Science 1206

Curriculum Guide 2018

Newfoundland Labrador

Education and Early Childhood Development

Department of Education and Early Childhood Development Mission Statement

The Department of Education and Early Childhood Development will improve provincial early childhood learning and the K-12 education system to further opportunities for the people of Newfoundland and Labrador.

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Acknowledgements

The Department of Education and Early Childhood Development gratefully acknowledges the contribution of the following individuals in the development of the *Science 1206 Curriculum Guide (2018):*

Amanda Craig
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NLESD - Western Regional Office

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Section One: Newfoundland and Labrador Curriculum

Introduction

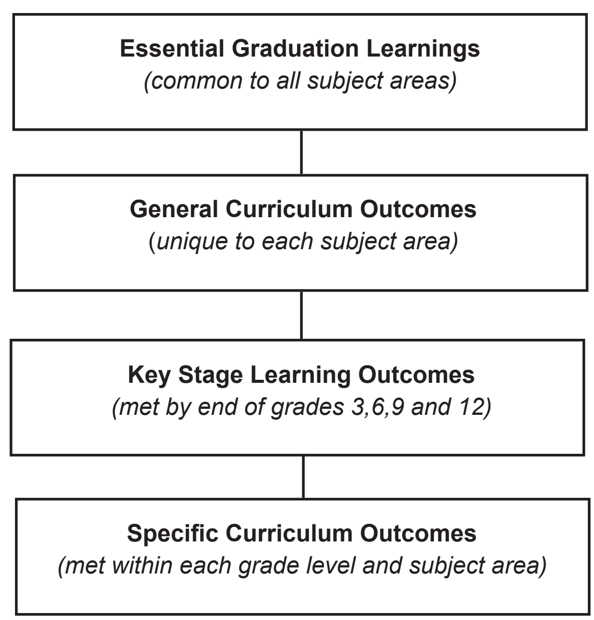
There are multiple factors that impact education: technological developments, increased emphasis on accountability, and globalization. These factors point to the need to consider carefully the education students receive.

The Newfoundland and Labrador Department of Education and Early Childhood Development believes that curriculum design with the following characteristics will help teachers address the needs of students served by the provincially prescribed curriculum:

- Curriculum guides must clearly articulate what students are expected to know and be able to do by the time they graduate from high school.
- There must be purposeful assessment of students' performance in relation to the curriculum outcomes.

Outcomes Based Education

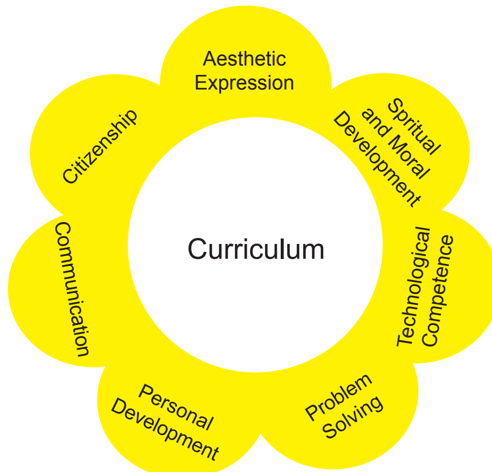
The K-12 curriculum in Newfoundland and Labrador is organized by outcomes and is based on *The Atlantic Canada Framework for Essential Graduation Learning in Schools* (1997). This framework consists of Essential Graduation Learnings (EGLs), General Curriculum Outcomes (GCOs), Key Stage Curriculum Outcomes (KSCOs) and Specific Curriculum Outcomes (SCOs).



Essential Graduation Learnings

EGLs provide vision for the development of a coherent and relevant curriculum. They are statements that offer students clear goals and a powerful rationale for education. The EGLs are delineated by general, key stage, and specific curriculum outcomes.

EGLs describe the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the EGLs will prepare students to continue to learn throughout their lives. EGLs describe expectations, not in terms of individual subject areas, but in terms of knowledge, skills, and attitudes developed throughout the K-12 curriculum. They confirm that students need to make connections and develop abilities across subject areas if they are to be ready to meet the shifting and ongoing demands of life, work, and study.



Aesthetic Expression – Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.

Citizenship – Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.

Communication – Graduates will be able to use the listening, viewing, speaking, reading and writing modes of language(s), and mathematical and scientific concepts and symbols, to think, learn and communicate effectively.

Problem Solving – Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, and mathematical and scientific concepts.

Personal Development – Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.

Spiritual and Moral Development – Graduates will demonstrate understanding and appreciation for the place of belief systems in shaping the development of moral values and ethical conduct.

Technological Competence – Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.

Curriculum Outcomes

Curriculum outcomes are statements that articulate what students are expected to know and be able to do in each program area in terms of knowledge, skills, and attitudes.

Curriculum outcomes may be subdivided into General Curriculum Outcomes, Key Stage Curriculum Outcomes, and Specific Curriculum Outcomes.

General Curriculum Outcomes (GCOs)

Each program has a set of GCOs which describe what knowledge, skills, and attitudes students are expected to demonstrate as a result of their cumulative learning experiences within a subject area. GCOs serve as conceptual organizers or frameworks which guide study within a program area. Often, GCOs are further delineated into KSCOs.

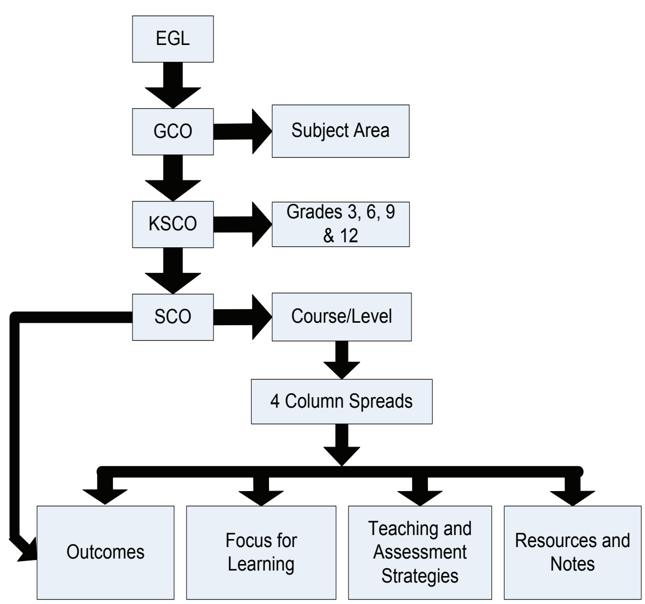
Key Stage Curriculum Outcomes (KSCOs)

Key Stage Curriculum Outcomes (KSCOs) summarize what is expected of students at each of the four key stages of grades three, six, nine, and twelve.

Specific Curriculum Outcomes (SCOs)

SCOs set out what students are expected to know and be able to do as a result of their learning experiences in a course, at a specific grade level. In some program areas, SCOs are further articulated into delineations. *It is expected that all SCOs will be addressed during the course of study covered by the curriculum guide.*

EGLs to Curriculum Guides



Context for Teaching and Learning

Teachers are responsible to help students achieve outcomes. This responsibility is a constant in a changing world. As programs change over time so does educational context. Several factors make up the educational context in Newfoundland and Labrador today: inclusive education, support for gradual release of responsibility teaching model, focus on literacy and learning skills in all programs, and support for education for sustainable development.

Inclusive Education

Valuing Equity and Diversity

Effective inclusive schools have the following characteristics: supportive environment, positive relationships, feelings of competence, and opportunities to participate. (The Centre for Inclusive Education, 2009)

All students need to see their lives and experiences reflected in their school community. It is important that the curriculum reflect the experiences and values of all genders and that learning resources include and reflect the interests, achievements, and perspectives of all students. An inclusive classroom values the varied experiences and abilities as well as social and ethno-cultural backgrounds of all students while creating opportunities for community building. Inclusive policies and practices promote mutual respect, positive interdependencies, and diverse perspectives. Learning resources should include a range of materials that allow students to consider many viewpoints and to celebrate the diverse aspects of the school community.

Differentiated Instruction

Differentiated instruction is a teaching philosophy based on the premise that teachers should adapt instruction to student differences. Rather than marching students through the curriculum lockstep, teachers should modify their instruction to meet students' varying readiness levels, learning preferences, and interests. Therefore, the teacher proactively plans a variety of ways to 'get it' and express learning. (Carol Ann Tomlinson, 2008)

Curriculum is designed and implemented to provide learning opportunities for all students according to abilities, needs, and interests. Teachers must be aware of and responsive to the diverse range of learners in their classes. Differentiated instruction is a useful tool in addressing this diversity.

Differentiated instruction responds to different readiness levels, abilities, and learning profiles of students. It involves actively planning so that the process by which content is delivered, the way the resource is used, and the products students create are in response to the teacher's knowledge of whom he or she is interacting with. Learning environments should be flexible to accommodate various learning preferences of the students. Teachers continually make decisions about selecting teaching strategies and structuring learning activities that provide all students with a safe and supportive place to learn and succeed.

Planning for Differentiation

Create a dynamic classroom	• present authentic and relevant communication situations • manage routines and class organization • provide realistic and motivating classroom experiences
Vary teaching strategies	• allow students to construct meaning and connect, collaborate and communicate with each other in a positive learning community • form essential links between the text and the students
Respond to student differences	• allow students to make relevant and meaningful choices • provide students ownership of learning goals • empower students through a gradual release of responsibility • allow students multiple ways to demonstrate their learning

Differentiating the Content

Differentiating content requires teachers to pre-assess students to identify those who require prerequisite instruction, as well as those who have already mastered the concept and may therefore apply strategies learned to new situations. Another way to differentiate content is to permit students to adjust the pace at which they progress through the material. Some students may require additional time while others will move through at an increased pace and thus create opportunities for enrichment or more indepth consideration of a topic of particular interest.

Teachers should consider the following examples of differentiating content:

- Meet with small groups to reteach an idea or skill or to extend the thinking or skills.
- Present ideas through auditory, visual, and tactile means.
- Use reading materials such as novels, websites, and other reference materials at varying reading levels.

Differentiating the Process

Differentiating the process involves varying learning activities or strategies to provide appropriate methods for students to explore and make sense of concepts. A teacher might assign all students the same product (e.g., presenting to peers) but the process students use to create the presentation may differ. Some students could work in groups while others meet with the teacher individually. The same assessment criteria can be used for all students.

Teachers should consider flexible grouping of students such as whole class, small group, or individual instruction. Students can be grouped according to their learning styles, readiness levels, interest areas, and/or the requirements of the content or activity presented. Groups should be formed for specific purposes and be flexible in composition and short-term in duration.

Teachers should consider the following examples of differentiating the process:

- Offer hands-on activities for students.
- Provide activities and resources that encourage students to further explore a topic of particular interest.
- Use activities in which all learners work with the same learning outcomes but proceed with different levels of support, challenge, or complexity.

Differentiating the Product

Differentiating the product involves varying the complexity and type of product that students create to demonstrate learning outcomes. Teachers provide a variety of opportunities for students to demonstrate and show evidence of what they have learned.

Teachers should give students options to demonstrate their learning (e.g., create an online presentation, write a letter, or develop a mural). This will lead to an increase in student engagement.

Differentiating the Learning Environment

The learning environment includes the physical and the affective tone or atmosphere in which teaching and learning take place, and can include the noise level in the room, whether student activities are static or mobile, or how the room is furnished and arranged. Classrooms may include tables of different shapes and sizes, space for quiet individual work, and areas for collaboration.

Teachers can divide the classroom into sections, create learning centres, or have students work both independently and in groups. The structure should allow students to move from whole group, to small group, pairs, and individual learning experiences and support a variety of ways to engage in learning. Teachers should be sensitive and alert to ways in which the classroom environment supports their ability to interact with students.

Teachers should consider the following examples of differentiating the learning environment:

- Develop routines that allow students to seek help when teachers are with other students and cannot provide immediate attention.
- Ensure there are places in the room for students to work quietly and without distraction, as well as places that invite student collaboration.
- Establish clear guidelines for independent work that match individual needs.
- Provide materials that reflect diversity of student background, interests, and abilities.

The physical learning environment must be structured in such a way that all students can gain access to information and develop confidence and competence.

Meeting the Needs of Students with Exceptionalities

All students have individual learning needs. Some students, however, have exceptionalities (defined by the Department of Education and Early Childhood Development) which impact their learning. The majority of students with exceptionalities access the prescribed curriculum. For details of these exceptionalities see www.gov.nl.ca/edu/k12/studentsupportservices/exceptionalities.html

Supports for these students may include

1. Accommodations
2. Modified Prescribed Courses
3. Alternate Courses
4. Alternate Programs
5. Alternate Curriculum

For further information, see Service Delivery Model for Students with Exceptionalities at www.cdli.ca/sdm/

Classroom teachers should collaborate with instructional resource teachers to select and develop strategies which target specific learning needs.

Meeting the Needs of Students who are Highly Able
(includes gifted and talented)

Some students begin a course or topic with a vast amount of prior experience and knowledge. They may know a large portion of the material before it is presented to the class or be capable of processing it at a rate much faster than their classmates. All students are expected to move forward from their starting point. Many elements of differentiated instruction are useful in addressing the needs of students who are highly able.

Teachers may

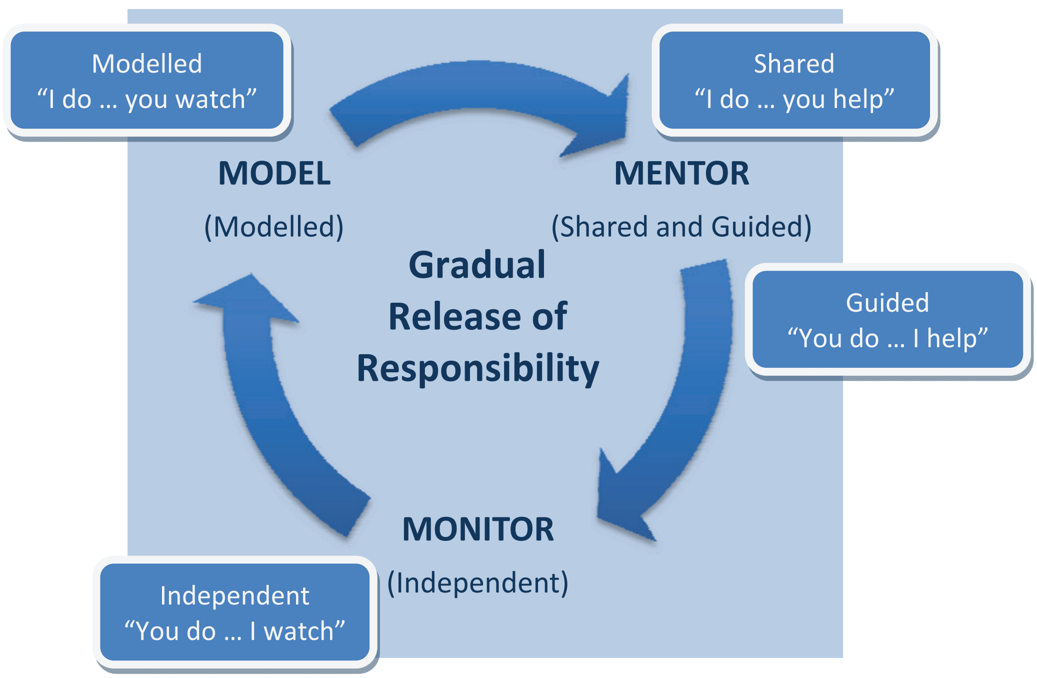
- assign independent study to increase depth of exploration in an area of particular interest;
- compact curriculum to allow for an increased rate of content coverage commensurate with a student's ability or degree of prior knowledge;
- group students with similar abilities to provide the opportunity for students to work with their intellectual peers and elevate discussion and thinking, or delve deeper into a particular topic; and
- tier instruction to pursue a topic to a greater depth or to make connections between various spheres of knowledge.

Highly able students require the opportunity for authentic investigation to become familiar with the tools and practices of the field of study. Authentic audiences and tasks are vital for these learners. Some highly able learners may be identified as gifted and talented in a particular domain. These students may also require supports through the Service Delivery Model for Students with Exceptionalities.

Gradual Release of Responsibility

Teachers must determine when students can work independently and when they require assistance. In an effective learning environment, teachers choose their instructional activities to model and scaffold composition, comprehension, and metacognition that is just beyond the students' independence level. In the gradual release of responsibility approach, students move from a high level of teacher support to independent work. If necessary, the teacher increases the level of support when students need assistance. The goal is to empower students with their own learning strategies, and to know how, when, and why to apply them to support their individual growth. Guided practice supports student independence. As a student demonstrates success, the teacher should gradually decrease his or her support.

Gradual Release of Responsibility Model



Literacy

"Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society". To be successful, students require a set of interrelated skills, strategies and knowledge in multiple literacies that facilitate their ability to participate fully in a variety of roles and contexts in their lives, in order to explore and interpret the world and communicate meaning. (The Plurality of Literacy and its Implications for Policies and Programmes, 2004, p.13)

Literacy is

- a process of receiving information and making meaning from it; and
- the ability to identify, understand, interpret, communicate, compute, and create text, images, and sounds.

Literacy development is a lifelong learning enterprise beginning at birth that involves many complex concepts and understandings. It is not limited to the ability to read and write; no longer are we exposed only to printed text. It includes the capacity to learn to communicate, read, write, think, explore, and solve problems. Individuals use literacy skills in paper, digital, and live interactions to engage in a variety of activities:

- Analyze critically and solve problems.
- Comprehend and communicate meaning.
- Create a variety of texts.
- Make connections both personally and inter-textually.
- Participate in the socio-cultural world of the community.
- Read and view for enjoyment.
- Respond personally.

These expectations are identified in curriculum documents for specific subject areas as well as in supporting documents, such as *Cross-Curricular Reading Tools* (CAMET).

With modelling, support, and practice, students' thinking and understandings are deepened as they work with engaging content and participate in focused conversations.

Reading in the Content Areas

The focus for reading in the content areas is on teaching strategies for understanding content. Teaching strategies for reading comprehension benefits all students as they develop transferable skills that apply across curriculum areas.

When interacting with different texts, students must read words, view and interpret text features, and navigate through information presented in a variety of ways including, but not limited to

Advertisements	Movies	Poems
Blogs	Music videos	Songs
Books	Online databases	Speeches
Documentaries	Plays	Video games
Magazine articles	Podcasts	Websites

Students should be able to interact with and comprehend different texts at different levels.

There are three levels of text comprehension:

- Independent level – Students are able to read, view, and understand texts without assistance.
- Instructional level – Students are able to read, view, and understand most texts but need assistance to fully comprehend some texts.
- Frustration level – Students are not able to read or view with understanding (i.e., texts may be beyond their current reading level).

Teachers will encounter students working at all reading levels in their classrooms and will need to differentiate instruction to meet their needs. For example, print texts may be presented in audio form, physical movement may be associated with synthesizing new information with prior knowledge, or graphic organizers may be created to present large amounts of print text in a visual manner.

