.24 KWL Plus

11.14 Chain Concept Map

13.21 Journal Evaluation

Galileo

Galileo, trans. Stillman Drake (Berkeley and Los Angeles: University of California Press, 1967) 145–149. A Galileo dialogue concerning the two chief world systems.

Appendices

3.3 Force and Natural Motion

3.4 Galileo’s Thought Experiment

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p><i>(continued)</i></p> <p>S2-3-04 Outline the historical development of the concepts of force and “natural” motion.</p> <p>Include: Aristotle, Galileo, Newton’s First Law</p> <p>GLO: A2, A4, B1</p>

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

Collaborative Teamwork S2-0-4f, 4g 8c, 8e

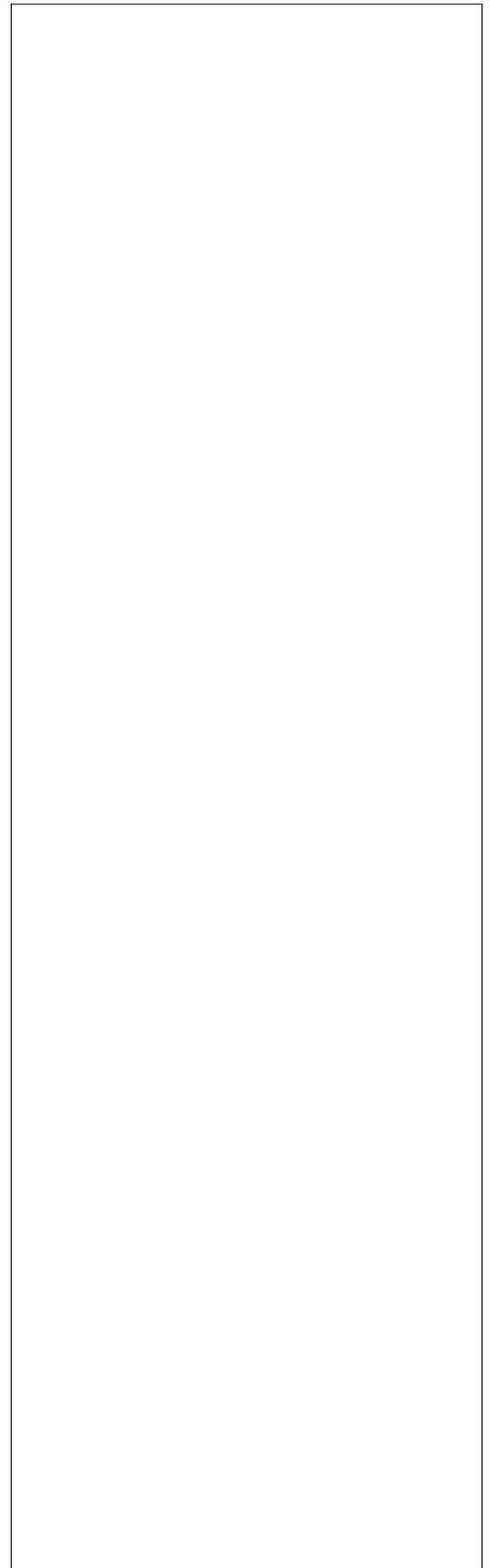
Student groups summarize the work of different scientists with respect to the historical development of the concepts of force and “natural” motion, and then share their work with their classmates in a Jigsaw format (see *SYSTH* 3.20).

Journal Writing S2-0-8c, 8e, 8g, 9c

Students develop a timeline or Chain Concept Map outlining the historical development of the concepts of force and “natural” motion (see *SYSTH* 11.14).

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

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PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p>S2-3-05 Experiment to illustrate the effects of inertia in car collisions. Include: distance traveled (of an unrestrained passenger) is proportional to velocity squared GLO: C2, C6, C7, E3</p>

SUGGESTIONS FOR INSTRUCTION

(2 HOURS)

➤ **Entry-Level Knowledge**

In Grade 5, students were introduced to balanced and unbalanced forces, and Newton’s Laws. Students will also have personal experience with inertia from accelerating and decelerating in automobiles, planes, bikes, skateboards, et cetera.

➤ **Notes for Instruction**

Activate prior knowledge of this learning outcome with a discussion of the effects of inertia in car collisions. A Knowledge Chart could be used (see *SYSTH* 9.25). Hands-on activities and laboratory experiments will aid in student understanding of the concept.

➤ **Student Learning Activities**

Laboratory Activity S2-0-3a, 3b, 4b, 5a

See Appendix 3.5: Newton’s First Law, for a student learning activity to investigate the inertia of an unrestrained passenger in a car collision. The distance is proportional to the velocity squared. Note that it is not necessary to “straighten the curve” to determine the relationship; the relationship can simply be modeled as exponential since the graph curves upward. The important idea for students to understand is that if the velocity doubles, the distance the passenger travels more than doubles.

Debate S2-0-1d, 2b, 2d, 3e

Students debate the statement, “It is better to be thrown out of the car and clear of the crash than to be trapped in the car by a seat belt.”

Journal Writing S2-0-2c, 7e, 9d

Encourage reflection on the debate. Have students summarize the arguments given by each team and ask the following:

- What surprising points were raised during the debate?
- What is your opinion, based on the evidence presented in the debate?

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Laboratory Report S2-0-5c, 6a, 7a, 7b

Students interpret their laboratory results, and prepare a report describing their investigation findings (see *SYSTH* 14.12 for a lab report format). Word-processing, graphing, and spreadsheet software can be used for report writing.