When interacting with information that is unfamiliar to students, it is important for teachers to monitor how effectively students are using strategies to read and view texts:

- Analyze and think critically about information.
- Determine importance to prioritize information.
- Engage in questioning before, during, and after an activity related to a task, text, or problem.
- Make inferences about what is meant but not said.
- Make predictions.
- Synthesize information to create new meaning.
- Visualize ideas and concepts.

Learning Skills for Generation Next

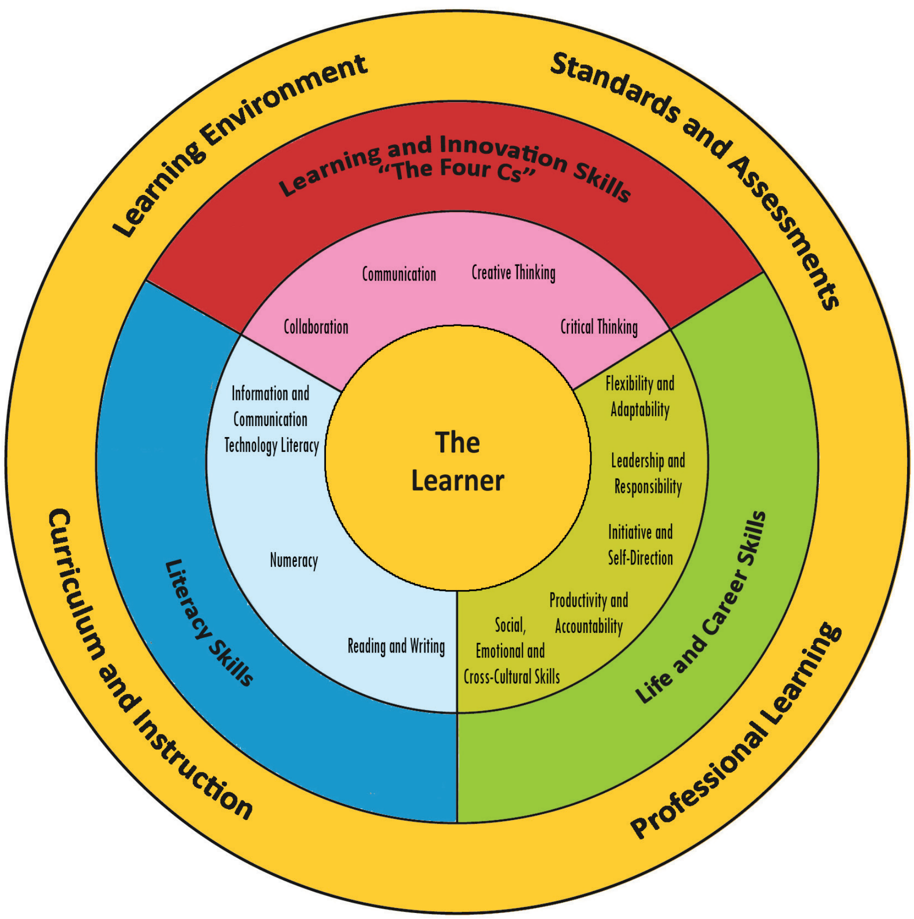
Generation Next is the group of students who have not known a world without personal computers, cell phones, and the Internet. They were born into this technology. They are digital natives.

Students need content and skills to be successful. Education helps students learn content and develop skills needed to be successful in school and in all learning contexts and situations. Effective learning environments and curricula challenge learners to develop and apply key skills within the content areas and across interdisciplinary themes.

Learning Skills for Generation Next encompasses three broad areas:

- Learning and Innovation Skills enhance a person's ability to learn, create new ideas, problem solve, and collaborate.
- Life and Career Skills address leadership, and interpersonal and affective domains.
- Literacy Skills develop reading, writing, and numeracy, and enhance the use of information and communication technology.

The diagram below illustrates the relationship between these areas. A 21st century curriculum employs methods that integrate innovative and research-driven teaching strategies, modern learning technologies, and relevant resources and contexts.



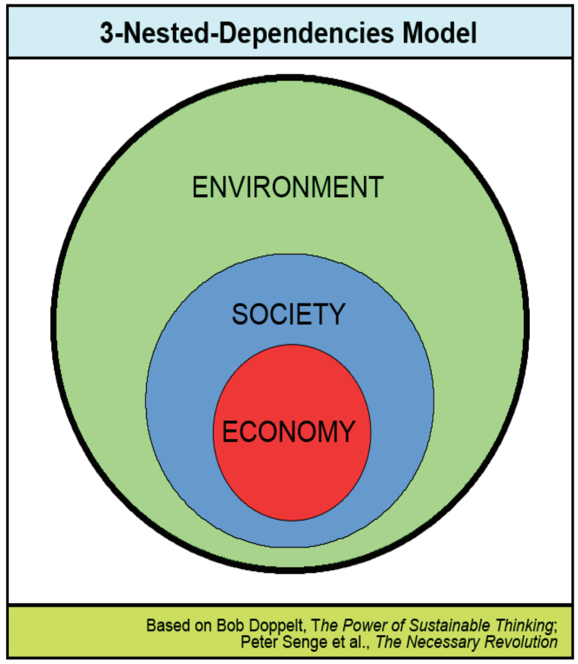
Support for students to develop these abilities and skills is important across curriculum areas and should be integrated into teaching, learning, and assessment strategies. Opportunities for integration of these skills and abilities should be planned with engaging and experiential activities that support the gradual release of responsibility model. For example, lessons in a variety of content areas can be infused with learning skills for Generation Next by using open-ended questioning, role plays, inquiry approaches, self-directed learning, student role rotation, and Internet-based technologies.

All programs have a shared responsibility in developing students' capabilities within all three skill areas.

Education for Sustainable Development

Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". (Our Common Future, 43)

Sustainable development is comprised of three integrally connected areas: economy, society, and environment.



As conceived by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) the overall goal of Education for Sustainable Development (ESD) is to integrate the knowledge, skills, values, and perspectives of sustainable development into all aspects of education and learning. Changes in human behaviour should create a more sustainable future that supports environmental integrity and economic viability, resulting in a just society for all generations.

ESD involves teaching *for* rather than teaching *about* sustainable development. In this way students develop the skills, attitudes, and perspectives to meet their present needs without compromising the ability of future generations to meet their needs.

Within ESD, the knowledge component spans an understanding of the interconnectedness of our political, economic, environmental, and social worlds, to the role of science and technology in the development of societies and their impact on the environment. The skills necessary include being able to assess bias, analyze consequences of choices, ask questions, and solve problems. ESD values and perspectives include an appreciation for the interdependence of all life forms, the importance of individual responsibility and action, an understanding of global issues as well as local issues in a global context. Students need to be aware that every issue has a history, and that many global issues are linked.

Assessment and Evaluation

Assessment

Assessment is the process of gathering information on student learning.

How learning is assessed and evaluated and how results are communicated send clear messages to students and others about what is valued.

Assessment instruments are used to gather information for evaluation. Information gathered through assessment helps teachers determine students' strengths and needs, and guides future instruction.

Teachers are encouraged to be flexible in assessing student learning and to seek diverse ways students might demonstrate what they know and are able to do.

Evaluation involves the weighing of the assessment information against a standard in order to make a judgement about student achievement.

Assessment can be used for different purposes:

1. Assessment *for* learning guides and informs instruction.
2. Assessment *as* learning focuses on what students are doing well, what they are struggling with, where the areas of challenge are, and what to do next.
3. Assessment *of* learning makes judgements about student performance in relation to curriculum outcomes.

1. Assessment for Learning

Assessment *for* learning involves frequent, interactive assessments designed to make student learning visible. This enables teachers to identify learning needs and adjust teaching accordingly. Assessment *for* learning is not about a score or mark; it is an ongoing process of teaching and learning:

- Pre-assessments provide teachers with information about what students already know and can do.
- Self-assessments allow students to set goals for their own learning.
- Assessment *for* learning provides descriptive and specific feedback to students and parents regarding the next stage of learning.
- Data collected during the learning process from a range of tools enables teachers to learn as much as possible about what a student knows and is able to do.

2. Assessment as Learning

Assessment *as* learning involves students' reflecting on their learning and monitoring their own progress. It focuses on the role of the student in developing metacognition and enhances engagement in their own learning. Students can

- analyze their learning in relation to learning outcomes,
- assess themselves and understand how to improve performance,
- consider how they can continue to improve their learning, and
- use information gathered to make adaptations to their learning processes and to develop new understandings.

3. Assessment of Learning

Assessment *of* learning involves strategies designed to confirm what students know in terms of curriculum outcomes. It also assists teachers in determining student proficiency and future learning needs. Assessment *of* learning occurs at the end of a learning experience and contributes directly to reported results. Traditionally, teachers relied on this type of assessment to make judgements about student performance by measuring learning after the fact and then reporting it to others. Used in conjunction with the other assessment processes previously outlined, assessment *of* learning is strengthened. Teachers can

- confirm what students know and can do;
- report evidence to parents/guardians, and other stakeholders, of student achievement in relation to learning outcomes; and
- report on student learning accurately and fairly using evidence obtained from a variety of contexts and sources.

Involving Students in the Assessment Process

Students should know what they are expected to learn as outlined in the specific curriculum outcomes of a course as well as the criteria that will be used to determine the quality of their achievement. This information allows students to make informed choices about the most effective ways to demonstrate what they know and are able to do.

It is important that students participate actively in assessment by co-creating criteria and standards which can be used to make judgements about their own learning. Students may benefit from examining various scoring criteria, rubrics, and student exemplars.

Students are more likely to perceive learning as its own reward when they have opportunities to assess their own progress. Rather than asking teachers, "What do you want?", students should be asking themselves questions:

- What have I learned?
- What can I do now that I couldn't do before?
- What do I need to learn next?

Assessment must provide opportunities for students to reflect on their own progress, evaluate their learning, and set goals for future learning.

Assessment Tools

In planning assessment, teachers should use a broad range of tools to give students multiple opportunities to demonstrate their knowledge, skills, and attitudes. The different levels of achievement or performance may be expressed as written or oral comments, ratings, categorizations, letters, numbers, or as some combination of these forms.

The grade level and the activity being assessed will inform the types of assessment tools teachers will choose:

Anecdotal Records	Photographic Documentation
Audio/Video Clips	Podcasts
Case Studies	Portfolios
Checklists	Presentations
Conferences	Projects
Debates	Questions
Demonstrations	Quizzes
Exemplars	Role Plays
Graphic Organizers	Rubrics
Journals	Self-assessments
Literacy Profiles	Tests
Observations	Wikis

Assessment Guidelines

Assessments should measure what they intend to measure. It is important that students know the purpose, type, and potential marking scheme of an assessment. The following guidelines should be considered:

- Collect evidence of student learning through a variety of methods; do not rely solely on tests and paper and pencil activities.
- Develop a rationale for using a particular assessment of learning at a specific point in time.
- Provide descriptive and individualized feedback to students.
- Provide students with the opportunity to demonstrate the extent and depth of their learning.
- Set clear targets for student success using learning outcomes and assessment criteria.
- Share assessment criteria with students so that they know the expectations.

Evaluation

Evaluation is the process of analyzing, reflecting upon, and summarizing assessment information, and making judgements or decisions based on the information gathered. Evaluation is conducted within the context of the outcomes, which should be clearly understood by learners before teaching and evaluation take place. Students must understand the basis on which they will be evaluated and what teachers expect of them.

During evaluation, the teacher interprets the assessment information, makes judgements about student progress, and makes decisions about student learning programs.

Section Two: Curriculum Design

Rationale

The vision of science education in Newfoundland and Labrador is to develop scientific literacy.

> *Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem solving, and decision making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them.*

To develop scientific literacy, students require diverse learning experiences which provide opportunities to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment that will affect their personal lives, careers, and futures.

Science education which strives for scientific literacy must engage students in science inquiry, problem solving, and decision making.

Science Inquiry

Science inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as “the” scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analyzing data, and interpreting data are fundamental to engaging in science. These skills are often represented as a cycle which involves the posing of questions, the generation of possible explanations, and the collection of evidence to determine which of these explanations is most useful in accounting for the phenomenon under investigation. Teachers should engage students in science inquiry activities to develop these skills.

Problem Solving

Problem solving involves seeking solutions to human problems. It may be represented as a cycle consisting of the proposing, creating, and testing of prototypes, products, and techniques in and attempt to reach an optimum solution to a given problem. The skills involved in this cycle facilitate a process which has different aims and procedures from science inquiry. Students should be given opportunities to propose, perform, and evaluate solutions to problem solving or technological tasks.

Decision Making

Decision making involves determining what we should do in a particular context or in response to a given situation. Increasingly, the types of problems that we deal with, both individually and collectively, require an understanding of the processes and products of science and technology. The process of decision making involves identification of the problem or situation, generation of possible solutions or courses of action, evaluation of the alternatives, and a thoughtful decision based on the information available. Students should be actively involved in decision making situations. While important in their own right, decision making situations also provide a relevant context for engaging in science inquiry and/or problem solving.

Curriculum Outcomes Framework

The foundation of the curriculum outcomes framework are the general curriculum outcomes (GCOs). Four general curriculum outcomes have been identified to delineate the four critical aspects of students' scientific literacy: science, technology, society, and the environment (STSE), skills, knowledge, and attitudes. These four GCOs are common to all science courses.

General Curriculum Outcomes

GCO 1: Science, Technology, Society, and the Environment

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

GCO 2: Skills

Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

GCO 3: Knowledge

Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

GCO 4: Attitudes

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Key Stage Curriculum Outcomes

Key stage curriculum outcomes (KSCOs) align with the GCOs and summarize what students are expected to know and be able to do by the end of Grade 12.

GCO 1: STSE

By the end of Grade 12, students will be expected to

- describe and explain disciplinary and interdisciplinary processes used to understand natural phenomena and develop technological solutions
- distinguish between science and technology in terms of their respective goals, products, and values, and describe the development of scientific theories and technologies over time
- analyze and explain how science and technology interact with and advance one another
- analyze how individuals, society, and the environment are interdependent with scientific and technological endeavours
- evaluate social issues related to the applications and limitations of science and technology, and explain decisions in terms of advantages and disadvantages for sustainability ,considering a variety of perspectives

GCO 2: Skills

By the end of Grade 12, students will be expected to

- ask questions about observed relationships and plan investigations of questions, ideas, problems, and issues
- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information
- analyze data and apply mathematical and conceptual models to develop and assess possible explanations
- work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

GCO 3: Knowledge

By the end of Grade 12, students will be expected to

Earth and Space science

- demonstrate an understanding of the nature and diversity of energy sources and matter in the universe
- describe and predict the nature and effects of changes to terrestrial systems
- demonstrate an understanding of the relationships among systems responsible for changes to Earth's surface

Chemistry

- identify and explain the diversity of organic compounds and their impact on the environment
- demonstrate an understanding of the characteristics and interactions of acids and bases
- illustrate and explain the various forces that hold structures together at the molecular level, and relate the properties of matter to its structure
- use the redox theory in a variety of contexts related to electrochemistry
- demonstrate an understanding of solutions and stoichiometry in a variety of contexts

Physics

- analyze and describe relationships between force and motion
- analyze interactions within systems, using the laws of conservation of energy and momentum
- predict and explain interactions between waves and with matter, using the characteristics of waves
- explain the fundamental forces of nature, using characteristics of gravitational, electric, and magnetic fields
- analyze and describe different means of energy transmission and transformation

Life science

- compare and contrast the reproduction and development of representative organisms
- determine how cells use matter and energy to maintain organization necessary for life
- demonstrate an understanding of the structure and function of genetic materials
- analyze the patterns and products of evolution
- compare and contrast mechanisms used by organisms to maintain homoeostasis
- evaluate relationships that affect the biodiversity and sustainability of life within the biosphere

GCO 4: Attitudes

By the end of Grade 12, students will be expected to

- value the role and contributions of science and technology in our understanding of phenomena that are directly observable and those that are not
- appreciate that the applications of science and technology can raised ethical dilemmas
- value the contributions to scientific and technological developments made by individuals from many societies and cultural backgrounds
- show a continuing and more informed curiosity and interest in science and science-related issues
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research
- consider further studies and careers in science- and technology-related fields
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations
- use factual information and rational explanations when analyzing and evaluating
- value the processes for drawing conclusions
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas
- have a sense of personal and shared responsibility for maintaining a sustainable environment
- project the personal and shared social, and environmental consequences of proposed action
- want to take action for maintaining a sustainable environment
- show concern for safety and accept the need for rules and regulations
- be aware of the direct and indirect consequences of their actions

Specific Curriculum Outcomes

Specific curriculum outcomes (SCOs) align to KSCOs and GCOs and describe what students should know and be able to do at the end of each course. They are intended to serve as the focus for the design of learning experiences and assessment tasks. SCOs are organized into units for each science course.

Course Overview

Science 1206 is the final common course of the Newfoundland and Labrador science program. Similar to Science 1-9, it contains one Earth or space science unit, one life science unit, and two physical science units. These content units represent the final four pieces of the common K-10 science framework.

SCOs for Science 1206 have been organized into five units:

- Integrated Skills
- Weather Dynamics
- Chemical Reactions
- Motion
- Sustainability of Ecosystems

Note, the Integrated Skills unit (Unit i) is not intended to be taught as a separate, stand alone unit.

Suggested Yearly Plan

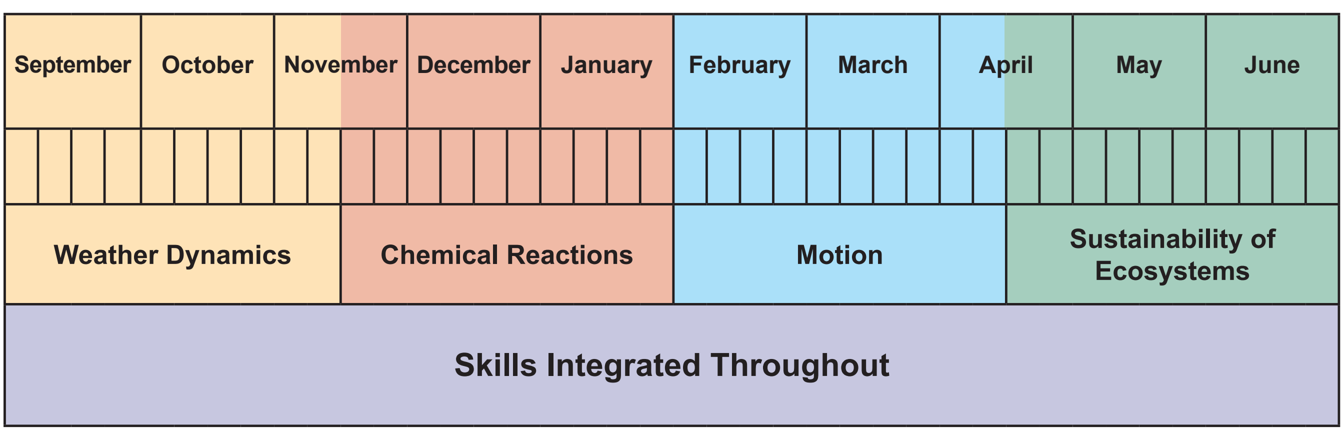
The order in which units are presented in the curriculum guide is the recommended sequence. Each unit is of equal value.

Unit 1 - Weather Dynamics

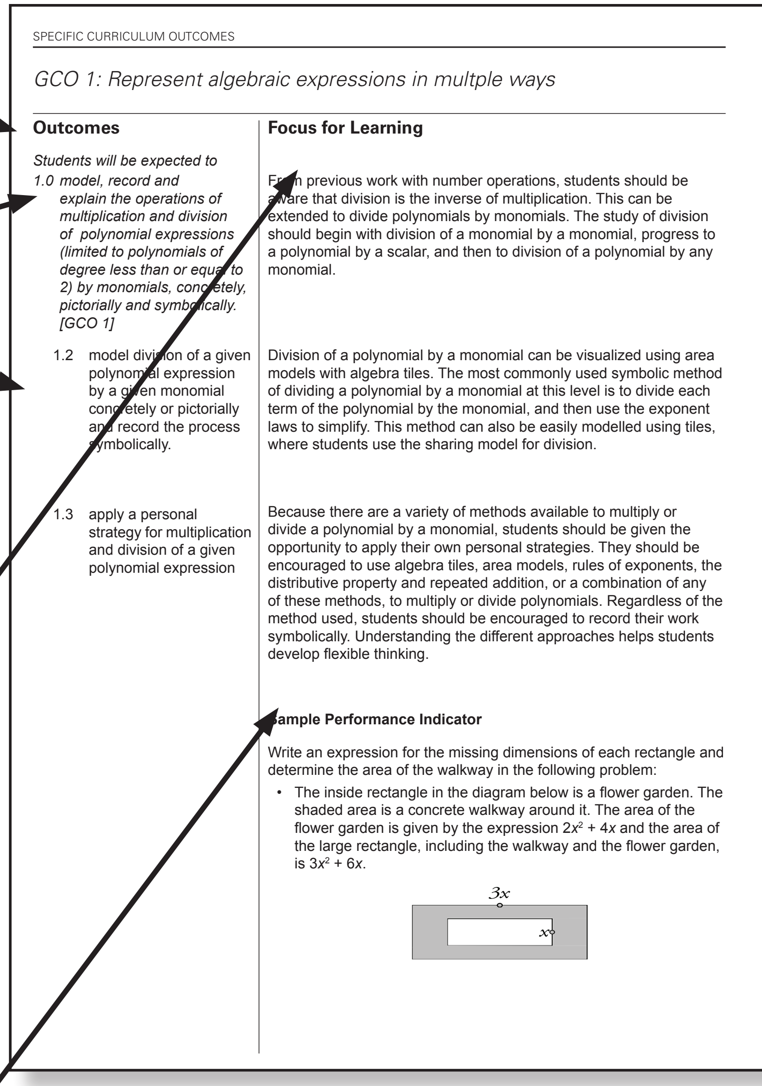
Unit 2 - Chemical Reactions

Unit 3 - Motion

Unit 4 - Sustainability of Ecosystems



How to Use the Four Column Curriculum Layout


SPECIFIC CURRICULUM OUTCOMES

GCO 1: Represent algebraic expressions in multple ways

Outcomes	Focus for Learning
Students will be expected to	
1.0 model, record and explain the operations of multiplication and division of polynomial expressions (limited to polynomials of degree less than or equal to 2) by monomials, concretely, pictorially and symbolically. [GCO 1]	From previous work with number operations, students should be aware that division is the inverse of multiplication. This can be extended to divide polynomials by monomials. The study of division should begin with division of a monomial by a monomial, progress to a polynomial by a scalar, and then to division of a polynomial by any monomial.
1.2 model division of a given polynomial expression by a given monomial concretely or pictorially and record the process symbolically.	Division of a polynomial by a monomial can be visualized using area models with algebra tiles. The most commonly used symbolic method of dividing a polynomial by a monomial at this level is to divide each term of the polynomial by the monomial, and then use the exponent laws to simplify. This method can also be easily modelled using tiles, where students use the sharing model for division.
1.3 apply a personal strategy for multiplication and division of a given polynomial expression	Because there are a variety of methods available to multiply or divide a polynomial by a monomial, students should be given the opportunity to apply their own personal strategies. They should be encouraged to use algebra tiles, area models, rules of exponents, the distributive property and repeated addition, or a combination of any of these methods, to multiply or divide polynomials. Regardless of the method used, students should be encouraged to record their work symbolically. Understanding the different approaches helps students develop flexible thinking.

Sample Performance Indicator

Write an expression for the missing dimensions of each rectangle and determine the area of the walkway in the following problem:

- The inside rectangle in the diagram below is a flower garden. The shaded area is a concrete walkway around it. The area of the flower garden is given by the expression $2x^2 + 4x$ and the area of the large rectangle, including the walkway and the flower garden, is $3x^2 + 6x$.

Outcomes

Column one contains specific curriculum outcomes (SCO) and accompanying delineations where appropriate. The delineations provide specificity in relation to key ideas.

Outcomes are numbered in ascending order.

Delineations are indented and numbered as a subset of the originating SCO.

All outcomes are related to general curriculum outcomes.

Focus for Learning

Column two is intended to assist teachers with instructional planning. It also provides context and elaboration of the ideas identified in the first column.

This may include

- cautionary notes
- clarity in terms of scope
- common misconceptions
- depth of treatment
- knowledge required to scaffold and challenge student's learning
- references to prior knowledge

Sample Performance Indicator(s)

This provides a summative, higher order activity, where the response would serve as a data source to help teachers assess the degree to which the student has achieved the outcome.

Performance indicators are typically presented as a task, which may include an introduction to establish a context. They would be assigned at the end of the teaching period allocated for the outcome.

Performance indicators would be assigned when students have attained a level of competence, with suggestions for teaching and assessment identified in column three.

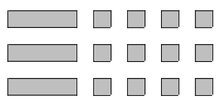
SPECIFIC CURRICULUM OUTCOMES

GCO 1: Represent algebraic expressions in multple ways

Sample Teaching and Assessment Strategies

Teachers may use the following activities and/or strategies aligned with the corresponding assessment tasks:

Modeling division using the sharing model provides a good transition to the symbolic representation. For example, $\frac{3x+12}{3} = \frac{3x}{3} + \frac{12}{3}$. To model this, students start with a collection of three *x*-tiles and 12 unit tiles and divide them into three groups.



For this example, $x + 4$ tiles will be a part of each group, so the quotient is $x + 4$.

Activation

Students may

- Model division of a polynomial by a monomial by creating a rectangle using four x^2-tiles and eight *x*-tiles, where $4x$ is one of the dimensions.

Teachers may

- Ask students what the other dimension is and connect this to the symbolic representation.

Connection

Students may

- Model division of polynomials and determine the quotient
  - (i) $(6x^2 + 12x - 3) \div 3$
  - (ii) $(4x^2 - 12x) \div 4x$

Consolidation

Students may

- Draw a rectangle with an area of $36a^2 + 12a$ and determine as many different dimensions as possible.

Teachers may

- Discuss why there are so many different possible dimensions.

Extension

Students may

- Determine the area of one face of a cube whose surface area is represented by the polynomial $24s^2$.
- Determine the length of an edge of the cube.

Resources and Notes

Authorized

- *Math Makes Sense 9*
- Lesson 5.5: Multiplying and Dividing a Polynomial by a Constant
- Lesson 5.6: Multiplying and Dividing a Polynomial by a Monomial
- ProGuide: pp. 35-42, 43-51
- CD-ROM: Master 5.23, 5.24
- See It Videos and Animations:
- Multiplying and Dividing a Polynomial by a Constant, Dividing
- Multiplying and Dividing a Polynomial by a Monomial, Dividing
- SB: pp. 241-248, 249-257
- PB: pp. 206-213, 214-219

Resources and Notes

Column four references supplementary information and possible resources for use by teachers.

These references will provide details of resources suggested in column two and column three.

Suggestions for Teaching and Assessment

This column contains specific sample tasks, activities, and strategies that enable students to meet the goals of the SCOs and be successful with performance indicators. Instructional activities are recognized as possible sources of data for assessment purposes. Frequently, appropriate techniques and instruments for assessment purposes are recommended.

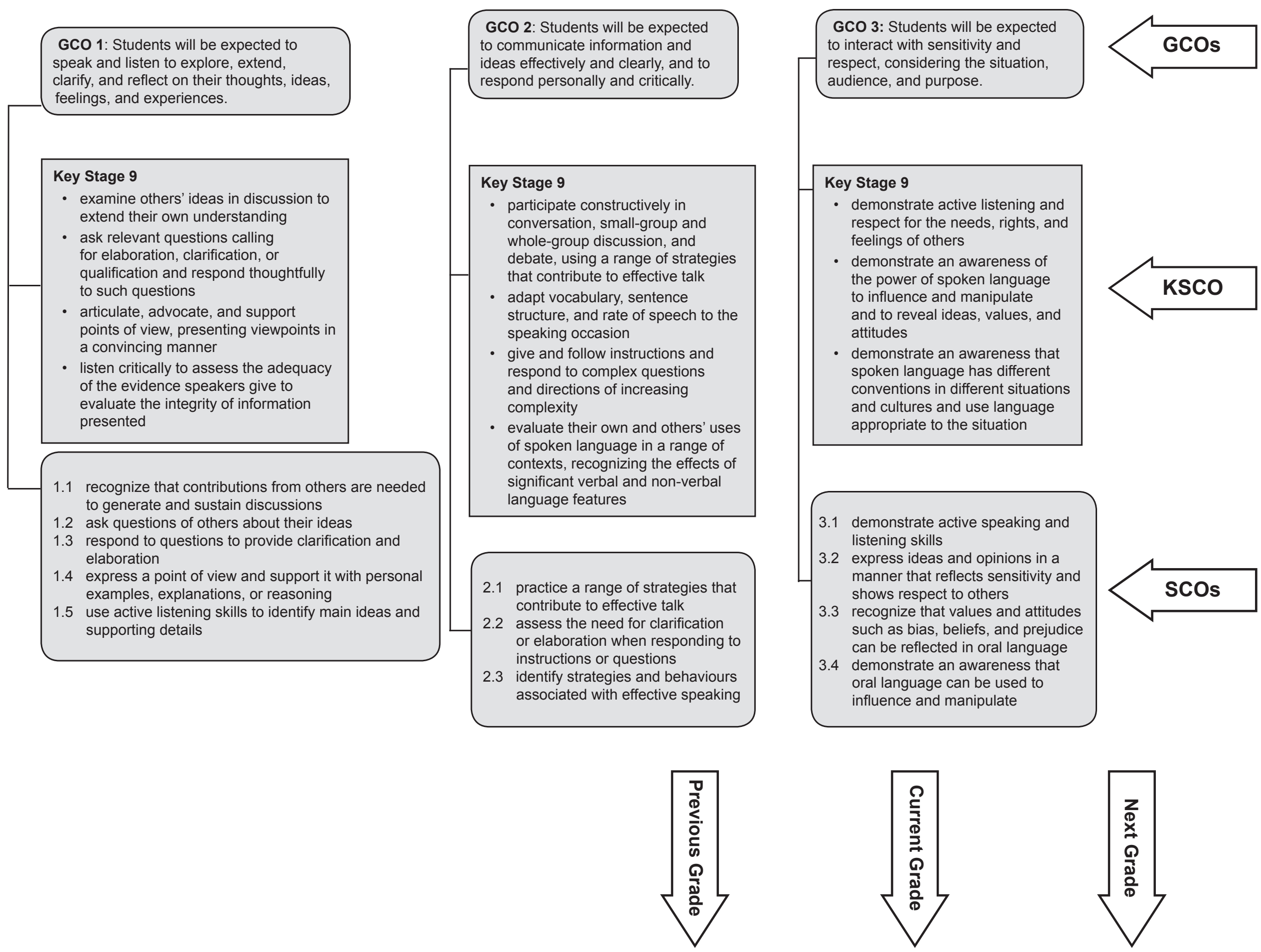
Suggestions for instruction and assessment are organized sequentially:

- Activation – suggestions that may be used to activate prior learning and establish a context for the instruction
- Connection – linking new information and experiences to existing knowledge inside or outside the curriculum area
- Consolidation – synthesizing and making new understandings
- Extension – suggestions that go beyond the scope of the outcome

These suggestions provide opportunities for differentiated learning and assessment.

How to use a Strand overview

At the beginning of each strand grouping there is explanation of the focus for the strand and a flow chart identifying the relevant GCOs, KSCOs and SCOs.



The SCOs Continuum follows the chart to provide context for teaching and assessment for the grade/course in question. The current grade is highlighted in the chart.

GCO

SCOs

GCO 1: Students will be expected to speak and listen to explore, extend, clarify, and reflect on their thoughts, ideas, feelings, and experiences.

Grade 6	Grade 7	Grade 8
1.0 examine how sharing experiences, explanations or reasoning with others clarifies and extends thinking	1.1 recognize that contributions from others are needed to generate and sustain discussions	1.1 reflect upon the contribution of others' ideas during discussion
2.0 use active listening strategies for a variety of purposes	1.2 ask questions of others about their ideas	1.2 ask questions of others for clarification
3.0 assess how thinking may be affected as a result of listening to others	1.3 respond to questions to provide clarification and elaboration	1.3 respond to questions to provide accuracy, relevancy, and validity
	1.4 express a point of view and support it with personal examples, explanations, or reasoning	1.4 express a point of view and support it with personal examples and evidence from various sources
	1.5 use active listening skills to identify main ideas and supporting details	1.5 use active listening skills to interpret main ideas and the relevancy of supporting details

Section Three: Specific Curriculum Outcomes

Unit i: Integrated Skills

Focus

Students use a variety of skills when investigating questions, ideas, problems, and issues. While these skills are not unique to science, they play an important role in the development of scientific understandings and in the application of science and technology to new situations.

The listing of skills is not intended to imply a linear sequence or to identify a single set of skills required in each science investigation. Every investigation has unique features that determine the particular mix and sequence of skills.

Four broad areas of skills are outlined and developed:

- Initiating and Planning - These are the skills of questioning, identifying problems, and developing initial ideas and plans.
- Performing and Recording - These are the skills of carrying out action plans, which involves gathering evidence by observation and, in most cases, manipulating materials and equipment.
- Analyzing and Interpreting - These are the skills of examining information and evidence, of processing and presenting data so that it can be interpreted, and interpreting, evaluating, and applying the results.
- Communication and Teamwork - In science, communication skills are essential at every stage where ideas are being developed, tested, interpreted, debated, and agreed upon. Teamwork skills are also important, since the development and application of science ideas is a collaborative process both in society and in the classroom.

Students should be provided with opportunities to develop and apply their skills in a variety of contexts. These contexts connect to the STSE component of the curriculum by linking to three processes for skills application:

- Science inquiry - seeking answers to questions through experimentation and research
- Problem solving - seeking solutions to science-related problems by developing and testing prototypes, products, and techniques to meet a given need.
- Decision making - providing information to assist the decision making process.

Unit i - Integrated Skills

Unit i, the *Integrated Skills* unit, appears at the beginning of this curriculum guide. A total of 43 different skill outcomes are identified and addressed throughout high school science courses, however, all skills do not appear in each course or content unit. In Science 1206, students are expected to develop proficiency with respect to 29 skills listed in the outcomes framework.

Outcomes Framework

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Initiating and Planning

1.0 identify questions to investigate that arise from practical problems and issues
2.0 design an experiment identifying and controlling major variables
3.0 state a prediction and a hypothesis based on available evidence and background information
4.0 design an experiment and identify specific variables
5.0 formulate operational definitions of major variables
6.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making
7.0 develop appropriate sampling procedures

Performing and Recording

8.0 carry out procedures controlling the major variables and adapting or extending procedures where required
9.0 use instruments effectively and accurately for collecting data
10.0 estimate quantities
11.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
12.0 use library and electronic research tools to collect information on a given topic
13.0 select and integrate information from various print and electronic sources or from several parts of the same source
14.0 select and use apparatus and materials safely
15.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

Analyzing and Interpreting

16.0 describe and apply classification systems and nomenclatures used in the sciences
17.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
18.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
19.0 compare theoretical and empirical values and account for discrepancies
20.0 evaluate the relevance, reliability, and adequacy of data and data collection methods
21.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
22.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
23.0 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan
24.0 identify new questions or problems that arise from what was learned

Communication and Teamwork

25.0 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others
26.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
27.0 identify multiple perspectives that influence a science-related decision or issue
28.0 develop, present, and defend a position or course of action, based on findings
29.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise

SCO Skill Continuum

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Science 7-9	Science 10-12
• identify questions to investigate arising from practical problems and issues • rephrase questions in a testable form and clearly define practical problems • define and delimit questions and problems to facilitate investigation	• identify questions to investigate that arise from practical problems and issues
• state a prediction and a hypothesis based on background information or an observed pattern of events	• state a prediction and a hypothesis based on available evidence and background information
• formulate operational definitions of major variables and other aspects of their investigations	• formulate operational definitions of major variables
• design an experiment and identify major variables	• design an experiment identifying and controlling major variables • design an experiment and identify specific variables
• select appropriate methods and tools for collecting data and information and for solving problems	• evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making
	• develop appropriate sampling procedures
• carry out procedures controlling the major variables	• carry out procedures controlling the major variables and adapting or extending procedures where required
• use instruments effectively and accurately for collecting data	• use instruments effectively and accurately for collecting data
• estimate measurements	• estimate quantities
• organize data using a format that is appropriate to the task or experiment	• compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
• select and integrate information from various print and electronic sources or from several parts of the same source	• use library and electronic research tools to collect information on a given topic • select and integrate information from various print and electronic sources or from several parts of the same source
• use tools and apparatus safely	• select and use apparatus and materials safely
• demonstrate a knowledge of WHMIS standards by using proper techniques for handling and disposing of lab materials	• demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

SCO Skill Continuum

Science 7-9	Science 10-12
• use or construct a classification key	• describe and apply classification systems and nomenclatures used in the sciences
• compile and display data, by hand or computer, in a variety of formats	• compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
• predict the value of a variables by interpolating and extrapolating from graphical data • identify the line of best fit on a scatter plot and interpolate or extrapolate on the line of best fit • interpret patterns and trends in data, and infer and explain relationships among the variables	• interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
• calculate theoretical values of a variable	• compare theoretical and empirical values and account for discrepancies
• identify the strengths and weaknesses of different methods of collecting and displaying data	• evaluate the relevance, reliability, and adequacy of data and data collection methods
• identify, and suggest explanations for, discrepancies in data	• identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
• state a conclusion, based on experimental data, and explain how evidence gathered supports or refutes an initial idea • identify and evaluate potential applications of findings	• provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
• propose alternative solutions to a given practical problem, select one, and develop a plan	• propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan
• identify new questions and problems that arise from what was learned	• identify new questions or problems that arise from what was learned
• receive, understand, and act on the ideas of others • communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means	• communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others • select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
• work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise	• work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise
• defend a given position on an issue or problem, based on their findings	• develop, present, and defend a position or course of action, based on findings
	• identify multiple perspectives that influence a science-related decision or issue

Suggested Unit Plan

The *Integrated Skills* unit is not intended to be taught as a separate, stand alone unit. Rather, as skill outcomes [GCO 2] are encountered in Units 1-4, teachers should refer out to the focus for learning elaborations and teaching and assessment suggestions provided in this unit.