Journal Writing S2-0-2c, 7e, 9d

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Pencil-and-Paper Tasks

Students

- define *inertia*
- discuss how seat belts acting with air bags help protect passengers in a car accident
- explain why a person standing on a bus falls backward when the bus moves forward, and falls forward when the bus stops
- discuss whether it is better to be thrown out of the car and clear of the crash, than to be trapped in the car by a seat belt
- describe the relationship between the speed of a car and the distance traveled by an unrestrained passenger in a car crash
- explain why a transport truck (e.g., grain truck) has a sturdy wall behind the driver's cab

SUGGESTED LEARNING RESOURCES

In Motion

Ch. 3 Inertia

The Velocity of a Car on an Inclined Plane

Investigation #2—Inertia and the Unrestrained Occupant

SYSTH

9.25 Knowledge Chart

13.21 Journal Evaluation

14.12 Lab Report Format

Appendices

3.6 Inertia and the Unrestrained Passenger

6.4 Lab Report Assessment

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
<p><i>Students will...</i></p>	<p>(3 HOURS)</p>
<p>S2-3-06 Describe qualitatively how force is related to motion. Include: no force; constant force; the relationship among force, mass, and acceleration (Newton’s Second Law) GLO: D4, E3</p>	<p>➤ Entry-Level Knowledge In Grade 5, students were introduced to balanced and unbalanced forces, and Newton’s Laws.</p> <p>➤ Notes for Instruction Newton’s Second Law is $F = ma$ (i.e., force equals mass times acceleration). It is not the intention to derive this relationship experimentally, or to use a mathematical problem-solving approach. In order to examine car collisions, students need only be familiar with the basic principles of applying the law. These principles include the following:</p> <ol style="list-style-type: none"> 1. Force is proportional to acceleration. If we apply a greater force, we will have a greater acceleration (remember that this includes speeding up and slowing down). 2. Force is proportional to mass. More massive objects require more force to accelerate (change speed). 3. Force can change the direction of motion. <p>➤ Student Learning Activities Laboratory Activity S2-0-1a, 1b, 3c, 4a Students or student groups investigate qualitatively how force is related to motion. Activities can include the following:</p> <ul style="list-style-type: none"> • Attach a ticker tape to the rear of a toy car and release the car down a ramp. Increase the angle of the plane and repeat several times. Examine the dots on the ticker tape. As the force increases, the acceleration increases. • Place a mass on the plane attached to a spring scale and raise the ramp. The spring scale will reach a maximum when the plane is vertical. This shows that the force increases as the angle of the plane increases. • Place a small mass (like a block of wood) at the bottom of an inclined plane and release a cart down the plane. Record how far the mass moves. Double the mass and repeat. In order to move the heavier mass the same distance, the force must be increased. • Use a pulley system to accelerate a cart on a table. <p>Journal Writing S2-0-2a Students complete a Word Cycle of the following terms: <i>velocity, Galileo, inertia, acceleration, force, Newton, motion, and mass</i> (see SYSTH 10.21).</p>

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Laboratory Report S2-0-6a, 6b, 7a, 7b

Students interpret their laboratory results, and prepare a report describing their investigation findings (see *SYSTH* 14.12 for a lab report format). Word-processing, graphing, and spreadsheet software can be used for report writing.

Journal Writing S2-0-2a

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Pencil-and-Paper Tasks

Students

- explain why a person wearing a cast on one leg becomes more tired than usual by the end of the day
- suggest reasons why large automobiles such as vans and sport-utility vehicles tend to have larger engines and higher rates of fuel consumption than compact and sub-compact cars
- use Newton's Laws to explain why people in cars often get neck injuries (e.g., whiplash) when struck from behind
- explain why small gazelles often escape bigger and faster cheetahs in pursuit by zigzagging as they run
- predict when serious injuries are more likely to occur—when a car crashes into a large tree or into a wooden fence
- complete a Word Cycle of the following terms: *velocity*, *Galileo*, *inertia*, *acceleration*, *force*, *Newton*, *motion*, and *mass* (see *SYSTH* 10.21)

SUGGESTED LEARNING RESOURCES

In Motion

Ch. 4 Forces and Motion

Investigation #3—Force and Acceleration

Investigation #4—Mass and Acceleration

Investigation #5—Force and Mass

Force and Direction

SYSTH

10.21 Word Cycle

13.21 Journal Evaluation

14.12 Lab Report Format

Appendix

6.4 Lab Report Assessment

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION (1 HOUR)
<p><i>Students will...</i></p>	
<p>S2-3-07 Investigate and describe qualitatively Newton’s Third Law. <i>Examples: balloon-powered car, model rockets, head-on collision...</i> GLO: C2, C6, C7, E3</p>	<p>➤ Entry-Level Knowledge</p> <p>In Grade 5, students were introduced to balanced and unbalanced forces, and Newton’s Laws. In Grade 6, gravity, thrust, drag, and the use of unbalanced forces to steer air and spacecraft were examined.</p> <p>➤ Notes for Instruction</p> <p>Newton’s Third Law is commonly known as the action-reaction law. It is often misunderstood that forces always occur in pairs. The head-on collision should also be examined in this context. It is a common misconception that in a collision between a large vehicle and a small vehicle, the large vehicle exerts a larger force. According to Newton’s Third Law, each vehicle experiences the same force. Of course, the smaller vehicle will probably experience the most damage.</p> <p>➤ Student Learning Activities</p> <p>Teacher Demonstration</p> <p>Newton’s Third Law can be demonstrated using a model rocket or a go-cart powered by a fire extinguisher. Ensure safety precautions are observed.</p> <p>Laboratory Activity S2-0-3c, 3e, 4a, 4e</p> <p>Students design and build a balloon-powered car. Plastic bottle caps can be used for wheels and a contest can be organized.</p> <p>Student Research S2-0-2a, 2b, 2c, 3d</p> <p>Students research and describe everyday applications of Newton’s Third Law. Topics can include</p> <ul style="list-style-type: none"> • slingshots • swimming • rockets • skateboarding • rollerblading <p>Case studies and Internet sources can be used.</p> <p>Visual Display/Collaborative Teamwork S2-0-4f, 4g, 5c</p> <p>Student groups research and prepare visual displays illustrating everyday applications of Newton’s Third Law.</p> <p style="text-align: right;"><i>(continued)</i></p>

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Laboratory Report S2-0-5d, 6c, 6d, 7d

Students interpret their laboratory results, and prepare a report describing their investigation findings (see *SYSTH* 14.12 for a lab report format). Word-processing, graphing, and spreadsheet software can be used for report writing.

Research Report/Presentation S2-0-8a, 8d, 9b, 9c

Students present research findings with

- written reports
- oral presentations
- newspaper articles
- demonstrations
- dramatic presentations

Visual Display S2-0-8a, 8d, 9b, 9c

Student groups present their visual displays of everyday applications of Newton's Third Law with

- posters
- dioramas
- bulletin board presentations
- multimedia presentations
- diagrams

Journal Writing S2-0-7f

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

In Motion

Ch. 4 Forces and Motion
Action-Reaction Forces
Design Challenge: The
"Rocket" Car Race

Science 10

9.6 Investigation: Balloon Car Contest

ABLM 9.6 Balloon Car Contest

ABLM 9.6a Balloon Car Contest-
Evaluation Table

Science Power 10

Investigation 9-B Air Power

SYSTH

13.21 Journal Evaluation

14.12 Lab Report Format

Appendices

6.1 Rubric for the Assessment of
Class Presentations

6.2 Rubric for the Assessment of a
Research Project

6.4 Lab Report Assessment

(continued)

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p><i>(continued)</i></p> <p>S2-3-07 Investigate and describe qualitatively Newton’s Third Law. <i>Examples: balloon-powered car, model rockets, head-on collision...</i></p> <p>GLO: C2, C6, C7, E3</p>

SUGGESTIONS FOR INSTRUCTION

(1-1/2 HOURS)

Journal Writing S2-0-7f

Students reflect on and respond to the following questions:

- How has your understanding of motion changed since the start of the cluster?
- What new questions do you have about motion?
- What new information in this cluster surprises you?

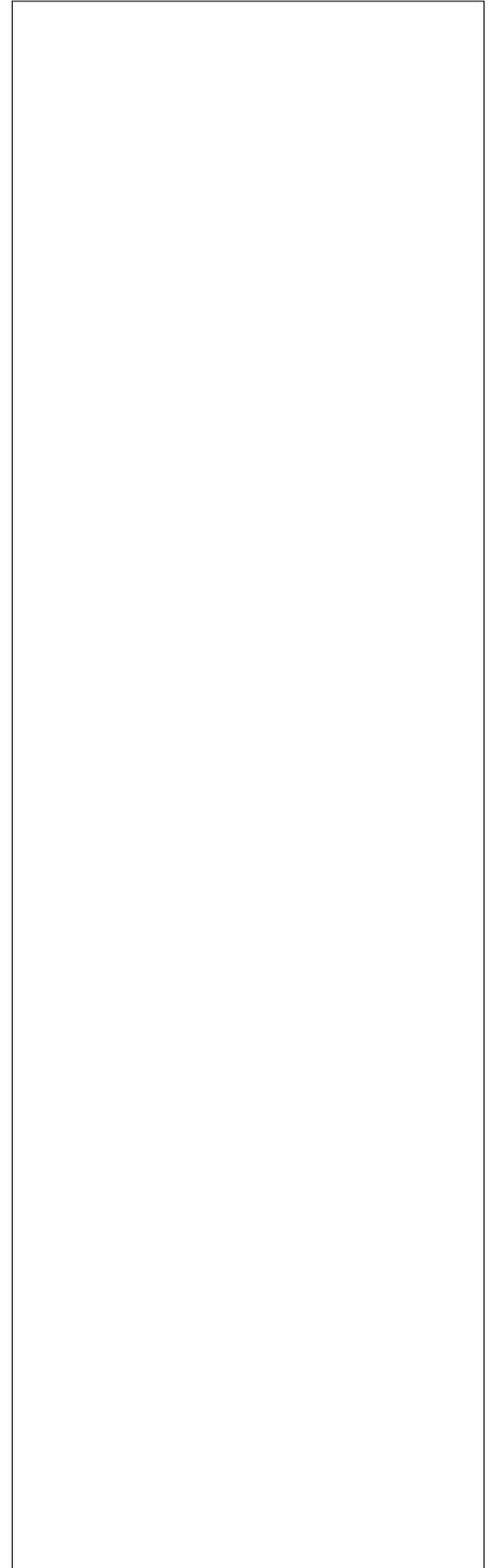
SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Pencil-and-Paper Tasks

Students

- summarize, in their own words, Newton’s Third Law of Motion
- describe how the reaction engine of a rocket is an application of the Third Law of Motion
- predict and explain, with the use of diagrams that include force vectors, what would happen if a person stepped out of a boat onto a dock without first securing the boat to the dock
- discuss Newton’s Third Law of Motion in the context of a head-on car collision
- explain how walking is an example of Newton’s Third Law of Motion
- explain whether astronauts in a space station should choose pencils with a hard lead or a soft lead for taking notes



PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p>S2-3-08 Define <i>momentum</i> and <i>impulse</i> and qualitatively relate impulse to change in momentum for everyday situations.</p> <p>Include: car collisions, bumpers, restraints, air bags</p> <p>GLO: A5, B1, B2, D4</p>

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➤ **Entry-Level Knowledge**

In Grade 7, forces and structures were examined. Students determined the effect of a force on a structure, and described how common structural shapes and components can increase the strength and stability of a structure. Students may also have personal experience with car collisions.