Skill outcomes should be integrated throughout all content units. Provide opportunities for students to develop and apply these skills in varied contexts:

- Science Inquiry - seeking answers to questions through experimentation and research.
- Problem Solving - seeking solutions to science-related problems by developing and testing prototypes, products, and techniques to meet a given need.
- Decision Making - providing information to assist the decision making process.

The inclusion of science projects is strongly recommended to address and assess skill outcomes.

<table>
<tr><th colspan="4">September</th><th colspan="4">October</th><th colspan="4">November</th><th colspan="4">December</th><th colspan="4">January</th><th colspan="4">February</th><th colspan="4">March</th><th colspan="4">April</th><th colspan="4">May</th><th colspan="4">June</th></tr>
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<tr><td colspan="10">Weather Dynamics</td><td colspan="10">Chemical Reactions</td><td colspan="10">Motion</td><td colspan="10">Sustainability of Ecosystems</td></tr>
<tr><td colspan="40">Skills Integrated Throughout</td></tr>
</table>

Initiating and Planning

Outcomes

Students will be expected to

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

Focus for Learning

Students should ask questions about observed relationships and plan investigations of questions, ideas, problems, and issues (p. 21). A number of skills aligned with this expectation are included in the Science 1206 curriculum.

Science begins with a question. Scientific questions arise in a variety of ways. They can arise from

- curiosity about the natural and constructed world;
- personal observations of phenomena;
- examination of scientific models and theories, and their predictions;
- the findings of previous investigations;
- processes to find solutions to practical problems, or
- processes to reach a decision on a science-related issue.

Scientific questions differ from other types of questions in that their answers lie in explanations supported by empirical evidence (i.e., information acquired through observation and investigation).

Building on Science K-9 experiences, students should

- identify questions to investigate;
- phrase, or rephrase, questions in a testable form; and
- evaluate questions to determine if they are testable.

Often, the inquiry question to investigate is provided to students. To achieve this outcome, however, students must identify the question to investigate.

This outcome is addressed in the *Weather Dynamics* unit, where students, for example, develop questions to investigate regarding the effect of heat transfer within the atmosphere and hydrosphere. The skill, however, should be addressed at every opportunity throughout the course.

Identifying a question to investigate is an initial step in starting a science fair project.

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Students may

- Participate in a book walk through *NL Science 10.* Locate the Conduct an Investigation labs and read the identified question to investigate, where provided.

Connection

Teachers may

- Model the identification of questions to investigate arising from problems and issues.
- Facilitate a discussion regarding criteria to use to determine if a question is testable.
- Present general “I Wonder” questions and ask students to rephrase them in a testable form (e.g., I wonder...What factors affect the rate of a chemical reaction?).

Students may

- Use a question matrix to generate initial questions.
- Record potential questions to investigate in a personal science journal which is updated regularly.
- Record questions in the “What I Want to Know” section of a KWL chart.
- Apply criteria to determine whether a question is testable within the constraints and limits of resources.

Consolidation

Students may

- Identify potential questions to investigate as part of a science project.
- Read or view science-related articles and videos and identify potential questions to investigate.

Resources and Notes

Authorized

NL Science 10 (Student Resource [SR])

- pp. 376-377

Initiating and Planning

Outcomes

Students will be expected to

2.0 design an experiment identifying and controlling major variables [GCO 2]

Focus for Learning

Students have prior experience designing experiments to determine cause and effect relationships among variables. In Science 1206, students should design experiments identifying and controlling major variables.

When planning investigations, students should

- identify and define the major variables (i.e., dependent, independent, and control variables);
- phrase the inquiry question to investigate (i.e., cause and effect);
- design an experiment to generate relevant data; and
- devise a procedure that controls potential confounding variables.

Additionally, students should evaluate the designs of others experiments to identify the inquiry question and major variables, and assess whether confounding variables are controlled.

This skill is addressed in the *Chemical Reactions* unit. Students design an experiment to determine how different variables (e.g., concentration of a reactant) affect the rate of a reaction.

3.0 state a prediction and a hypothesis based on available evidence and background information [GCO 2]

Students began stating predictions and hypotheses in Science 4 using an “If..., then...because...” template. The “If..., then...” component is the prediction. The “because...” is the hypothesis.

Students should recognize that a prediction specifies what is expected to happen to the dependent variable when the independent variable is manipulated, while a hypothesis provides a more general explanation for the prediction. They should design experiments to test predictions. If their collected data confirms the prediction, it serves as evidence to support the hypothesis. If their prediction is rejected, the hypothesis may require modification or abandonment. Students should recognize that the vast majority of scientific hypotheses fail. They should, however, consider these failed experiments as successful because something has been learned.

In Science 1206, students should state predictions and hypotheses based on available evidence and background information.

This skill is referenced in each of four content units. Students predict and hypothesize, for example, future weather conditions, the affect of temperature on reaction rates, the movement of a vehicle based on displacement, time, and velocity, and the affect of soil-related variables on agricultural production. Additionally, this skill could be addressed whenever students are engaged in scientific investigations, if appropriate.

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Review the role of variables in science inquiry investigations.
- Distinguish between a prediction and a hypothesis.

Students may

- Choose an element from the periodic table. Based on its placement on the table, predict some of its properties.

Connection

Teachers may

- Model stating predictions and hypotheses.
- Provide questions to investigate and ask students to identify the independent and dependent variables, as well as confounding variables that would need to be controlled.
- Ask students to state predictions and hypotheses prior to conducting simple demonstrations related to the particle theory of matter.
- Collaboratively design an experiment with students identifying and controlling major variables to model the skill.
- Provide stations with differing data sets and background information and ask students to move from one station to another, making written predictions and hypotheses. A summary and group sharing may follow to compare and discuss.

Students may

- Review Appendix B Science Skills: Scientific Inquiry (*NL Science 10,* pp.376-380) for information on designing experiments and stating predictions and hypotheses.
- Read the Conduct an Investigation labs in *NL Science 10* and identify the independent, dependent, and controlled variables, where possible.
- Review the procedure section of an experiment and identify major variables and assess whether confounding variables have been adequately controlled.

Consolidation

Teachers may

- Provide questions to investigate and ask students to design experiments identifying and controlling major variables and state predictions and hypotheses.

Students may

- Design an experiment identifying and controlling major variables for a science project.

Resources and Notes

Authorized

NL Science 10 (Teachers resource [TR])

- BLMs G-7, G-8, G-10

NL Science 10 (SR)

- pp. 377-379

Initiating and Planning

Outcomes

Students will be expected to

4.0 design an experiment and identify specific variables [GCO 2]

Focus for Learning

Students should design an experiment to identify a specific, quantitative variable (e.g., acceleration of a toy car).

Students should

- identify and define the variable of interest;
- determine the type, amount, and accuracy of data needed to quantify the variable;
- consider the measuring tools and instruments available and their limitations (e.g., capacity, precision); and
- devise an experimental procedure to generate relevant data, while controlling potential confounding variables.

This skill is addressed in the *Motion* unit. Students design an experiment to determine the speed of a moving object. They are required to operationally define distance and time, determine how they will measure speed, select measuring tools and instruments, and devise a fair testing procedure to generate relevant data.

This skill could also be addressed when determining the pH of a solution, rate of a chemical reaction, or acceleration of a moving object.

5.0 formulate operational definitions of major variables [GCO 2]

When designing experiments, students should operationally define variables. Operational definitions are procedural statements. They are specific to an investigation and define the process used to determine the nature of variables and their properties.

When designing an experiment to determine the effect of fertilizer on plant growth (*NL Science 10*, p. 314), for example, students must operationally define fertilizer and plant growth. What type of fertilizer will be used (e.g., solid or liquid, chemical composition, nutrient ratio)? How will the fertilizer be added (e.g., frequency, amount, concentration, method, tools)? What type of plant will be used? Will they be young plants, established plants, or plants started from seed? What property will be used to measure growth (e.g., fresh or dry mass, height, number of leaves, leaf surface area, germination rate, number of days till flowering) and how will it be measured (e.g., tool, method, frequency)?

This skill is addressed in the *Motion* and *Sustainability of Ecosystems* units. Students operationally define speed, velocity, acceleration, displacement, biotic factors, abiotic factors, and biomass, when designing experiments. Formulating operational definitions, however, can be addressed and assessed whenever students should design experiments or devise procedures.

Initiating and Planning

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Provide examples of visual representations of a science inquiry process. Ask students to note similarities in their stages.
- Distinguish between definitions and operational definitions.
- Ask students a series of questions related to pendulums (e.g., What is a pendulum? How does it work? What are its parts? What is the period of a pendulum? What is its frequency?). Then, collaboratively design with students an experiment to determine the frequency of a pendulum, formulating operational definitions in the process (e.g., What pendulum length, bob mass, and start angle will be used? What will constitute a period? What measurement tools and units will be used? Is once enough, or should the test be repeated?). Additionally, consider a number of potential variables that might affect the frequency of a pendulum (e.g., length, bob mass, start angle) and devise an outline for an experiment, formulating operational definitions for the independent, dependent, and controlled variables.
- Conduct a demonstration of an experiment. Ask students to describe how the major variables are operationally defined in the experiment.

Students may

- Locate the Conduct an Investigation labs in *NL Science 10.* Read the procedures and describe how the major variables are operationally defined within the experiments.

Consolidation

Students may

- Formulate operational definitions for major variables when designing an experiment for a science project.
- Suggest alternative ways to operationally define major variables in experiments.
- Design an experiment to determine the pH of a solution, rate of a chemical reaction, or acceleration of a moving object. Formulate operational definitions of the major variables.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 377-379

Initiating and Planning

Outcomes

Students will be expected to

6.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making [GCO 2]

Focus for Learning

When planning investigations of questions, ideas, problems, and issues, students should evaluate and select instruments and processes appropriate for the task.

While students have prior experience with scientific inquiry, problem solving, and decision making processes, a general review of these processes is warranted.

With respect to instruments, students should evaluate alternatives and select the instruments most appropriate for the task. Given the context, for example, what is the most appropriate instrument to measure distance, mass, volume, time, or angles.

This skill is addressed in the *Chemical Reactions* unit. Students evaluate the advantages and disadvantages of selecting different instruments to determine pH (e.g., pH paper, indicators, pH meters). Similar evaluations could also occur when selecting instruments within the *Weather Dynamics* (e.g., to measure temperature, atmospheric pressure, humidity, precipitation, wind speed) and *Motion* units (e.g., to measure speed and acceleration). Evaluation of measuring instruments should consider the precision and accuracy required.

7.0 develop appropriate sampling procedures [GCO 2]

When planning investigations, developing appropriate sampling procedures (i.e., sample selection, measurement, and analysis procedures) is critical. Sampling procedures significantly impact the quality of results obtained from investigations.

Students' procedures should consider sample size, random or representative sampling, sampling technique, and procedures for sample analysis. Adhering to standardized procedures allows for repeatability. Students should ensure selection of appropriate instruments to meet specific sampling requirements.

This skill is addressed in the *Motion* unit. To determine the speed of a moving object, students should define the time or distance intervals at which measurements will be taken and the number of intervals required, and devise detailed procedures for the collection, measurement, and analysis of samples.

Additional opportunities to address and assess this skill include

- measuring weather conditions (e.g., developing sampling procedures for use of an aneroid barometer);
- determining the pH of solutions (e.g., developing sampling procedures for use of a pH meter); and
- investigating population size in an ecosystem.

Determining what procedures are appropriate for a given investigation is a skill that will develop gradually over time, as students are increasingly exposed to investigations from different disciplines.

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Review scientific inquiry, problem-solving, and decision making processes.
- Distinguish between and provide examples of probability and non-probability sampling.
- Discuss the project completed in Mathematics 9 which introduced students to sampling techniques. They developed and implemented a project plan for the collection, display, and analysis of data. They considered factors such as: the collection method used, data reliability and usefulness of data, and the ability to make, from a sample, generalizations about the population. Students also described factors affecting the collection of data: bias, language use, ethics, cost, time and timing, privacy, and cultural sensitivity.

Connection

Teachers may

- Model evaluating and selecting appropriate instruments, for example, to calculate distance, determine pH, or measure temperature.
- Where possible, provide a variety of instruments for students to choose from when collecting evidence.
- Demonstrate the capabilities and limitations of various instruments.

Students may

- Where applicable, analyze experimental procedures to describe the sampling procedures used and discuss whether they were appropriate.
- Collaboratively identify potential limitations of specific sampling instruments or procedures.

Consolidation

Students may

- Evaluate and select appropriate instruments and develop appropriate sampling procedures when planning an experiment (e.g., science project).
- Develop appropriate sampling procedures (e.g., quadrat sampling) to investigate shoreline biodiversity.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 376-380, 397-400

Performing and Recording

Outcomes	Focus for Learning
Students will be expected to	Students should conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information (p. 21). A number of skills aligned with this expectation are included in the Science 1206 curriculum.
8.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]	A controlled experiment tests only one variable at a time, while keeping all other variables constant. This ensures that tests are valid and unbiased. Occasionally, while conducting an experiment, a confounding variable, that has not been accounted for, is identified. Failure to isolate and control this variable will compromise the validity of results and conclusions. In these instances, students should adapt or extend procedures to ensure fair testing. This skill is addressed in the *Chemical Reactions* unit. Students carry out procedures controlling major variables when investigating the effects of temperature, concentration of reactants, and surface area on a given reaction. Additionally, this outcome can be addressed whenever students conduct experiments.
9.0 use instruments effectively and accurately for collecting data [GCO 2]	When conducting investigations, students should use analog and digital data collection tools and instruments effectively and accurately. In Science 1206, instruments are used to collect data and information related to mass, temperature, distance, time, angles, weather conditions, pH, conductivity, velocity, and acceleration. Teachers should demonstrate proper techniques for effective use and measurement accuracy of different instruments, and discuss potential sources of error caused by improper use. When using a balance to measure mass of chemical substance, for example, teachers should demonstrate techniques such as taring a balance or weighing by difference. Provide opportunities for students to practice effective and accurate instrument use prior to use in investigations. Students should assess the precision and accuracy of measuring instruments and, when required, calibrate instruments prior to use. When using analog instruments, measurements should be recorded using the correct number of significant digits (i.e., all certain digits plus one estimated digit). See Appendix A for elaboration. This skill is addressed in the *Motion* unit where instruments are used to collect data in velocity and acceleration investigations. The outcome, however, could be addressed and assessed whenever students use instruments to collect data.

Performing and Recording

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Demonstrate use of instruments such as thermometers, weather instruments, graduated cylinders, conductivity testers, electronic balances, pH paper, indicators, and meters, stopwatches, ticker tape and recording timers, and motion sensors and common errors.
- Differentiate between the accuracy and precision using measurements collected with a bathroom scale, as an example.

Students may

- Identify variables to control in an experiment.

Connection

Students may

- Demonstrate how to accurately use instruments such as a(n) aneroid barometer, electronic balance, pH meter, and ticker tape and recording timer.
- View video of their group or classmates conducting experiments, assess whether variables were adequately controlled, and suggest improvements.

Consolidation

Teachers may

- Use direct observations to assess whether students carry out procedures controlling major variables during investigations.
- Assess student proficiency using data collection instruments during investigations and as part of a lab exam.

Resources and Notes

Authorized

NL Science 10 (TR)

- BLMs G-17, G-18, G-19

NL Science 10 (SR)

- pp. 382-386

Appendices

- Appendix A

Performing and Recording

Outcomes

Students will be expected to

10.0 estimate quantities
[GCO 2]

Focus for Learning

Students should estimate quantities when gathering and recording data. Estimating quantities is useful when

- selecting a measurement instrument with sufficient capacity,
- obtaining precise quantities is impractical,
- approximated quantities are sufficient for the task, and
- used as a rough check of the accuracy of calculated values.

Students have experience estimating and calculating exact values in mathematics and should have experience estimating uncertain digits when using measuring tools and instruments in science.

Estimation in science includes

- extrapolating and interpolating from graphs or data sets,
- guess and check estimation in calculations, and
- trial and error in problem solving.

This skill is addressed in the *Motion* unit. Students estimate quantities when performing calculations and analyzing and interpreting graphs.

11.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
[GCO 2]

Students should compile and organize data, while conducting investigations of questions, ideas, problems, and issues. They should select and use formats and data treatments (e.g., charts, diagrams, lists, tables, log books, maps, observational journals) that facilitate interpretation and analysis of the data and information. A digital spread sheet, for example, could be used to compile and organize quantitative data, recorded using the appropriate number of significant digits and units.

When selecting formats and treatments, the most important criteria should be ease of future data interpretation.

This skill is addressed in the *Chemical Reactions* unit. Students compile and organize data from an investigation of the properties of ionic and molecular compounds. To facilitate interpretation of data, students could use a table and record compounds investigated using their chemical formulas, instead of their name.

Each unit of Science 1206 provides additional opportunities to address and assess this performing and recording skill.

If different student groups select different formats and treatments to compile and organize similar data, students should evaluate the appropriateness of each with respect to ease of data interpretation.

Performing and Recording

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss the difficulty that young, inexperienced science students may have with estimation.
- Discuss efficient ways to organize data (e.g., formats, significant digits, units) that facilitate future interpretation.

Students may

- Brainstorm and discuss common examples of estimation that occur in everyday life (e.g., estimating temperature, total cost of a set of items, wait times).

Connection

Teachers may

- Direct students to always estimate the first uncertain digit when measuring.
- Provide students raw, unorganized data or information from an investigation and ask them to organize it in an appropriate format.

Students may

- Brainstorm alternative ways to compile and organize sets of data and information and discuss their advantages and disadvantages.
- Estimate, within the classroom, sample distances, volumes, masses, temperatures and angle measures. Use appropriate instruments to measure them and assess the accuracy of their estimates.
- Capture digital images of measurements taken with analog tools and instruments. Enlarge the images to make more accurate estimations of the first uncertain digit.