➤ **Notes for Instruction**

Newton actually formulated his law in terms of the change of velocity.

That is, $F = ma$ is the same as $F = mDv/Dt$.

If we multiply each side by Dt , then we have $F Dt = m Dv$.

Once again, the mathematical application of this relationship is NOT necessary. The basic principles to be discussed are as follows:

1. The product of force and time (left-hand side) is called *impulse*. To increase impulse, we must increase the force applied or the time over which we apply the force.
2. The product of mass and velocity is called *momentum*. Momentum is known as a quantity of motion. A 100 000-kg train moving at 5.0 m/s has more momentum than a 10-g toy car moving at 5.0 m/s (and consequently is more difficult to stop).
3. In order to change momentum (i.e., change an object's velocity) we must apply an impulse. For example, to kick or hit a ball we apply a force on the ball for a period of time. To kick or hit the ball further we must have a greater change in velocity (and therefore momentum). To do this, we can increase our force by kicking or hitting harder (build up your muscles!) or we can apply the force for a greater length of time (or, as the coach says, "follow through"). This principle applies to many everyday types of activities like kicking, throwing, or hitting a ball, puck, or other object.

Manitoba Public Insurance's website <www.mpi.mb.ca> offers information on road safety and other topics. Visit <www.hwysafety.org> for highway and vehicle safety statistics. Automaker websites provide information on automobiles and their safety features.

(continued)

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Laboratory Report S2-0-6c, 6d, 7c, 7d

Students interpret their laboratory results, and prepare a report describing their investigation findings (see *SYSTH* 14.12 for a lab report format). Word-processing, graphing, and spreadsheet software can be used for report writing.

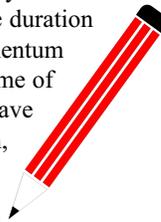
Research Report/Presentation S2-0-7e, 8c, 8d

Students present their investigation findings of the various technologies that cushion the impact of the second collision in a car accident with

- written reports
- oral presentations
- dioramas
- dramatic presentations
- newspaper articles
- multimedia presentations

Teacher Background

In a car collision, the impulse that is most threatening to drivers and passengers is called the second collision. The second collision occurs when an individual hits the steering wheel, windshield, tree, or any other rigid object. To bring a moving object, such as a passenger thrown from a car, to rest, an impulse is required to reduce the momentum to zero. Since impulse is the product of $F \cdot t$, when a person collides with a fixed object, the duration of time is very small and the force is very large. This causes damage and severe personal injury. To protect passengers in moving vehicles, engineers try to “cushion” the blow. That is, a cushioning effect increases the duration of time during which the force is applied, to reduce the momentum to zero. Since the same impulse is required, increasing the time of impact reduces the force of the impact. Many technologies have been developed to cushion the impact of the second collision, including seat belts and air bags.



(continued)

SUGGESTED LEARNING RESOURCES

In Motion

Ch. 5 Momentum and Energy
Momentum
Impulse and Momentum
Cushioning Devices
The Great Egg Drop Competition

Science 10

10.6 Case Study: Buying a Car?

Science Power 10

Unit 3: Ask an Expert

SYSTH

13.21 Journal Evaluation

13.23 RAFTS

14.12 Lab Report Format

Appendices

6.1 Rubric for the Assessment of Class Presentations

6.2 Rubric for the Assessment of a Research Project

6.4 Lab Report Assessment

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p><i>(continued)</i></p> <p>S2-3-08 Define <i>momentum</i> and <i>impulse</i> and qualitatively relate impulse to change in momentum for everyday situations.</p> <p>Include: car collisions, bumpers, restraints, air bags</p> <p>GLO: A5, B1, B2, D4</p>

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

Teacher Demonstration

An effective demonstration of momentum and impulse is the egg toss. Throw or drop an egg onto a hard surface. The egg will splatter easily, as a larger force is applied for a short period of time to stop the egg. Get a blanket and hold it vertically. Throw the egg into the blanket (you can actually throw the egg quite fast, but make sure you do not squeeze the egg!). The impulse necessary to stop the egg is the same but the cushioning of the blanket spreads the impulse over a longer period of time and the force is considerably less.

➤ **Student Learning Activities**

Laboratory Activity S2-0-1a, 1b, 3e, 3f

Suggested ways to approach an egg-drop activity:

- Given a set of materials, students can build a landing pad and drop an egg from a height onto the landing pad.
- Using a vehicle analogy, students can build a restraint system to protect a passenger (the egg) in a collision. The restraint system could be used to investigate the effects of seat belts, air bags, dashboards, and bumpers.

Student Research S2-0-1c, 1d, 2b, 3e

Students research the benefits of various technologies that cushion the impact of the second collision in a car accident. Technologies include

- seat belts
- air bags
- dashboards
- side panels
- bumpers

Visual Display/Collaborative Teamwork S2-0-2d, 3d, 3f, 5d

Student groups develop advertising campaigns to increase community awareness of how various technologies cushion the impact of the second collision in a car accident.

Journal Writing S2-0-7f

As a crash-test dummy, students write a diary entry describing their day at work. A RAFTS format could be used (see *SYSTH* 13.23).

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Visual Display S2-0-7c, 7d, 8d, 9f

Student groups present their advertising campaigns. Displays may take the form of

- radio commercials
- posters
- bulletin board displays
- television commercials
- pamphlets
- brochures
- newspaper/magazine advertisements

Journal Writing S2-0-7f

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Pencil-and-Paper Tasks

Students

- define *impulse* and *momentum*
- predict what a smaller football player's velocity must be if his momentum is enough to stop a larger player
- describe how seat belts help reduce injury to passengers
- explain why long jumpers sprint up the approach before jumping
- discuss the importance of follow-through on a golf swing, swimming stroke, or soccer kick
- predict what will happen to the momentum of a person who falls off a roof, upon landing on the ground
- suggest why headrests help the driver and passenger of a car that has been rear-ended
- explain why the engines of supertankers must be shut off several kilometres before they need to stop
- describe how air bags cushion the impact of the second collision in a car accident
- discuss how a bullet can have the same momentum as a truck

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION (1 HOUR)
<p><i>Students will...</i></p>	
<p>S2-3-09 Investigate the conservation of energy in a motor vehicle collision.</p> <p>Include: kinetic energy, heat energy, sound</p> <p>GLO: B2, D4, E4</p>	<p>➤ Entry-Level Knowledge</p> <p>In Grade 6, students were introduced to the Law of Conservation of Energy, where they recognized that energy can neither be created nor destroyed but changed from one form to another.</p> <p>➤ Notes for Instruction</p> <p>Activate prior knowledge of the conservation of energy in motor vehicle collisions. A Listen-Draw-Pair-Share strategy could be used (see <i>SYSTH</i> 9.15). The Law of Conservation of Energy is not derived from any of the dynamic laws of motion. It is an independent statement about order in nature. In a car crash, energy is dissipated through the transfer of energy to other forms and other systems (like the pavement, the crumpling of fenders, breaking of bones). <i>Kinetic energy</i> can be defined as the energy of motion; <i>potential energy</i> as the energy of position (with respect to the surface of the Earth), heat energy as the energy of molecules in motion; and <i>sound energy</i> as the disturbance of a medium. In a car collision, huge amounts of kinetic energy are transferred to other systems. As the kinetic energy reduces to zero, other forms of energy increase.</p> <p>➤ Student Learning Activities</p> <p>Class Discussion S2-0-7f</p> <p>Challenge students with the statement, “What would our world be like if energy was not conserved?” Examine a picture of a car collision and summarize the energy changes.</p> <p>Student Research/Collaborative Teamwork S2-0-1b, 2c, 4f, 4g</p> <p>Student groups investigate the conservation of energy in a motor vehicle collision. Groups should be assigned to</p> <ul style="list-style-type: none"> • kinetic energy • heat • sound <p>Case studies, newspaper articles, and Internet sources may be used. Groups then share their findings with their classmates in a Jigsaw format (see <i>SYSTH</i> 3.20).</p> <p>Journal Writing S2-0-2a</p> <p>Students complete a Concept Frame or Concept Overview of the conservation of energy in motor vehicle collisions (see <i>SYSTH</i> 11.24, 11.25).</p>

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Research Report/Presentation S2-0-9b, 9c, 9d

Student groups prepare and present their research findings with

- written reports
- oral presentations
- posters
- dioramas
- models
- multimedia presentations
- newspaper articles
- bulletin board displays

Journal Writing S2-0-2a

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Pencil-and-Paper Tasks

Students

- state how the Law of Conservation of Energy applies to car crashes
- compare and contrast kinetic and potential energy (see *SYSTH* 10.24)
- explain, from the standpoint of kinetic energy, why a loaded semi-trailer is more dangerous than a sub-compact car in a collision, even though they are both traveling at the same speed.
- describe how bouncing on a trampoline illustrates both potential and kinetic energy
- identify various energy conversions involved in a car collision
- explain, in terms of energy transfers, how air bags greatly reduce the chance of injury in a car accident

SUGGESTED LEARNING RESOURCES

In Motion

Ch. 5 Momentum and Energy in a Collision

SYSTH

- 3.20 Jigsaw
- 9.15 Listen-Draw-Pair-Share
- 11.24 Concept Frame
- 11.25 Concept Overview
- 13.21 Journal Evaluation

Appendices

- 6.1 Rubric for the Assessment of Class Presentations
- 6.2 Rubric for the Assessment of a Research Project

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p>S2-3-10 Investigate conditions that illustrate the effects of friction on motion.</p> <p>Include: weather conditions</p> <p>GLO: C2, C5, D4, E2</p>

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

➤ **Entry-Level Knowledge**

In Grade 5, students were introduced to the effects of friction on motion. Students may have personal knowledge of conditions that illustrate the effects of friction on motion.

➤ **Notes for Instruction**

There are many conditions that illustrate the effects of friction on motion. Activate students' knowledge of this learning outcome. A Sort and Predict activity can be used (see *SYSTH* 10.23).

➤ **Student Learning Activities**

Visual Display/Collaborative Teamwork S2-0-2d, 3e, 3f, 5d

Student groups research and prepare visual displays of technologies used to increase or reduce friction. Examples may include

- how and why cyclists reduce friction
- how and why drag racers increase tire friction
- how and why snowboarders reduce friction

Case studies, newspaper articles, and Internet sources can be used.