Consolidation

Teachers may

- Allow different groups to compile and organize data in different ways. Then ask students to compare the utility of the different formats.

Students may

- Identify estimations made when conducting an investigation. Indicate why the estimation was made, what form it took, and how it compared to the measured or accepted value.
- Compile and organize data collected as part of a science project.

Resources and Notes

Authorized

NL Science 10 (TR)

- BLMs G-12, G-16

NL Science 10 (SR)

- pp. 382-387, 396, 406-411

Performing and Recording

Outcomes

Students will be expected to

12.0 use library and electronic research tools to collect information on a given topic [GCO 2]

13.0 select and integrate information from various print and electronic sources or from several parts of the same source [GCO 2]

14.0 select and use apparatus and materials safely [GCO 2]

Focus for Learning

Students should use a broad range of tools and techniques to gather information when investigating questions, ideas, problems, and issues. The intent of these outcomes is for students to use research inquiry tools and techniques to collect information on a topic.

Review relevant acceptable use of library and electronic research tools, practices, and policies. Students will continue to develop practical skills necessary to evaluate the validity, reliability, and bias of a source. They should determine origin of material and check sources for age appropriateness, organized links, and important and accessible information. They should also be able to use advanced search techniques and keywords.

A review of citing, referencing, types of information, sources, and plagiarism may be necessary.

In Science 1206, these skills are developed when students

- use research inquiry to describe and explain the development and characteristics of extreme weather (i.e., hurricanes, nor'easters, thunderstorms, tornadoes, El Niño, La Niña);
- analyze and interpret meteorological data to develop, present, and defend a short-range forecast; and
- analyze issues related to sustainability of ecosystems.

When performing demonstrations, teachers should review relevant safety considerations and demonstrate proper handling and use of apparatus, tools, and materials.

Students should have the requisite knowledge to select and use apparatus, tools, and materials safely. They should select and safely use, for example, thermometers and other analog weather instruments, chemicals, glassware, hotplates, electronic balances, pH meters, ticker tape and recording timers, digital sensors, and microscopes. Additionally, they should select and effectively use personal protective and safety equipment, as required.

Assess student use of apparatus and materials during investigations using direct observations, checklists, and self and peer assessment.

Routinely address safe and appropriate use of apparatus, tools, and materials. A discussion, with students, of relevant safety policies, rules, and procedures when working in laboratory environments should occur before students are permitted to conduct investigations. This practice should be part of the school safety plan, reviewed annually.

Performing and Recording

Sample Teaching and Assessment Strategies

Activation

Teachers may
- Review research and citing protocol.
- Invite a representative from Newfoundland and Labrador Public Libraries (NLPL) to provide an overview of NLPL services and databases. Request library cards for students. Alternatively, the teacher librarian may provide an overview of school library and learning commons services.

Students may
- Discuss topics from previous science courses on which they or their classmates conducted research.
- Discuss why Facebook™ or Wikipedia™ may not be reliable sources. Discuss the necessity of research reliability and validity.
- Discuss the difference between a valid source and a reliable source when conducting research (i.e., a reliable source may not necessarily be valid).

Connection

Teachers may
- Demonstrate safe use of apparatus, tools, and materials. This may be completed on an as needed basis, or can encompass a set of equipment to be used throughout the year. Assessment of student understanding is required.

Students may
- Select and safely set up apparatus of be used in investigations.
- Develop safety signage or safe operating procedure information sheets for lab apparatus, tools and materials.

Consolidation

Students may
- Use research inquiry to investigate a science-related idea or issue. Ensure use of proper sources and citations including a bibliography.
- Use research inquiry to collect background information (i.e., literature review) for a science project.
- Integrate data and information from a variety of sources when communicating findings of investigations of questions, ideas, problems, or issues.

Resources and Notes

Authorized

NL Science 10 (TR)
- BLM G-27

NL Science 10 (SR)
- 402-405

Performing and Recording

Outcomes

Students will be expected to

15.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
[GCO 2]

Focus for Learning

WHMIS (Workplace Hazardous Materials Information System) safety symbols, along with safety data sheets (SDS), are used to identify dangerous materials. The symbols and SDS help students understand all aspects of safe handling and disposal of hazardous materials.

While students have prior experience with WHMIS standards, they should be readdressed in Science 1206. Student knowledge of WHMIS standards and techniques should be assessed for mastery, and documented, before students are permitted to conduct investigations in a laboratory environment.

WHMIS symbols were updated in 2015.

At the beginning of each investigation, review WHMIS standards and proper techniques for safe handling and disposal of lab materials. For example, when conducting an investigation related to the properties of ionic and molecular compounds, review with students, and make available, relevant WHMIS and SDS information for each compound used. Additionally, review proper techniques for chemical handling (pouring liquids into test tubes, stoppering and swirling, observing) and disposal, and required personal protective equipment.

Students should demonstrate proper techniques for handling and disposing of lab materials, when conducting investigations.

Students should recognize that the global information systems allow scientists, technologists, and workers to effectively communicate about hazardous materials. WHMIS could be discussed as an example of why classification systems and nomenclature are important in science.

Performing and Recording

Sample Teaching and Assessment Strategies

An overview of proper safety policies and procedures in laboratory environments for students is required before undertaking any activities. This should be part of the school emergency plan and reviewed on an annual basis.

Activation

Teachers may

- Demonstrate proper techniques for storing, handling, and disposing of lab materials at the outset of investigations.

Connection

Teachers may

- Identify the location where SDS are housed. Provide examples of SDS for chemicals used in Science 1206 for students to explore.
- Model accidental chemical spills in the lab and ask students to use relevant SDS to identify proper handling and disposal techniques.

Students may

- Create safety posters for the lab outlining WHMIS symbols and standards.
- Develop a WHMIS safety symbol mix and match game using the symbol, name, and descriptor.

Consolidation

Teachers may

- Present symbols and ask students to name the hazard and identify the main concern with these types of materials.
- Provide students with a chemical bottle and relevant SDS. Ask them to identify potential hazard(s) from symbols on the label and use the SDS to identify appropriate storage, handling, and disposal techniques.

Students may

- Safely and appropriately handle and dispose of lab materials when investigating properties of ionic and molecular compounds, types of chemical reactions, chemical reaction rates, and acids and bases.

Resources and Notes

Authorized

NL Science 10 (TR)

- BLMs G-1, G-2

NL Science 10 (SR)

- pp. ix-xiii

Analyzing and Interpreting

Outcomes

Students will be expected to

16.0 describe and apply classification systems and nomenclatures used in the sciences [GCO 2]

17.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

Focus for Learning

Students should analyze data and apply mathematical and conceptual models to develop and assess possible explanations (p. 21). A number of skills aligned with this expectation are included in the Science 1206 curriculum.

Classification systems and nomenclatures are human constructs that attempt to make sense of the physical world. Students should describe and apply classification systems and nomenclatures used in Science 1206. These include classifying weather fronts, acids and bases, types of chemical reactions, and biotic and abiotic factors, and naming and writing formulas for molecular and ionic compounds.

Students should recognize IUPAC as the nomenclature system used in chemistry today to ensure that each pure substance has a unique name which describes its composition.

Students should compile and display data and information from investigations in a variety of formats:

- Diagrams are used to symbolically represent information.
- Flow charts are used to represent a process.
- Tables organize data and information into labelled columns and rows.
- Graphs (e.g., bar, histogram, pictograph, line) help visualize relationships in data.
- Scatter plots are used to determine the degree of correlation between variables.

Students should select the most appropriate format to represent their data and information and, where possible, use digital technologies in their creation. Representations should be clear, concise, and include titles, headings, labels, scales, and units, where appropriate. Accurate representation of data and information is paramount to facilitate analysis and interpretation, identify patterns and trends, and infer or calculate relationships among variables.

This outcome is specifically addressed in the *Weather Dynamics* and *Sustainability of Ecosystems* units. Students should compile and display evidence and information when developing and presenting a weather forecast and when presenting and defending a proposed course of action related to an environmental issue. This skill, however, could be addressed and assessed whenever students analyze data and information gathered from investigations.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Describe examples of classification systems used in previous science courses. Classifying
  - rocks as igneous, sedimentary, or metamorphic;
  - elements as metal or non-metal, or according to group;
  - circuits as series or parallel; and
  - types of reproduction as sexual or asexual.
- Discuss the need for IUPAC nomenclatures used in chemistry.

Connection

Teachers may

- Discuss how the discovery of new species, elements, or planets have disrupted classifications systems, requiring reorganization or reclassification.
- Review appropriate use of diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots to compile and display data and how to draw a line of best fit.
- Stress the importance of including titles, labelling axes, and choosing appropriate scales when displaying data in a graph.
- Highlight and discuss common graphing errors (e.g., selecting inappropriate type, variables on wrong axes, incorrect scaling).

Students may

- Apply IUPAC rules for formula-writing and naming common ionic and molecular compounds.
- Justify selection of a particular format to compile and display data from an investigation.

Consolidation

Teachers may

- Provide raw, unorganized data or information compiled from an investigation. Ask students to accurately display the data or information in an appropriate, selected format.

Students may

- Compile and display data and information from class investigations and science projects in appropriate formats, including diagrams, flow charts, tables, graphs, and scatter plots.
- Compile and display data and information using a variety of digital technologies.

Resources and Notes

Authorized

NL Science 10 (TR)

- BLMs G-13, G-15

NL Science 10 (SR)

- pp. 380-381, 387-393, 396, 406-411

Analyzing and Interpreting

Outcomes

Students will be expected to

18.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]

19.0 compare theoretical and empirical values and account for discrepancies [GCO 2]

Focus for Learning

Students should analyze data and apply mathematical models to develop and assess possible explanations. Analyzing data includes interpreting trends and patterns, and inferring or calculating relationships.

- A trend is the general tendency of a data set to change (i.e., increasing, decreasing, constant). While individual data points may vary, the overall data trends in one direction. With respect to global warming, for example, the temperature trend increases over time.
- Patterns refer to data or information that repeat in a predictable way. When red litmus is added to acidic substances, for example, it turns blue.
- Relationships are similar to trends, but have a clear mathematical relationship. When measuring the time it takes an object to travel one metre at different velocities, for example, velocity and time have an indirect (i.e., negative) linear relationship.

Identifying trends, patterns, and relationships requires accurate representation of data in tables, graphs, and scatter plots. Scatter plots show the correlation among variables.

This skill is specifically addressed in the *Chemical Reactions* unit where students infer relationships between reaction rate and variables such as heat, concentration, light, and surface area.

Students should draw a line best fit (straight or curved) for graphs, when appropriate.

Theoretical values and empirical values obtained through observation or investigation should be compared, and identified discrepancies accounted for.

In the *Motion* unit, students conduct a directed investigation to measure the acceleration due to gravity of a falling object. The accepted theoretical value is 9.8 m/s^2 for objects dropped near Earth's surface and in the absence of air resistance. Most discrepancies can be explained by confounding variables and/or procedural and measurement errors.

Students should compare theoretical and empirical values, calculate percentage error, and account for discrepancies. Additionally, students should suggest changes to investigative and measurement procedures to improve accuracy.

Students have previous experience, from intermediate Mathematics curricula, using experimental or theoretical probabilities to represent and solve problems involving uncertainty.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Present exemplars of tables and graphs illustrating typical trends and patterns in data, and linear and non-linear relationships.
- Model interpreting patterns and trends in data and inferring or calculating linear and non-linear relationships among variables.
- Demonstrate examples of discrepancies between theoretical and empirical values (e.g., measure the voltage of a 9V battery) and use the values to calculate percent discrepancy.

Students may

- Draw lines of best fit by hand and using digital technologies.
- Identify discrepancies within and among data sets and suggest explanations for them.

Consolidation

Teachers may

- Present graphs and ask students to
  - explain what the graph is communicating,
  - interpolate and extrapolate information,
  - identify patterns or trends,
  - infer relationships among variables, and
  - calculate, where possible, linear and non-linear relationships.

Students may

- Interpret patterns and trends, and infer and calculate relationships, in data compiled and displayed as part of class investigations and science projects.
- Calculate percentage error if the measured value of acceleration due to gravity is 9.63 m/s^2.
- Reflect on major variables, experimental procedures, and measurement tools and techniques used, when attempting to account for discrepancies between theoretical and empirical values.
- View digital recordings of group members carrying out procedures and making measurements to identify potential sources of error.

Resources and Notes

Authorized

NL Science 10 (TR)

- BLM G-14

NL Science 10 (SR)

- pp. 381, 387-393

Analyzing and Interpreting

Outcomes

Students will be expected to

20.0 evaluate the relevance, reliability, and adequacy of data and data collection methods
[GCO 2]

Focus for Learning

Students should evaluate data and data collection methods with respect to

- relevance (i.e., Does the collected data help answer the initial question?);
- reliability (i.e., Can the data and findings be replicated?); and
- adequacy (i.e., Is the quality and quantity of the data sufficient to draw a conclusion?).

As part of the *Motion* unit, students should design and carry out an open inquiry investigation to calculate the speed of a moving object. The intent of this introductory activity is to raise issues related to data and data collection:

- What data is needed to calculate speed? How can distance and time data be collected?
- What measurement tools and instruments are available? What is their unit of measure? What is the appropriate SI unit?
- How should the measurements be taken? How many measurements should be taken? How many significant digits should measurements include?
- How accurate and precise are the collected measurements? What variables were controlled during data collection? Are there any confounding variables? Can the data be replicated?

Students should evaluate data and data collection methods of others and make suggestions to improve relevance, reliability, and adequacy.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Use political polling as the context to discuss sampling and the relevance, reliability, and adequacy of data and data collection methods. Discuss examples of inaccurate polling when compared to actual election results.

Connection

Teachers may

- Review what is meant by relevance, reliability, and adequacy of data and data collection methods.
- Model evaluating the data and data collection methods of student investigations and the published investigations of others.

Students may

- Discuss the relevance, reliability, and adequacy of data and data collection methods within the context of population estimates in biology (e.g., estimating wild Atlantic Salmon populations).

Consolidation

Students may

- Evaluate the relevance, reliability, and adequacy of data and data collection methods as part of their written conclusion in formal lab reports.
- View the procedures and findings of investigations, evaluate the relevance, reliability, and adequacy of data and data collection methods, and make suggestions for improvement.
- Suggest improvements to the data collection methods used by classmates in science projects.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 378-379, 386, 396

Analyzing and Interpreting

Outcomes

Students will be expected to

21.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty [GCO 2]

Focus for Learning

Error and uncertainty exist in every measurement, but, with care and refinement of experimental methods, they can be reduced.

Students should identify and explain sources of error in measurements, including systematic and random errors.

Systematic errors consistently cause measurements to be too high or too low. They can be caused by

- faulty measurement tools and instruments (e.g., a mis-calibrated balance or force meter);
- inaccurate measurement tools and instruments (e.g., metre stick, stop watch); or
- incorrect use of measurement tools and instruments (e.g., human error measuring distance from the end of a ruler instead of the zero mark).

Systematic errors may be difficult to identify. Once identified, however, they can be eliminated. If a lab thermometer, for example, measures the freezing point of water as 2 °C, two degrees can be subtracted from all future measurements to reduce systematic error. Greater understanding of the limitations and proper use of different measurement tools and instruments may also reduce uncertainty and error.

Random error in measurement occurs without a pattern. When using a stopwatch to measure time, for example, sometimes the measurement will be less than the actual time and other times more than the actual time. Another example comes from reading scales on measurement tools and instruments and estimating the first uncertain digit. Estimates will sometimes be too high and other times too low. Random errors may be reduced by repeating trials and using average measurements or increasing sample size.

Students should express data and results in a form that acknowledges the degree of uncertainty. In Science 1206, students should express measurements and calculations using the appropriate number of significant digits. Rules for their use can be found in Appendix A. Application of these rules from memory, is not an expectation of Science 1206. Students should be able to refer to the rules when expected to use them.

Teachers should note that scientific notation is not part of the existing Mathematics program.

This outcome is specifically addressed in the *Weather Dynamics* and *Motion* units. It is of particular relevance when investigating to determine the speed and acceleration of moving objects.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Demonstrate and discuss possible sources of error when measuring temperature with a lab thermometer. Extend the discussion to include other tools and instruments students will use in Science 1206.

Connection

Teachers may

- Differentiate between and provide examples of systematic and random errors.
- Provide rules for the use of significant digits and model their use when measuring and performing calculations.

Students may

- Identify examples of potential systematic and random errors to avoid when using measuring tools and instruments (e.g., anemometer, aneroid barometer, sling psychrometer, hygrometer, thermometer, digital scale and balance, graduated cylinder, stopwatch, force meter, meter stick and ruler).
- Describe how to appropriately use a specific measuring tool or instrument to reduce potential error.
- Record and view video of classmates conducting investigations to identify possible sources of error.
- Record values using the appropriate number of significant digits for the measurement tool or instrument used.

Consolidation

Teachers may

- Require students to examine and comment on sources of error when writing conclusions for investigations.

Students may

- Identify and explain sources of error when conducting investigations (e.g., science project).
- Suggest ways to reduce systematic and random errors in investigations.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 381, 386, 394-396

Appendices

- Appendix A

Analyzing and Interpreting

Outcomes

Students will be expected to

22.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
[GCO 2]

Focus for Learning

Following data analysis, students should develop possible explanations for the trends, patterns, and relationships identified and draw conclusions. Conclusions should

- be based on their data analysis;
- relate to the hypothesis and indicate whether it is supported or refuted;
- compare the results obtained with those expected;
- examine and comment on sources of error and uncertainty;
- assess the effectiveness of the investigative design;
- indicate how results support the conclusion; and
- suggest possible applications of the findings, or how the question could be investigated further.

While this skill outcome is specifically referenced in the *Weather Dynamics* unit, it could be addressed and assessed whenever students investigate questions, ideas, problems, and issues.

23.0 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan
[GCO 2]

This skill relates to investigating problems and issues. As part of these processes, students should

- propose alternative solutions,
- identify the strengths and weaknesses of each alternative, and
- select a preferred solution to serve as the basis for a plan.

Students should collaboratively define the problem or issue, identify constraints, and establish criteria for the evaluation of solutions. Alternative solutions generally emerge from brainstorming, research, and identifying multiple perspectives. The use of graphic organizers may be helpful when identifying the potential strengths and weaknesses of alternatives and evaluating them against criteria.

This skill is addressed in the *Chemical Reactions* unit. Students analyze an issue related to chemical use and disposal in their community (e.g., alternative energies, antibacterial products, agricultural pesticides, oil spills, use and disposal of electric cells). Through issue analysis, they propose and assess alternatives, and select a preferred solution to form the basis of their action plan.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present images of various problem solving and decision making processes. Highlight where alternatives are identified and analyzed in the processes.

Students may

- Recount prior experiences engaging in design challenges to solve problems.