Student Research S2-0-1b, 1d, 2a, 2c

Students investigate conditions that illustrate the effects of friction on motion. These may include

- road conditions (icy, wet, snow-covered, dry, gravel, dirt)
- type of vehicle (sub-compact car, sport-utility vehicle, pickup truck)
- type of tire (snow tire, studded tire, racing slick, all-season radial)

Case studies, newspaper articles, and Internet sources can be used.

Journal Writing S2-0-7f

Students complete a fact- or issue-based article analysis of a current newspaper, Internet, or magazine article related to this learning outcome (see *SYSTH* 11.40, 11.41).

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Visual Display S2-0-8a, 8b, 8d, 8g

Student groups present visual displays such as

- posters
- models
- dioramas
- bulletin board displays
- cartoons

Research Report/Presentation S2-0-9b, 9c, 9d

Students present investigation findings with

- written reports
- oral presentations
- demonstrations
- newspaper articles
- multimedia presentations

Journal Writing S2-0-7f

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Pencil-and-Paper Tasks

Students

- explain why sand is sprinkled on icy roads and sidewalks
- suggest ways to reduce friction between a bicycle and the road
- describe why studded tires or chains are used in icy winter driving conditions
- discuss why skiers and snowboarders use wax

In Motion

Ch. 6 Braking

Challenge—The Effects of Friction on Braking

Science 10

11.6 Explore an Issue: Athletes on the Edge

12.3 Case Study: Technology and Skiing

Science Power 10

Investigation 10-B: The Better Bicycle

SYSTH

10.23 Sort and Predict

11.40 Issue-Based Article Analysis

11.41 Fact-Based Article Analysis

13.21 Journal Evaluation

Appendices

6.1 Rubric for the Assessment of Class Presentations

6.2 Rubric for the Assessment of a Research Project

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p>S2-3-11 Investigate the factors that influence braking distance. Include: reaction time, friction, condition of driver, speed GLO: C2, C3, C6, D4</p>

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➤ **Entry-Level Knowledge**

From personal experience, as well as radio and television advertising, students will have knowledge of the factors that influence braking distance.

➤ **Notes for Instruction**

There are many factors that influence the braking distance of a car. Activate prior knowledge using a brainstorming activity such as Rotational Graffiti (see *SYSTH* 3.15).

It is not necessary to complete a graphical analysis. Students should realize that we can model a curve that bends upward using a power of 2, in this case, $d \propto v^2$. If the velocity doubles, the distance the car takes to stop will increase four times. Hands-on activities and laboratory experiments will aid in student understanding of this topic.

➤ **Student Learning Activities**

Laboratory Activity S2-0-3a, 4a, 4e, 5b

Another toy car activity (see Appendix 3.7: Braking Distance) can be used to investigate the relationship between speed and braking distance. Release the car down an incline from various heights. At the bottom of the incline, place a “braking sled” made of paper. The braking sled simulates a locked braking system on a vehicle. Record the distance that the sled slides to a stop. Students can graph distance versus velocity to observe that the distance increases exponentially with the velocity.

Student Research S2-0-1d, 2a, 2c, 3d

Students research factors that influence braking distance. These factors can include

- alcohol
- wet road surfaces
- hallucinogenic drugs
- age of the driver
- icy road surfaces
- depressant drugs
- driver fatigue

Case studies, newspaper articles, and Internet sources can be used.

(continued)

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Laboratory Report S2-0-6a, 6b, 7a, 7b

Students interpret their laboratory results, and prepare a report describing their investigation findings (see *SYSTH* 14.12 for a lab report format). Word-processing, graphing, and spreadsheet software can be used for report writing.

Research Report/Presentation S2-0-8d, 8g, 9c, 9f

Students or student groups prepare and present their research findings with

- written reports
- oral presentations
- newspaper articles
- dramatic presentations
- posters
- bulletin board displays
- multimedia presentations

Journal Writing S2-0-7f

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

SUGGESTED LEARNING RESOURCES

In Motion

- Ch. 6 Braking
 Investigation #6—Braking Distance
 Challenge—The Effects of Friction on Braking

Science 10

- 9.11 Career Profile: Marilyn Reynolds, Police Constable

Science Power 10

- Investigation 11-D: Hit the Brakes!

SYSTH

- 3.15 Rotational Cooperative Graffiti
 10.24 Compare and Contrast
 11.11 Category Concept Map
 13.21 Journal Evaluation
 14.12 Lab Report Format

Appendices

- 6.1 Rubric for the Assessment of Class Presentations
 6.2 Rubric for the Assessment of a Research Project
 6.4 Lab Report Assessment

(continued)

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p><i>(continued)</i></p> <p>S2-3-11 Investigate the factors that influence braking distance.</p> <p>Include: reaction time, friction, condition of driver, speed</p> <p>GLO: C2, C3, C6, D4</p>

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

Journal Writing S2-0-7f

Students create a Category Concept Map of the factors that influence braking distance (see *SYSTH* 11.11).

Collaborative Teamwork S2-0-4a, 4f, 4g

Students work in teams to test each other's reaction time. Give the following instructions. Students hold a ruler vertically above their partner's outstretched hand between the thumb and forefinger. They drop the ruler and record the centimetre mark where the ruler is caught. The reaction time will be the square root of the distance divided by five (see Appendix 3.3: Force and Natural Motion).

Community Connection S2-0-8f

Law enforcement agencies and insurance companies are good sources of information about accident reconstruction and factors that influence braking distance. Invite a community member such as a law enforcement officer, driving instructor, or claims adjuster to come into the classroom and answer student-generated questions. Students could also visit the community members in the workplace. The questions could be prepared in advance so that appropriate topics are covered.