Connection

Teachers may

- Model drawing conclusions from investigations and provide exemplars of well written conclusions.
- Model proposing and considering alternative solutions to practical problems.
- Model use of CurioCity *Benefit Analysis* and *Consequence Mapping* learning strategies (CurioCityto identify the potential strengths and weaknesses of each, and select one as the basis for a plan.

Students may

- Use graphic organizers (e.g., PMI chart, t-chart) to compare the potential strengths and weakness of alternative solutions.
- Conduct research to identify and consider possible alternative solutions to problems.
- Predict the outcome of selecting possible alternative solutions.

Consolidation

Teachers may

- Require a detailed conclusion be included in formal lab reports.
- Provide a formal lab report with the conclusion omitted. Ask students to write a conclusion for the report.

Students may

- Draw conclusions for investigations conducted in class and science projects.
- Use a cost-benefit analysis to identify strengths and weaknesses of alternatives solutions.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 380-381, 397-400

Suggested

- www.explorecuriocity.org (website)

Analyzing and Interpreting

Outcomes

Students will be expected to

24.0 identify new questions or problems that arise from what was learned [GCO 2]

Focus for Learning

Science begins with a question or problem, and investigations gather data and information to help answer or solve them. Inevitably, what is learned, will lead to new questions or problems to investigate. Science is an iterative process. Initial questions or problems lead to successive investigations, but at deeper and deeper levels.

With respect to climate change, for example, initial investigations confirmed that global and regional climate patterns were changing and attributed those changes to increased levels of atmospheric carbon dioxide. This learning spawned successive investigations of secondary questions and problems, which in turn led to more questions and problems. Through this iterative process our collective understanding of climate change continues to grow.

Students should identify new questions or problems to investigate from what is learned related to weather dynamics, chemical reactions, motion, and sustainability of ecosystems.

Routinely ask students to reflect on what was learned from investigations of questions, ideas, problems, and issues, and identify new questions or problems to investigate.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Model identifying new questions or problems to investigate from what is learned.
- Routinely ask students what new questions they have or what new problems they have identified.
- Require students to include how to investigate a question or problem further as part of their conclusion in formal reports

Students may

- Record new questions in the M section of a KWLM chart.
- Identify new questions arising after reading a science-related article or watching a video.

Consolidation

Teachers may

- Ask students to identify what new questions or problems they have, when orally communicating the findings of investigations (e.g., presenting findings of an science project).

Students may

- Identify new questions to investigate after conducting an initial investigation of a question.
- Read formal lab reports and identify possible new questions to investigate that arise from the findings.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 376, 381

Communication and Teamwork

Outcomes	**Focus for Learning**
Students will be expected to	
	Students should work as a member of a team when investigating questions and addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results (p. 21). A number of skills aligned with this expectation are included in the Science 1206 curriculum.
25.0 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others [GCO 2]	Most scientists work in collaborative environments, surrounded by other scientists and students. Effective communication is critical to success. Students should • effectively communicate their questions, ideas, and intentions, using appropriate scientific terminology; • attentively receive and interpret the ideas of others; • suspend judgement and respond to the ideas of others by asking clarifying questions to ensure understanding; and • evaluate ideas, lending them support or constructive criticism. In the *Sustainability of Ecosystems* unit, for example, students should demonstrate effective communication when analyzing the issue of marine protected areas, and developing, presenting, and defending a course of action. Additionally, this skill could be addressed and assessed whenever students work in collaborative group settings.
26.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]	Effective science communication requires students to appropriately select and use numbers, symbols, diagrams, charts, tables, graphs, and oral and written language to communicate ideas, plans, and results. This outcome is specifically addressed in the *Motion* unit where students select and use a position versus time graph to communicate results of a uniform motion investigation. This skill outcome, however, could be assessed whenever students communicate. Within the *Chemical Reactions* unit, for example, this skill could be assessed when students • investigate properties of ionic and molecular compounds; • name and write chemical formulas for ionic and molecular compounds; • represent chemical reactions and the conservation of mass using molecular models and balanced symbolic equations; • investigate to distinguish between acids, bases, and salts; • propose alternative solutions to a chemical use and disposal issue, select a preferred alternative, and develop, present and defend a course of action; and • devise and conduct an investigation of factors that affect the rate of a chemical reaction. Emphasize appropriate, accurate, and effective student use of numbers, symbols, graphs, and oral and written language when communicating in science.

Communication and Teamwork

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Organize students in pairs and small groups, where possible, to investigate questions, ideas, problems, and issues.

Students may

- Brainstorm ideas related to what effective science communication looks and sounds like.
- Play a game where a model idea is presented and appropriate responses are developed, shared, and evaluated for effectiveness.

Connection

Teachers may

- Encourage students to think aloud, orally communicating their questions, ideas, and intentions when conducting investigations.
- Request students digitally record their group communication when conducting investigations. Recordings may be used for assessment of communication.
- Use checklists to assess student use of scientific terminology when investigating.
- Provide guidelines for creating formal lab reports.
- Review how to effectively communicate findings using diagrams, flow charts, tables and graphs.
- Provide opportunities for student groups to communicate the findings of investigations in a format of their choosing. Then, compare and discuss the effectiveness of the different formats.

Students may

- Seek the advice and opinions of others when investigating.
- Consider the pros and cons of representing a set of data using a table or a graph.

Consolidation

Teachers may

- Assess effective science communication (i.e., use appropriate numeric, symbolic, graphical, and linguistic modes of representation) in formal lab reports.

Students may

- Reflect on and assess their personal effectiveness, and the effectiveness of peers, communicating during investigations.
- Use appropriate modes of representation to communicate ideas, plans, and results of in-class investigations and science projects.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 374-375, 381, 387-393

Communication and Teamwork

Outcomes	Focus for Learning
Students will be expected to	
27.0 identify multiple perspectives that influence a science-related decision or issue [GCO 2]	Individuals may have strong feelings about social and environmental issues that affect them. Their perspective influences their decisions. When analyzing science-related issues, students should identify relevant stakeholders and their perspectives (i.e., How do they define or perceive the issue?, What assumptions do they make?, What are their values?). Understanding multiple perspectives is an essential component of effective communication and collaboration within problem solving and decision making processes. This skill is specifically addressed in the *Sustainability of Ecosystems* unit. Students should identify multiple perspectives when analyzing, for example, the issue of establishing a marine protected area.
28.0 develop, present, and defend a position or course of action, based on findings [GCO 2]	As part of problem solving and decision making processes, once students have selected a preferred solution or position, the next step is to communicate the decision and take action. This often requires persuading others to act, including those with differing perspectives. Students should develop a position or a course of action regarding a science-related issue. In the *Weather Dynamics* unit, for example, they develop a position in response to climate change deniers or a course of action to mitigate or adapt to a climate change effect. Students are further expected to present and defend their position or course of action. This could be facilitated through debate, role play, or formal presentations with follow up question and answer sessions. Cross curricular connections could be made to English Language Arts 1201 outcomes related to communicating information and ideas effectively and clearly, and responding personally and critically.
29.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]	Students should work collaboratively in science contexts. Collaboration requires that students, for example, • willingly work with others and accept assigned roles; • communicate effectively, listen, and respond appropriately; • seek other points of view and consider multiple perspectives; • suspend personal views and objectively evaluate the ideas of others; • provide and accept constructive criticism; and • use procedures that enable everyone to participate. While this skill is specifically referenced in the *Chemical Reactions* unit, it can be assessed whenever students work in pairs or small groups to investigate, problem solve, and make decisions.

Communication and Teamwork

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss the multiple perspectives that influenced the historical acceptance of the scientific ideas of Galileo and led to his virtual house imprisonment.
- Organize students in pairs and small groups, where possible, to investigate problems, issues, and decisions.

Students may

- Brainstorm possible stakeholders and their perspectives when considering science-related decisions or issues.
- Share past experiences related to cooperative group work and develop a set of guidelines or best practices.

Connection

Teachers may

- Present and use the CurioCity *Issues and Stakeholders* learning strategy to identify the issues and key stakeholders associated with a science-related problem or decision.
- Model developing a position or course of action, based on findings, using the decision to develop gravity based platforms to collect offshore oil as the context.

Students may

- Collaboratively develop a rubric to assess cooperation in group settings from previously established guidelines and best practices. Compare the rubric with the norms of collaboration from English Language Arts and adapt as deemed necessary.
- Use various sources to develop arguments in support of a position or course of action related to a decision or issue.

Consolidation

Students may

- Analyze a science-related issue and, based on findings, adopt a position statement or develop an action plan. Present the position or course action to an audience of peers and defend it.
- Adopt a specific stakeholder perspective and debate science-related decisions and issues with peers.
- Self and peer evaluate cooperation in science contexts when developing and carrying out plans and trouble shooting problems.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 397-400

Suggested

- Appendix D: Guidelines for Collaboration (English Language Arts 2201 Curriculum Guide, p. 97)

Section 3 :
Specific Curriculum Outcomes

Unit 1: Weather Dynamics

Focus

Global climate is controlled by conditions that affect the absorption of radiation from the Sun. An introduction to global weather dynamics is an opportunity for students to understand the relationship between weather patterns and heat transfer between the hydrosphere and atmosphere. As they develop these understandings, they can begin to appreciate the complexity of factors affecting weather dynamics.

The unit provides opportunities to develop and apply numerous inquiry-related skills. In particular, those associated with research inquiry and the analysis and interpretation of data.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

- 34.0 illustrate how science attempts to explain natural phenomena
- 36.0 analyze why scientific and technological activities take place in a variety of individual and group settings
- 37.0 identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology
- 38.0 describe examples of Canadian contributions to science and technology
- 39.0 explain how scientific knowledge evolves as new evidence comes to light
- 40.0 relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary studies

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

- 1.0 identify questions to investigate that arise from practical problems and issues
- 3.0 state a prediction and a hypothesis based on available evidence and background information
- 9.0 use instruments effectively and accurately for collecting data
- 11.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
- 12.0 use library and electronic research tools to collect information on a given topic
- 13.0 select and integrate information from various print and electronic sources or from several parts of the same source
- 17.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
- 21.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
- 22.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
- 24.0 identify new questions or problems that arise from what was learned
- 28.0 develop, present, and defend a position or course of action, based on findings

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

30.0 describe how the hydrosphere and atmosphere act as heat sinks
31.0 describe and explain heat transfer within the water cycle
32.0 describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water currents
33.0 describe and explain the effects of heat transfer within the hydrosphere and atmosphere on the development, severity, and movement of weather systems
35.0 analyze meteorological data for a given time span and predict future weather conditions, using appropriate methodologies and technologies

GCO 4 (Attitudes): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not
- value the contributions to scientific and technological development made by individuals from many societies and cultural backgrounds
- consider further studies and careers in science- and technology-related fields
- use factual information and rational explanations when analyzing and evaluating
- value the processes for drawing conclusions
- have a sense of personal and shared responsibility for maintaining a sustainable environment
- be aware of the direct and indirect consequences of their actions

SCO Continuum

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Science 5	Science 7	Science 1206
Weather	*Heat*	*Weather Dynamics*
• describe weather in terms of temperature, wind speed and direction, precipitation, and cloud cover • describe situations demonstrating that air takes up space, has weight, and expands when heated • relate the constant circulation of water on Earth to evaporation, condensation, and precipitation • describe and predict patterns of change in local weather conditions • identify patterns of indoor and outdoor air movement • describe key features of a variety of weather systems • relate the transfer of energy from the Sun to weather conditions	• compare instruments used to measure temperature • explain temperature, using kinetic energy and the particle model of matter • explain how matter reacts to temperature change • explain changes of state using the particle model • compare conduction, convection, and radiation • describe how various surfaces absorb radiant heat • explain using the particle model, differences among heat capacities of materials	• describe and explain heat transfer within the water cycle • describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water • describe how the hydrosphere and atmosphere act as heat sink within the water cycle • describe the effects of heat transfer within the hydrosphere and atmosphere on the development, severity, and movement of weather systems • analyze meteorological data for a given time span and predict future weather conditions using appropriate methodologies and technologies
	Science 8	
	• describe the water cycle • describe the interactions of ocean currents, winds and regional climates • describe the different types of electromagnetic radiation • compare visible light to other types of electromagnetic radiation • describe the relationship between mass, volume, and density using the particle model • explain the effects of temperature on density and relate to the particle model • describe quantitatively the relationship between force, area, and pressure • explain qualitatively the relationship between pressure, volume, and temperature of fluids	

Suggested Unit Plan

Weather Dynamics is the Earth science unit of the Science 1206 curriculum. It is the last Earth or space science unit in the common K-10 Science program.

The unit is positioned at the beginning of the course to capitalize on opportunities for outdoor weather observations and measurement of weather components.

September	October	November	December	January	February	March	April	May	June
Weather Dynamics			**Chemical Reactions**		**Motion**		**Sustainability of Ecosystems**		
Skills Integrated Throughout									

Inquiring About Weather

Outcomes

Students will be expected to

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

Focus for Learning

As part of the *Weather Dynamics* unit, students should analyze meteorological data and predict future weather. It is recommended that local weather data, weather maps, radar, satellite imagery, and forecasts be reviewed daily as part of class activities.

Weather-related knowledge outcomes, were addressed in previous science courses (Refer to the SCO continuum on p. 89 of this guide and pp. 4-7 of *NL Science 10*). Assessment of students' prerequisite knowledge and reteaching, where necessary, is recommended.

Students should routinely be asked to identify questions which they or others could investigate; questions whose answers require empirical evidence (i.e., information acquired from observations or experimentation). The complexity of factors affecting weather dynamics provide ample context to identify scientific questions. Throughout the unit, questions to investigate could arise from

- discussion of weather's influence on our lives and society;
- curiosity about weather and weather lore;
- careful observation and measurement of weather conditions;
- investigations to determine the relationships between variables (e.g., altitude and air temperature, albedo and the absorption of energy, atmospheric pressure and humidity) and unexpected results;
- examining how the particle theory of matter explains weather-related phenomena (e.g., density, heat transfer, state changes, temperature);
- examining the effects of heat transfer on air and water currents;
- reading weather- and climate-related informational texts;
- analyzing and interpreting weather reports, weather station models, weather maps, and radar and satellite imagery;
- forecasting future weather conditions;
- analyzing and interpreting historical meteorological data; or
- analyzing climate change evidence.

Refer to the *Integrated Skills* unit for elaboration of this skill outcome. Where possible, students should be provided opportunities to investigate their own questions and to share their findings.

Attitude

Encourage students to value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not. [GCO 4]

Inquiring About Weather

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Ask students to observe and describe weather using their senses.

Students may

- Personally create a concept map for weather. Repeating this activity later in the unit may provide evidence of learning.

Connection

Teachers may

- Create and play an interactive game, such as “Around the Room” or “Jeopardy” to review prerequisite weather-related concepts and terminology.
- Demonstrate conduction, convection, and radiation using appropriate tools and apparatus (e.g., conductometer, convection/ventilation box, convection of liquids tube).

Students may

- Complete the K and W sections of a KWLM chart for weather. As the unit progresses, learning and new questions can be recorded in the L and M sections.

Consolidation

Students may

- Engage in experiences to facilitate the identification of questions to investigate.
  - Research local weather lore.
  - Reflect on a weather report or forecast they recently saw on television, heard on the radio, or read online or in a newspaper and discuss with peers the conditions of the atmosphere that were described.
  - Discuss how weather information impacts our daily lives and decision making.
  - Explore nomenclature used to describe cloud types.
  - Explore a collection of weather-related tools and instruments.
  - Interpret diagrams of the electromagnetic spectrum, water cycle, and representations of matter particles in solids, liquids, and gases.
  - Use a flashlight and globe to model the affects of Earth’s tilt on levels of incoming solar energy.
  - Discuss how the density of a fluid (i.e., a liquid or gas) changes with temperature and pressure.

Resources and Notes

Authorized

NL Science 10 (Teacher Resource [TR])

- TR-1 pp. 7-15

NL Science 10 (Student Resource [SR])

- pp. 4-9

Supplementary

- Digital Weather Station

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Weather information sources (websites)

Heat Transfer and Earth's Spheres

Outcomes

Students will be expected to

30.0 describe how the hydrosphere and atmosphere act as heat sinks
[GCO 3]

Focus for Learning

Students should demonstrate understanding of the interactions among energy from the Sun and Earth's spheres (i.e., atmosphere, biosphere, hydrosphere, lithosphere), and their influence on weather. Students should

- describe Earth's energy budget (i.e., the flow of energy from the Sun to Earth, and the outward flow of energy from Earth);
- investigate and describe the effect of albedo on absorption of radiant energy;
- relate the high specific heat capacity of water, relative to land, to how the hydrosphere acts as a heat sink;
- investigate how the specific heat capacity of different surfaces (i.e., land and water) affects the temperature of the air above it;
- describe how energy absorbed by Earth's surface is transferred to the atmosphere by conduction, convection, and radiation; and
- describe the greenhouse effect and relate it to how the atmosphere acts as a heat sink.

Students should recognize that the ability of atmosphere and hydrosphere to store and transfer thermal energy has a significant influence on our local weather dynamics.

As indicated above, students should carry out investigations related to albedo and specific heat capacity. They could, for example, use a light source to

- heat different surface materials (e.g., sand, soil, water) to determine how colour and material affect an object's ability to absorb and release (emit) radiation; and
- compare how sand and water's ability to absorb and release heat affects the temperature of the air above them.

These initial investigations provide opportunities to review science inquiry processes and address outcomes from the *Integrated Skills* unit (e.g., 1.0-11.0, 14.0, 17.0, 18.0, 20.0-22.0, 24.0-26.0, 29.0).

Teachers should regularly reflect on where investigations fall on an inquiry continuum. Teacher-directed investigations provide limited evidence to assess students' achievement of skill outcomes. The use of guided and open inquiry, where possible, is strongly recommended.

Sample Performance Indicators

1. How does specific heat capacity explain temperature differences between coastal and inland communities in summer and winter?
2. Construct labelled diagrams to illustrate Earth's energy budget (i.e., energy flow from the Sun to Earth and outward from Earth).
3. Describe how energy absorbed by Earth's surface is transferred and transported to the atmosphere by conduction, convection, and radiation.

Heat Transfer and Earth's Spheres

Sample Teaching and Assessment Strategies

Activation

Students may

- Create a graphic organizer to represent the relationship among the atmosphere, biosphere, hydrosphere and lithosphere.

Connection

Teachers may

- Demonstrate the specific heat capacities of different solids and liquids (e.g., different metals, water, cooking oil).
- Discuss how and why heated rocks were traditionally placed under the blankets, by your feet, while sleeping.

Students may

- Plot the average temperature of the atmosphere at increasing altitudes (Activity 1-1B, *NL Science 10,* p. 12). Analyze the plotted graph and explain patterns and trends occurring in the troposphere, stratosphere and mesosphere.
- Interpret a diagram depicting Earth's radiation and solar radiation against the electromagnetic spectrum (Figure 1.3, *NL Science 10*, p. 13).
- Analyze regional sea surface temperature maps and compare with land temperatures. Discuss how observed differences might affect the movement of air.
- Discuss the albedo of sea ice and open water and potential heat-related effects.