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Pencil-and-Paper Tasks

Students

- describe the relationship between reaction time and braking distance
- discuss the accuracy of the advertising slogan “Speed Kills”
- compare and contrast disc brakes with anti-lock brakes (see *SYSTH* 10.24)
- explain why drinking and driving don’t mix
- identify substances that, when ingested, will adversely affect reaction time
- predict the effect of increased speed on braking distance
- describe how an escape ramp on a mountain road could be designed to help trucks with failed brakes stop
- discuss why braking distance on a gravel road is greater than that on a paved road
- suggest why fast-moving airplanes use air brakes, rather than disc brakes, to stop more quickly

Appendix

3.3 Force and Natural Motion

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
<p><i>Students will...</i></p>	<p>(1 HOUR)</p>
<p>S2-3-12 Using the relationship among displacement, velocity, and friction ($d=kv^2$), calculate the braking distance of a motor vehicle. GLO: C2, C3, C5, C8</p>	<p>➤ Notes for Instruction</p> <p>The characteristics of friction for different surfaces are represented as a coefficient of friction. Students can calculate braking distances using the equation $d = kv^2$. A table of common coefficients is included in the Appendix. The equation should only be modeled in terms of the relationship with velocity and friction. That is, as the coefficient of friction decreases, the surface becomes more slippery and the vehicle takes longer to stop. A detailed discussion, including a mathematical analysis, is included in Appendix 7, Chapter 6 for the teacher. Hands-on activities and laboratory experiments will aid in student understanding of this concept.</p> <p>➤ Student Learning Activities</p> <p>Laboratory Activity S2-0-3b, 4b, 4e, 5a</p> <p>The braking distance lab can also be used to investigate the effects of friction. Students repeat the experiment but cover the surface of the table beneath the braking sled with body oil. Students compare the resulting graphs of the braking distance. The time it takes to assess a dangerous situation and then apply appropriate actions is called the <i>reaction time</i>. During the reaction time, a vehicle will cover a distance calculated by velocity x time. This distance must be added to the previously calculated braking distance to arrive at a true braking distance.</p> <p>Collaborative Teamwork S2-0-4f, 4g</p> <p>Student groups solve problems using the relationship among displacement, velocity, and friction ($d = kv^2$).</p> <p>Journal Writing S2-0-7f</p> <p>Students complete a fact- or issue-based article analysis of a current newspaper, Internet, or magazine article related to this learning outcome (see <i>SYSTH</i> 11.40, 11.41).</p>

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Laboratory Report S2-0-5b, 5c, 6a, 7a

Students interpret their laboratory results, and prepare a report describing their investigation findings (see *SYSTH* 14.12 for a lab report format). Word-processing, graphing, and spreadsheet software can be used for report writing.

Journal Writing S2-0-7f

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Pencil-and-Paper Tasks

Students

- solve problems using $d = kv^2$ to calculate the braking distance of a motor vehicle
- suggest why dragsters “boil” or “smoke” their tires on the track before a race
- use coefficients of friction to predict changes in braking distance as a car moves from dry to wet pavement
- explain how brakes use friction to stop a moving vehicle
- predict which has the lower coefficient of friction: an icy road or dry pavement

SUGGESTED LEARNING RESOURCES

In Motion

- Ch. 6 Braking
 Math Connection
 Total Stopping Distance
 Reaction Time
 The Final Challenge

SYSTH

- 11.40 Issue-Based Article Analysis
 11.41 Fact-Based Article Analysis
 13.21 Journal Evaluation
 14.12 Lab Report Format

Appendix

- 6.4 Lab Report Assessment

PRESCRIBED LEARNING OUTCOMES
<i>Students will...</i>
<p>S2-3-13 Use the decision-making process to address an STSE issue related to safe driving conditions.</p> <p><i>Examples: adverse driving conditions, reaction time, narcotic influences such as blood alcohol level, excessive vehicle speed...</i></p> <p>GLO: B3, C4, C5, C8</p>

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➤ **Entry-Level Knowledge**

Students will have knowledge of STSE issues related to safe driving conditions from personal experience, as well as from the media.

➤ **Notes for Instruction**

Guide students through the steps of the Decision-Making Model (see the *Senior 2 Science Framework* and the Manitoba Foundations for Scientific Literacy section at the front of this document). Model the process, guide students, and provide opportunities for practice. Other Senior 2 clusters will provide more opportunities for decision making.

There are many websites that are devoted to driver/road safety including <www.mpi.mb.ca> and <www.hwysafety.org>. See Chapter 4 of *SYSTH* for strategies to use when exploring STSE issues. An activity such as an Anticipation Guide can be used to probe controversial STSE issues (see *SYSTH* 9.20).

➤ **Student Learning Activities**

Student Research/Collaborative Teamwork

S2-0-1c, 3e, 3f, 4e

Student groups develop public awareness campaigns to address STSE issues related to safe driving conditions. Topics can include

- drinking and driving
- speeding
- adjusting to icy road conditions
- driver fatigue
- cellphone use
- defensive driving

Case studies, newspaper articles, and Internet sources can be used.

Debate S2-0-3d, 7c, 7d, 7e

Students research and debate statements such as

- speed limits on Manitoba highways should be raised
- cellphone use by drivers should not be permitted
- all new drivers must take a Driver’s Education course

(continued)

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

See Appendix 6 for a variety of rubrics and checklists that can be used for self-, peer-, and teacher-assessment.