Consolidation

Students may

- Carry out Investigation 1-1E *Albedo and Surfaces, (NL Science 10,* p. 23) recording observations in data tables. Use the data to graph the heating and cooling of each material.
- Carry out Investigation 1-1F *Heat Sinks, (NL Science 10,* p. 24). Use the recorded data to graph how temperature changes both within each material and in the air directly above.
- Create a diagram to explain how conduction, convection, and radiation transfer thermal energy in Earth's atmosphere.
- Create a "day in the life" cartoon of one unit of solar energy on its journey from the Sun to Earth's surface and back into outer space.
- Discuss how local weather conditions would differ without the presence of the natural greenhouse effect.

Resources and Notes

Authorized

NL Science 10 (TR)

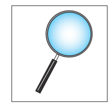
- TR-1 pp.16-20, 24-25

NL Science 10 (SR)

- pp. 10-17, 23-24

Notes

The magnifying glass icon is used throughout the unit to indicate investigations.



Heat Transfer in the Water Cycle

Outcomes

Students will be expected to

31.0 describe and explain heat transfer within the water cycle
[GCO 3]

11.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
[GCO 2]

17.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
[GCO 2]

22.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
[GCO 2]

Focus for Learning

The water cycle was previously addressed in Science 5 and 8. Students learned how water circulates between the hydrosphere and atmosphere through a continuous cycle of evaporation and condensation. In Science 1206, students should describe and explain the transfer of heat within the cycle.

Students should

- relate changes of state (e.g., condensation, evaporation, melting, solidification, sublimation) to the absorption or release of heat;
- relate heat transfer to the breaking and formation of bonds (i.e., attractive forces holding water molecules together) during changes of state;
- investigate changes in temperature as water changes states (i.e., heating curve of water) and define the latent heat of fusion and vapourization; and
- describe and explain heat transfer in the water cycle.

To investigate how water temperature changes as it changes state, student should add crushed ice to a beaker until at least half full and place it on a hot plate. Then, turning the hot plate on its highest setting, measure and record the temperature of the ice-water at regular intervals until the water has boiled for several minutes.

As part of this investigation, students should compile and organize their collected data (e.g., data table), display their data (e.g., a graph of the heating curve of water), and draw a conclusion. Assessment of SCOs 11.0 and 17.0 should focus on appropriateness of selected formats, labelling, accuracy, and aesthetic.

Additional skills which could be addressed and assessed include: carrying out procedures, adapting or extending where required (8.0); using instruments effectively and accurately to collect data (9.0); and interpreting patterns of trends in data (18.0). Refer to the *Integrated Skills* unit for elaboration of skill outcomes.

Attitude

Encourage students to value the processes for drawing conclusions.
[GCO 4]

Sample Performance Indicator

Annotate a blank diagram of the water cycle; describing and explaining how the cycle transfers heat.

Heat Transfer in the Water Cycle

Sample Teaching and Assessment Strategies

Activation

Students may

- Analyze and interpret varied diagrams of the water cycle.

Connection

Teachers may

- Demonstrate the processes of evaporation and condensation using appropriate tools and apparatus (e.g., heat a sample of water on a hot plate below a suspended container of ice water).
- Discuss the effects of evaporative cooling on temperature.

Students may

- Conduct a “heating curve of water” investigation then analyze and interpret temperature vs time graphs drawn from the collected data to define the latent heat of fusion and vapourization.
- Describe and explain heat transfer during the processes of melting and solidification (freezing).
- Create a diagram to represent the changes of state of water and whether energy is absorbed or released for each change.
- Describe and explain how heat is transported within the water cycle.
- Describe how the water cycle links the hydrosphere to Earth’s other spheres.

Consolidation

Students may

- Create a model that illustrates and describes the role energy plays in the movement of water and the transfer of heat in the water cycle (Activity 1-1D, *NL Science 10*, p. 22).
- Discuss the effect that energy released during condensation might have on the surrounding air.
- Create and annotate a diagram to trace the path of one unit of solar energy on its journey from the Sun to Earth’s oceans and then through the water cycle to the atmosphere.

Extension

Students may

- Devise and carry out investigations to identify factors that affect the evaporation of water.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 22-23

NL Science 10 (SR)

- pp. 21-22

The Effects of Heat Transfer in the Hydrosphere and Atmosphere

Outcomes

Students will be expected to

32.0 describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water currents
[GCO 3]

33.0 describe and explain the effects of heat transfer within the hydrosphere and atmosphere on the development, severity, and movement of weather systems
[GCO 3]

Focus for Learning

Students are expected to

- describe and explain convection and advection and their relation to air and water currents;
- relate Earth's shape and the angle of incoming solar energy to the unequal heating of Earth's surface (i.e., regions close to the equator absorb more energy and are generally warmer than regions closer to the poles);
- describe and explain how heat transfer from Earth's surfaces to the air directly above affects air density, movement, and pressure in the atmosphere;
- describe the formation and characteristics of air masses (i.e., arctic, continental polar, continental tropical, maritime polar, maritime tropical);
- explain the formation of high and low pressure systems and describe their characteristic wind movements and associated weather;
- describe how the combination of convection currents and the Coriolis effect create global wind patterns;
- identify global wind systems and relate prevailing winds to the movement of weather systems;
- describe the effects of the polar jet stream on the development, severity, and movement of local weather systems;
- describe the development of warm, cold, stationary, and occluded fronts and their associated weather conditions;
- describe how surface currents move thermal energy around Earth;
- describe the effects of the Gulf Stream and Labrador Current on local weather; and
- explain how differences in temperature and salt content form deep ocean currents that move thermal energy around Earth.

Sample Performance Indicators

1. Differentiate between convection and advection.
2. Explain the formation of atmospheric convection currents.
3. Identify and describe the characteristics of air masses affecting North America.
4. Compare and contrast the development of high and low pressure systems.
5. Explain how the polar jet stream and prevailing winds affect the development, severity, and movement of local weather systems.
6. Describe how a cold front develops and the kind of weather that is associated with this type of front.
7. Explain the effects of the Gulf Stream and Labrador Current on local weather.

The Effects of Heat Transfer in the Hydrosphere and Atmosphere

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Demonstration convection using a flying tea bag. Remove the tea, staple, and string from a tea bag so that a hollow cylinder remains. Stand the cylinder upright on a piece of aluminum foil and light the top of the cylinder. Students should observe and explain the movement of the tea bag.

Students may

- Create a "lava lamp" to model the movement of air in the atmosphere. Fill a 1 L plastic bottle ¾ full with water. Slowly add vegetable oil until the bottle is almost full. Once separate add ten drops of food colouring. Add ½ of an effervescent tablet to create movement.

Connection

Students may

- Use a flashlight and a sheet of graph paper to investigate how the angle of sunlight (e.g., 90°, 60°, 30° from horizontal) affects the amount of energy reaching Earth's surface.
- Place a coloured ice cube into a container of warm, salt water. Observe the movement of the coloured water over time and relate to the formation of currents in the atmosphere and hydrosphere.
- Model the Coriolis Effect (Activity 1-2A, *NL Science 10*, p. 29).
- Consider how prevailing winds and jet streams may affect the flight paths and flying times.
- Compare wind and surface current directions in diagrams of Earth's global wind patterns and global surface currents.

Consolidation

Students may

- Draw and annotate diagrams to explain the development of high and low pressure systems in the northern hemisphere.
- Explain how wind relates to high and low pressure systems.
- Discuss the role of landmasses and the Coriolis effect in the direction of surface currents.
- Discuss why deep ocean currents are referred to as the great ocean conveyor belt.

Extension

Students may

- Research and describe the effects of upwelling on local fisheries.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 20, 30-34

NL Science 10 (SR)

- pp. 16-17, 26-33

Scientific Explanations of Extreme Weather

Outcomes

Students will be expected to

34.0 illustrate how science attempts to explain natural phenomena [GCO 1]

Focus for Learning

This intent of this STSE outcome is to highlight the nature of science to construct explanations for natural phenomena.

To illustrate, students should use research inquiry to describe and explain the development and characteristics of extreme weather (i.e., hurricanes, nor'easters, thunderstorms, tornadoes, El Niño, La Niña). The use of a cooperative jigsaw strategy is recommended for this activity.

Students should use multiple information sources to collect information and summarize their results using a format of their choice.

This research activity provides an opportunity to address and assess other skills outcomes:

- Use library and electronic research tools to collect information on a given topic (SCO 12.0)
- Select and integrate information from various print and electronic sources or from several parts of the same source (SCO 13.0).
- Select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results (SCO 26.0).
- Work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (SCO 29.0).

Refer to the *Integrated Skills* unit for elaboration of these outcomes

Attitude

Encourage students to value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not. [GCO 4]

Sample Performance Indicator

Research how science explains hurricanes, nor'easters, thunderstorms, tornadoes, El Niño, or La Niña and communicate a summary of your research findings using an appropriate format.

Scientific Explanations of Extreme Weather

Sample Teaching and Assessment Strategies

It is recommended that students create and maintain a personal STSE portfolio (digital or print). As the course progresses, students should add science-related articles, from traditional or social media, to their portfolio, and tag them with one or more outcomes from a provided list of course STSE outcomes [GCO 1].

Activation

Students may

- View online videos of extreme weather events.
- View weather warnings and public alert sections of online weather information sources.

Connection

Teachers may

- Incorporate the tracking of current hurricanes and storms, when possible, into class activities.
- Facilitate a cooperative jigsaw activity. Organize students into home groups of six. In each home group, assign a different extreme weather type (i.e., hurricanes, nor'easters, thunderstorms, tornadoes, El Niño, La Niña) to each student. Reorganize students into expert groups according to extreme weather type and direct them to collaboratively carry out their research activities. Once completed, students individually prepare a summary of their research findings. Reform home groups and ask each student to communicate their findings to their group.

Students may

- Determine the date of a local, extreme weather event and view available historical weather data for that date from a weather information source.
- Brainstorm potential sources of extreme weather-related science information.
- Compile information related to their research topic from a variety of information sources.
- Discuss the merits of different formats that could be used to communicate scientific explanations to classmates.
- Analyze and interpret maps of sea surface temperatures (available daily from Environment Canada).

Consolidation

Students may

- Communicate the findings of their research to their peers in an appropriate format for conveying scientific explanations.
- Compare and contrast El Niño and La Niña years, and hurricanes and nor'easters.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 35-37

NL Science 10 (SR)

- pp. 34-38

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Hurricane centres (websites)

Observing, Measuring, and Recording Weather

Outcomes

Students will be expected to

9.0 use instruments effectively and accurately for collecting data
[GCO 2]

21.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
[GCO 2]

17.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
[GCO 2]

Focus for Learning

Students should investigate local weather conditions by observing, measuring, and recording meteorological data obtained firsthand using weather instruments and tools.

Students should

- observe and qualitatively describe weather, sky cover (i.e., clear, a few clouds, scattered clouds, partly cloudy, mostly cloudy, overcast) and precipitation intensity (i.e., light, moderate, heavy);
- measure atmospheric pressure using a barometer (kPa) and, if possible, indicate the pressure trend (i.e., rising, falling, stable);
- measure precipitation using a rain gauge (mm);
- measure relative humidity using a hygrometer or sling psychrometer (%);
- measure temperature using a thermometer (°C);
- determine wind direction using a wind vane and compass (compass points); and
- measure wind speed using an anemometer (km/h).

Instruction in the use of weather tools and instruments may be necessary. Potential sources of measurement error, for each instrument, should be discussed prior to use. Students' ability to use these instruments effectively and accurately for data collection should be assessed. Recorded measurements should include all definite digits and one estimated digits. The use of digital weather instruments and probeware, in addition to traditional instruments, is encouraged.

Normal atmospheric pressure should be identified as 101.3 kPa.

Students are also expected to compile and display their collected data and information in a weather report of current conditions. Online weather reports may be used as exemplars of appropriate formats. Students should use appropriate numeric, symbolic, and linguistic modes to represent their meteorological data and information (SCO 26.0). Refer to the *Integrated Skills* unit for elaboration of the associated skills.

Sample Performance Indicators

1. Peer out the nearest window. Qualitatively describe current weather conditions and predict quantitative values of measurable weather components (atmospheric pressure, humidity, temperature, wind direction and wind speed).
2. Use a(n)
   - sling psychrometer to measure relative humidity,
   - aneroid barometer to measure atmospheric pressure and indicate the pressure trend,
   - wind vane and compass to determine wind direction, and
   - anemometer to measure wind speed.
3. Use weather tools and instruments to collect indoor meteorological data and create a classroom weather report.

Observing, Measuring, and Recording Weather

Sample Teaching and Assessment Strategies

Firsthand collection of local, meteorological data may be incorporated into daily class routines, along with the review of current weather data and forecasts from weather information sources. It is recommended that a different student be made responsible for data collection each day and their ability to effectively and accurately use the tools and instruments be assessed.

Activation

Students may

- Analyze a weather report to identify the components of weather and discuss how each component may have been measured (Activity 2-1A, *NL Science 10*, p. 49)

Connection

Teachers may

- Review cloud types illustrated on page 5 of *NL Science 10.* Ask students to refer to the illustration when describing clouds.
- Provide a collection of weather-related tools and instruments for student use.

Students may

- Construct a sling psychrometer from two liquid-in-glass thermometers. Attach wet gauze to the tip of one thermometer. Twirl both thermometers in the air and record their temperatures. Temperature differences can be compared with a table of values to determine relative humidity.
- Discuss what a rising or falling pressure trend might indicate in terms of future weather.
- View exemplars of weather reports to determine appropriate formats to display collected meteorological data and information.

Consolidation

Students may

- Create a weather report from local meteorological data obtained firsthand using weather instruments and tools.
- Compare their firsthand collected data with data from digital tools and/or a school-based weather station and discuss discrepancies.

Extension

Students may

- Compile and display data as a surface weather station model.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 45-46
- BLMs 1-14, 2-4, 2-5, 2-6

NL Science 10 (SR)

- pp. 42-45, 49

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/teaching-and-learning-strategies.html
  - *Teaching Weather Dynamics*

Supplementary

- Digital weather station

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Science supply companies (websites)
- Weather information sources (websites)

Weather Forecasting and Limitations

Outcomes

Students will be expected to

35.0 analyze why scientific and technological activities take place in a variety of individual and group settings
[GCO 1]

21.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
[GCO 2]

Focus for Learning

Individuals can forecast weather based on analysis of a single data set. Meteorologists, however, use multiple data sets collected from multiple information sources (i.e., group setting).

Meteorologists combine data collected by individual observers, with data from automatic weather stations (land-based and weather buoys), weather balloons, weather radar, and weather satellites. Their forecasts are based on analysis of the combined meteorological data. Students should recognize that the accuracy of forecasts is enhanced when data from multiple sources are combined.

Students are expected to

- explore the methodologies and technologies (e.g., weather balloons, weather radar, weather satellites, weather maps, weather station models, computer models) used by meteorologists use to create short- and long-range forecasts;
- analyze and interpret radar and satellite images, and weather maps; and
- explain possible sources of error when interpreting radar and satellite images.

Additionally, students should devise and carry out a plan to evaluate the accuracy of hourly, short-range, and long-range forecasts produced by weather information sources (e.g., Environment Canada, The Weather Network). They should come to recognize that while short-range forecasts are quite accurate, long-range forecast are much less accurate, due to the unpredictability of the atmosphere. As technology continues to develop, however, the accuracy of long-range forecast will improve.

Devising and carrying their plan could provide evidence to assess numerous skill outcomes (e.g., SCOs 1.0, 11.0, 17.0, 18.0, 22.0, 26.0, 29.0). Refer to the *Integrated Skills* unit for elaboration of skill outcomes.

Sample Performance Indicators

1. Interpret a weather map, using a provided symbol key, and write the script for a television weather reporter to explain the current weather conditions described (See Activity 2-2B, *NL Science 10*, p. 54).
2. What advantage does combining data from multiple sources provide when creating short-range forecasts?
3. What is the main limitation of weather forecasting?

Weather Forecasting and Limitations

Sample Teaching and Assessment Strategies

Weather radar and satellite images use coordinated universal time (UTC). To convert to local time, students in the Newfoundland time zone should subtract 2½ hours from UTC during daylight savings and 3½ hours during standard time. Labrador students in the Atlantic time zone should subtract 3 hours from UTC during daylight savings and 4 hours during standard time.

Connection

Teachers may

- Review common symbols found on weather maps (i.e., fronts, jet stream, isobars, isotherms, pressure systems).

Students may

- Tag articles in their STSE portfolio exemplifying how science and technology take place in a variety of individual and group settings.
- View and interpret online, weather radar images from Holyrood or Marble Mountain weather stations.
- View and interpret weather satellite images for eastern Canada.
- Assess the following when analyzing a weather map
  - fronts (What weather is associated with each front type?);
  - pressure systems (What weather is associated with the system? What direction does wind flow around the system?);
  - isobars (How close are the isobars? [the closer together the stronger the winds]); and
  - isotherms (What is the temperature in different areas?).

Consolidation

Students may

- View current weather conditions, provided by a weather information source, and predict how weather conditions might change in the next 1-2 hours.
- Discuss possible sources of error when interpreting radar and satellite images used to predict the weather.
- Access *The Weather Network* online and record their hourly, 36 hour, and 14 day forecasts. Devise and carry out a plan to monitor weather conditions to determine and compare the accuracy of their hourly, 36 hour, and 14 day forecasts. Students should communicate a summary of their results.

Extension

Students may

- Analyze and interpret weather station models and describe the recorded weather conditions using written language (Activity 2-2C, *NL Science 10,* p. 54).

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 52-53

NL Science 10 (SR)

- pp. 44-49, 52-57, 60-65

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/teaching-and-learning-strategies.html
  - *Teaching Weather Dynamics*

Supplementary

- Digital weather station

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Weather information sources (websites)

Developing a Short-Range Weather Forecast

Outcomes

Students will be expected to

36.0 analyze meteorological data for a given time span and predict future weather conditions, using appropriate methodologies and technologies [GCO 3]

3.0 state a prediction and a hypothesis based on available evidence and background information [GCO 2]

13.0 select and integrate information from various print and electronic sources or from several parts of the same source [GCO 2]

Focus for Learning

Students should develop and present their own short-range forecast. In developing their forecast, students should analyze and interpret the following meteorological data to identify patterns and trends:

- local weather conditions for the past 24 hours,
- a sequence of weather maps,
- a sequence of satellite images for Eastern Canada, and
- a sequence of radar images, if available, for the local area.

Meteorological data should be obtained from weather information sources. Environment Canada, for example, provides satellite images every 15 minutes, radar images at 10-20 minute intervals, and detailed weather maps, which include weather station models, four times daily.