Research Report/Presentation S2-0-6d, 9c, 9e, 9f

Student groups present their public awareness campaigns using

- television/radio commercials
- cartoons
- posters
- pamphlets
- brochures
- bulletin board displays
- newspaper/magazine advertisements

Journal Writing S2-0-7f

Assess journal entries using a Journal Evaluation form (see *SYSTH* 13.21).

Pencil-and-Paper Tasks

Students

- describe the effect alcohol has on the human body and discuss implications for safe driving
- outline Manitoba's legislation regarding graduated driver licensing and discuss whether they support this approach
- suggest specific driving behaviours that can reduce the risk of accident when driving on gravel, wet, or icy roads
- explain how prescription drugs can affect a driver
- discuss the pros and cons of prohibiting cellphone use by drivers
- explain whether drinking coffee will sober a drunk driver
- outline Manitoba's legislation with respect to child car seats
- explain why tailgating is a dangerous driving practice
- describe what is meant by the "No-Zone"

SUGGESTED LEARNING RESOURCES

In Motion

Ch. 7 Driving Responsibility

Case Study #1

Case Study #2

Science 10

9.1 Explore an Issue: Progress and Speed on our Highways

9.8 Case Study: Smart Highways

9.11 Career Profile: Marilyn Reynolds, Police Constable

10.1 Explore an Issue: Traveling Off-Road

Unit 3 Challenge: Scientific Perspectives on Motion-Driver Training

Science Power 10

Investigation 12-C: Speeding, Safety, and Modern Life

Unit 3 Project: High-Tech Highway

Unit 3 Issue Analysis: Who's in the Driving Seat?

SYSTH

Chapter 4: Science-Technology-Society-Environment Connections

9.20 Anticipation Guide

13.21 Journal Evaluation

Appendices

6.1 Rubric for the Assessment of Class Presentations

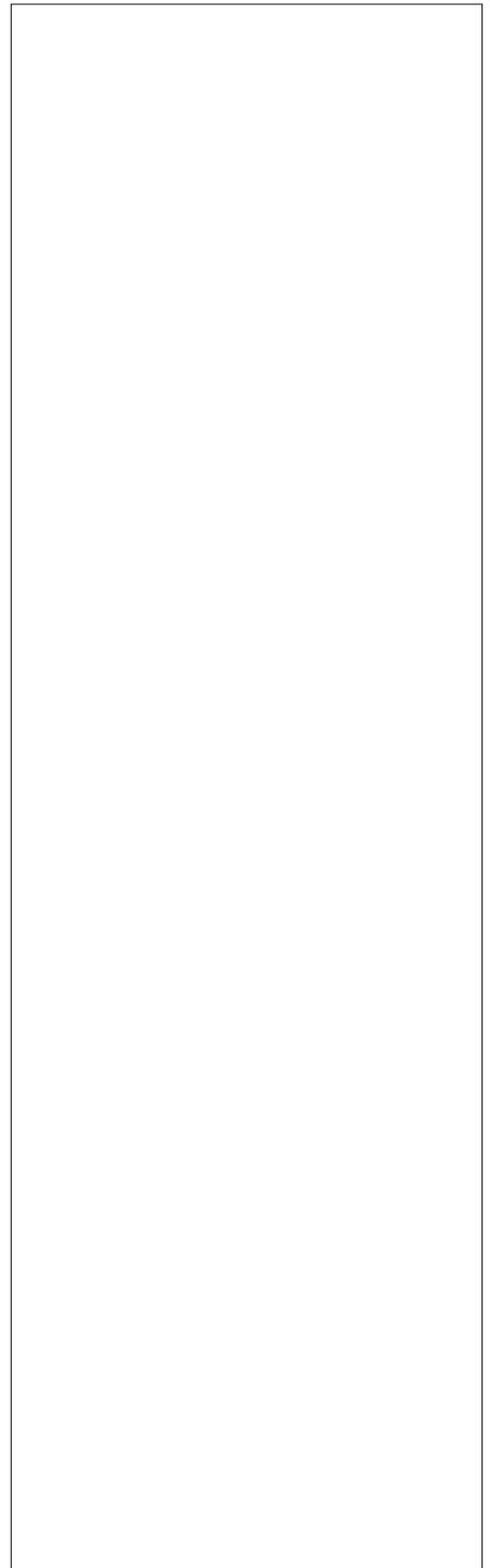
6.2 Rubric for the Assessment of a Research Project

6.3 Rubric for the Assessment of a Decision-Making Process Activity

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION (3 HOURS)
<p data-bbox="105 268 293 300"><i>Students will...</i></p> <p data-bbox="105 331 245 363"><i>(continued)</i></p> <p data-bbox="105 390 524 489">S2-3-13 Use the decision-making process to address an STSE issue related to safe driving conditions.</p> <p data-bbox="105 506 513 642"><i>Examples: adverse driving conditions, reaction time, narcotic influences such as blood alcohol level, excessive vehicle speed...</i></p> <p data-bbox="105 657 367 688">GLO: B3, C4, C5, C8</p>	<p data-bbox="651 327 1062 359">Community Connection S2-0-8f</p> <p data-bbox="651 375 1369 474">Invite a law enforcement officer to give a presentation to the class addressing an STSE issue related to safe driving conditions.</p> <p data-bbox="651 516 967 548">Journal Writing S2-0-7f</p> <p data-bbox="651 564 1349 632">Students reflect on how their driving habits can affect their safety and the safety of others.</p>

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

A large, empty rectangular box with a thin black border, intended for listing suggested learning resources. It occupies the right half of the page below the header.

NOTES