The process of developing and presenting a short-range forecast provides evidence to assess numerous skill outcomes. In addition to outcomes 3.0, 13.0, and 28.0, the following skill outcomes could be assessed:

- Evaluate and select appropriate instruments for collecting evidence (SCO 6.0).
- Compile and organize data to facilitate interpretation (SCO 11.0).
- Interpret patterns and trends in data (SCO 18.0).
- Compile and display evidence and information (SCO 17.0).
- Evaluate the relevance, reliability, and adequacy of data and data collection methods (SCO 20.0).
- Select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate results (SCO 26.0).

Refer to the *Integrated Skills* unit for elaboration of skill outcomes.

Attitude

Encourage students to use factual information and rational explanations when analyzing and evaluating. [GCO 4]

Sample Performance Indicator

Analyze a sequence of Canadian coverage weather maps, obtained from Environment Canada, and develop a forecast for your local community.

Developing a Short-Range Weather Forecast

Sample Teaching and Assessment Strategies

Student forecasts may be developed as part of a unit project. Alternatively, individual students may develop and orally present a short-term forecast as part of the daily routine review of local weather information sources.

Connection

Teachers may

- Differentiate between persistence forecasting and nowcasting.

Students may

- View *Weather Forecasting Tutorial* as an exemplar of methodologies and technologies used in the development of forecasts.
- View television weather forecasts as exemplars of appropriate formats for presenting short-range forecasts.
- Analyze local weather data for the past several hours, interpret how the data is changing, and predict weather conditions for the next 1-2 hours (i.e., persistence forecasting). Then monitor conditions to evaluate the accuracy of their forecast.
- Analyze a sequence of radar images from the Holyrood or Marble Mountain radar stations and predict future changes in precipitation for a specific community.
- Analyze a sequence of satellite images for Eastern Canada and predict future changes in cloud cover for their community.
- Analyze a sequence of daily weather maps obtained from a newspaper and predict future weather for their region.
- Analyze a sequence of weather maps used by meteorologists to predict future weather for their region.

Consolidation

Students may

- Compare their personally created short-term forecast with those produced by weather information sources.
- Monitor weather conditions to evaluate the accuracy of their personally created short-term forecast.
- Use video and green screen technology to create their own television style weather forecast.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 p. 55

NL Science 10 (SR)

- pp. 44-49, 52-55, 58

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/teaching-and-learning-strategies.html
  - *Weather Forecasting Tutorial*

Supplementary

Digital weather station

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Weather information sources (websites)

Role of Technology in Meteorology

Outcomes

Students will be expected to

37.0 identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology [GCO 1]

Focus for Learning

This STSE outcome highlights an aspect of the relationship between science and technology; the invention of new technologies enhance or revise our scientific understanding of phenomena.

When applied to the context of weather dynamics, students should identify examples where weather-related knowledge evolved as a consequence of technological development:

- The invention of weather tools and instruments led to quantitative record keeping of weather conditions. Identifying patterns in these records aided weather forecasting.
- The development of weather radar technology, used to detect precipitation and determine its speed and direction, enabled meteorologists to calculate the direction of movement and speed of weather systems.
- The development of orbiting weather satellites provided a wealth of continuous meteorological data. Monitoring changes in the data helped meteorologists better understand the development and movement of weather systems.
- The development and continuous improvement of computer-based analysis of past meteorological data and computer modelling have enhanced the accuracy of weather predictions.
- The development of weather-related tools and instruments for use on spacecrafts is enhancing and revising our understanding of atmospheric conditions on other objects in our solar system.

38.0 describe examples of Canadian contributions to science and technology [GCO 1]

Students are further expected to describe examples of Canadian contributions to weather-related science and technology. Examples could include the three cup anemometer, humidex scale, UV index, LIDAR and other components of the Mars *Phoenix* spacecraft's meteorological package (The Maple Leaf Lands on Mars, *NL Science 10*, p. 50), the first computer-based simulations of weather patterns and forecasts (André Robert), and the Canadian GEM global forecasting model.

Attitude

Encourage students to value the contributions to scientific and technological development made by individuals from many societies and cultural backgrounds. [GCO 4]

Sample Performance Indicator

Describe how scientific knowledge evolved as a consequence of the Canadian Space Agency's contributions to the Mars *Phoenix* spacecraft's meteorological package.

Role of Technology in Meteorology

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present for discussion, examples of local weather lore used in weather prediction:
  - In like a lion, out like a lamb.
  - Red sky at night, sailors delight; red sky in morning, sailors take warning.

Connection

Teachers may

- Facilitate a cooperative jigsaw activity to explore Canadian weather-related science and technology contributions.
- Assign different Canadian weather-related science or technology contributions to student groups. Ask them to briefly research and share their learning with classmates (Activity 2-2D, *NL Science 10*, p. 57).

Students may

- Tag articles in their STSE portfolio exemplifying Canadian contributions to science and technology and the enhancement or refinement of scientific knowledge as a consequence of the invention of technology.
- Predict future weather using firsthand observations of cloud types and movement (Activity 2-2A, *NL Science 10*, p. 52) as an example of forecasting before the development of weather-related technologies.
- Devise and carry out an investigation to evaluate the accuracy of local weather lore.

Consolidation

Students may

- Discuss how the development of weather-related technologies has improved, and will continue to improve, the accuracy of weather forecasting.

Extension

Students may

- Compare forecasts created by Canadian, American, and European forecasting models.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 47, 51, 54

NL Science 10 (SR)

- pp. 44-48, 50

Supplementary

- Digital weather station

Climate Change

Outcomes

Students will be expected to

39.0 explain how scientific knowledge evolves as new evidence comes to light [GCO 1]

Focus for Learning

Although reliable and durable, scientific knowledge is tentative; it is subject to change in the light of new evidence or a new interpretation of existing evidence. Students should explain this tenet of the nature of science using the evolution of knowledge related to climate change as the context.

Students should

- differentiate between weather and climate;
- recognize that data obtained from ice-cores, tree rings, and fossils, used to infer past conditions on Earth, suggest Earth's climate has naturally undergone periods of global cooling and warming;
- analyze and compare graphs representing changes in the concentration of atmospheric carbon dioxide and Earth's surface temperatures, over time, and describe their relationship;
- analyze graphs representing recent changes in Earth's surface temperatures (e.g., since 1880), recognize that the warming trend is occurring at a faster rate than previous warming periods, and explain how this new evidence suggests an enhanced, anthropogenic greenhouse effect;
- explain how human-produced greenhouse gases (GHG) contribute to the enhanced the greenhouse effect and an increased rate of global warming; and
- relate global warming to climate change (i.e., changes in local air and water temperatures, rain and snowfall patterns, frequency and severity of storms, wind patterns, ocean currents).

Attitude

Encourage students to have a sense of personal and shared responsibility for maintaining a sustainable environment. [GCO 4]

Climate Change

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Provide examples where scientific knowledge evolved as new evidence came to light, for example
  - Isaac Newton's observations supporting a heliocentric universe;
  - Louis Pasteur's experiments challenging the accepted theory of spontaneous generation;
  - lines of evidence corroborating Alfred Wegener's proposed theory of continental drift; and
  - discovery of previously hypothesized ice in Mars soil samples, by the *Phoenix* rover, suggesting that Mars may have been able to sustain life.

Students may

- Discuss prior knowledge of climate change (Activity 2-4A, *NL Science 10*, p. 68).

Connection

Students may

- Tag articles in their STSE portfolio exemplifying how scientific knowledge evolves in the light of new evidence.
- Complete an investigation to understand how ice-core data provides information on past climate conditions (Investigation 2-4B, *NL Science 10,* p. 75).
- Analyze, interpret, and draw conclusions from graphs representing Earth's average global surface temperatures and concentrations of atmospheric carbon dioxide, over time (e.g., Figure 2.21 A and 2.21B, *NL Science 10*, p. 69).
- Identify human activities that produce GHG (i.e., carbon dioxide, methane, nitrous oxide, and halocarbons).
- Carryout an investigation to model of the greenhouse effect (Investigation 2-4C, *NL Science 10*, p. 76).

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 65-68

NL Science 10 (SR)

- pp. 68-76

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Climate change resources (websites)

Impact of Climate Change

Outcomes

Students will be expected to

12.0 use library and electronic research tools to collect information on a given topic [GCO 2]

24.0 identify new questions or problems that arise from what was learned [GCO 2]

28.0 develop, present, and defend a position or course of action, based on findings [GCO 2]

Focus for Learning

Students should use research inquiry to investigate effects of climate change on an ecosystem. Investigation of marine ecosystems is the recommended context. As part of their investigation, students should

- work collaboratively with group members to develop and carry out a plan;
- use research tools to find sources of information;
- evaluate the relevance and reliability of information sources;
- select, organize, and integrate information from sources deemed reliable; and
- compile, display, and present the information, in an appropriate format of their choosing.

In addition to SCO 12.0, this research inquiry investigation could provide evidence to assess SCOs 13.0, 17.0, 26.0, and 29.0 (refer to the *Integrated Skills* unit for elaboration).

Identified impacts on marine ecosystems include

- oceans becoming warmer and more acidic;
- sea ice melting and sea levels rising;
- an increase in extreme weather;
- habitat changes, damage, and loss; and
- organism changes (i.e., altered habitats or behaviours, endangerment and extinction, survival of new invasive species).

Invariably, investigating effects of climate change on marine ecosystems will lead to new questions related to, for example,

- the impacts of warming oceans and acidification on local organisms and local marine ecosystems;
- the local impacts of disappearing Arctic sea ice, rising sea levels, and increased severity of storms; and
- mitigating and adapting to climate change.

Provide opportunity for students to collaboratively explore new questions or problems that arise.

Having investigated the issue of climate change, students should develop, present, and defend

- a position in response to climate change deniers (i.e., individuals who deny climate change is occurring, or agree it is occurring, but believe it is not caused by human activities); or
- a course of action (i.e., personal, local, or global) to mitigate or adapt to climate change.

Attitude

Encourage students to be aware of the direct and indirect consequences of their actions. [GCO 4]

Impact of Climate Change

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Present animations and videos depicting changes in Earth's global surface temperature.
- Present videos relating the impacts of global warming and climate change.
- Distinguish between climate change mitigation and adaptation.

Students may

- Add climate change-related articles to their STSE portfolio and tag them with appropriate STSE outcomes.
- Use an online calculator to determine their personal carbon footprint.
- Compile a list of personal, local, or global actions to mitigate climate change.

Consolidation

Teachers may

- Organize a marine ecosystem mini-conference. Ask student groups to briefly present their research findings related to a climate change impact. Following each presentation, ask student "attendees" to identify personal questions arising from what was learned.
- Organize a mock climate change debate by personally adopting the position of a climate change denier and challenging students to develop, present, and defend a position accepting climate change as accepted scientific knowledge.

Students may

- Select, in pairs or small collaborative groups, a personal, local, or global action to mitigate or adapt to climate and develop an implementation action plan.
- Complete a cost-benefit analysis of potential actions to address climate change (Unit 1 Project, *NL Science 10*, pp. 82-83).
- Investigate new questions that arise as part of a science project.

Extension

Students may

- Investigate and compare the albedo of ice and seawater and infer how the loss of arctic sea ice might affect northern aquatic ecosystems.
- Use research inquiry to investigate effects of climate change on local terrestrial ecosystems.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 65-68

NL Science 10 (SR)

- pp. 73-74, 82-83

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Climate change resources (websites)

Science Disciplines

Outcomes

Students will be expected to

40.0 relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary studies [GCO 1]

Focus for Learning

To meet the expectation of this nature of science and technology outcome, students should relate scientific and technological activities to specific science disciplines and interdisciplinary studies (i.e., involving two or more disciplines).

Students should relate, for example

- measuring weather phenomena to meteorology,
- analyzing atmospheric pressure to physics,
- investigating albedo of surfaces to chemistry,
- studying the water cycle to hydrology,
- measuring ocean currents to oceanography, and
- studying climate change effects to climatology.

Students should recognize, however, that many weather- and climate-related scientific and technological activities involve interdisciplinary studies; combining methodologies of two or more traditional disciplines. For example,

- weather prediction relates to meteorology, mathematics/statistics, and computational modelling;
- analyzing ice cores to infer past climate conditions relates to chemistry, paleontology, and climatology; and
- studying the impact of ocean acidification on cold-ocean corals relates to biology, chemistry, ecology, and oceanography.

Students need not get caught up in the names of interdisciplinary sciences (e.g., biogeochemistry, hydrometeorology, paleoclimatology, physical oceanography). Rather, they should recognize that finding answers to emerging scientific questions and solutions to emerging technological problems requires scientists, engineers, and technologists with interdisciplinary capabilities.

This outcome could be readdressed as part of the *Motion*, *Chemical Reactions*, and *Sustainability of Ecosystems* units.

Attitude

Encourage students to consider further studies and careers in science- and technology-related fields. [GCO 4]

Science Disciplines

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Refer students to the “What You Should Recall About ...” sections at beginning of each unit in *NL Science 10.* Ask them to relate the prerequisite knowledge to specific science disciplines.
- Model relating activities to science disciplines (e.g., biology, chemistry, mathematics, physics, Earth Science) and interdisciplinary studies throughout the course.

Students may

- Tag articles in their STSE portfolio to specific science disciplines and interdisciplinary studies.
- Peruse science department websites of various universities and compile a list of science disciplines and interdisciplinary studies which offer degree and certificate programs.
- View science information/communication websites and note the categories they use to tag and organize content.
- Relate scientific and technological careers to specific science disciplines and interdisciplinary studies.

Consolidation

Teachers may

- Present scientific and technological news headlines, articles, and videos, and ask students to relate them to specific science disciplines.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-1 pp. 65-68

NL Science 10 (SR)

- pp. 80-81

Section Three: Specific Curriculum Outcomes

Unit 2: Chemical Reactions

Focus

After students have developed an understanding of atomic structure and the periodic table in Science 9, the study of chemical reactions provides them with an opportunity to apply their understanding of atomic structure to how chemicals interact. By naming and writing common compounds and balancing equations, students will begin to make connections to a variety of chemical examples in everyday life.

This unit emphasizes the social and environmental contexts of science and technology and provides opportunities to address numerous skills related to designing and carrying out experiments.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

41.0 provide examples of how science and technology are an integral part of their lives and their community
43.0 describe the usefulness of scientific nomenclature systems
48.0 describe the functioning of domestic and industrial technologies, using scientific principles
49.0 identify examples where technologies were developed based on scientific understanding
50.0 compare examples of how society supports and influences science and technology
51.0 defend a decision or judgment and demonstrate that relevant arguments can arise from different perspectives
53.0 identify and describe science- and technology-based careers related to the science they are studying

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

2.0 design an experiment identifying and controlling major variables
3.0 state a prediction and a hypothesis based on available evidence and background information
6.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making
8.0 carry out procedures controlling the major variables and adapting or extending procedures where required
11.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
15.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
16.0 describe and apply classification systems and nomenclatures used in the sciences
18.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
23.0 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan
29.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

42.0 name and write formulas for some common ionic and molecular compounds, using the periodic table and a list of ions
44.0 represent chemical reactions and the conservation of mass using molecular models and balanced symbolic equations
45.0 classify chemical reactions based on type
46.0 classify substances as acids, bases, or salts, based on their characteristics, name, and formula
47.0 describe how neutralization involves tempering the effects of an acid with a base or vice versa
52.0 illustrate how factors such as heat, concentration, light, and surface area can affect chemical reactions

GCO 4 (Attitudes): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- appreciate that the applications of science and technology can raise ethical dilemmas;
- show a continuing and more informed curiosity and interest in science and science-related issues;
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research;
- consider further studies and careers in science- and technology-related fields
- value processes for drawing conclusions;
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas; and
- show concern for safety and accept the need for rules and regulations

SCO Continuum

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Science 9	Science 1206	Chemistry 2202
Atoms and Elements	*Chemical Reactions*	
• investigate materials and describe them in terms of their physical properties • describe changes in the properties of materials that result from some common chemical reactions • use models in describing the structure and components of atoms and molecules • identify examples of common elements, and compare their characteristics and atomic structure • identify and write the chemical symbol or molecular formula of common elements or compounds	• name and write formulas for some common ionic and molecular compounds, using the periodic table and a list of ions • represent chemical reactions and the conservation of mass using molecular models and balanced symbolic equations • classify chemical reactions based on type • classify substances as acids, bases, or salts, based on their characteristics, name, and formula • describe how neutralization involves tempering the effects of an acid with a base or vice versa • illustrate how factors affect chemical reactions	• write and name formulas of ionic and molecular compounds • perform stoichiometric calculations related to chemical equations • illustrate and explain the formation of ionic, covalent, and metallic bonds • explain the structural model of molecular and ionic substances • identify and describe properties of ionic and molecular compounds and metallic substances • describe how intermolecular forces account for the properties of ionic and molecular compounds and metallic substances

Suggested Unit Plan

The *Chemical Reactions* unit follows *Weather Dynamics* and is the first of two consecutive physical science units. It is the final chemistry-related unit of the common K-10 Science program.

Unit content is foundational for Chemistry 2202.

September	October	November	December	January	February	March	April	May	June
Weather Dynamics			Chemical Reactions		Motion			Sustainability of Ecosystems	
Skills Integrated Throughout									

Everyday Chemistry

Outcomes

Students will be expected to

41.0 provide examples of how science and technology are an integral part of their lives and their community [GCO 1]

15.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials [GCO 2]

Focus for Learning

The intent of this STSE outcome is to introduce the unit by exploring the integral role that chemistry plays in everyday life. Examples explored could include, but are not limited to, materials (i.e., chemicals) used in

- cosmetics and hygiene products;
- electric cells, batteries, and electronics;
- foods;
- fuels and transportation;
- household cleaning products;
- pharmaceuticals; and
- plastics.

In Science 9, students demonstrated knowledge of WHMIS standards by using proper techniques for handling and disposing of lab materials. In Science 1206, students should demonstrate knowledge by selecting and applying proper handling and disposal techniques.

A review of WHMIS safety symbols, safety data sheets (SDS), and science lab safety rules and procedures is warranted.

It is important to note that WHMIS symbols were updated in 2015. Older resources and chemical containers may have out-of date symbols.

Students should

- identify potential hazards from WHMIS symbols,
- identify procedures and precautions for safe handling and disposal from SDS, and
- implement proper handling and disposal techniques.

The focus should be students' ability to access, interpret, and apply the information. For further elaboration of skill outcome 15.0, refer to the *Integrated Skills* unit.

Attitude

Encourage students to show concern for safety and accept the need for rules and regulations. [GCO 4]

Everyday Chemistry

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Ask students to reflect on a typical day and create a detailed list of the chemicals interacted with between waking and arriving at school.
- Introduce the unit with a launch activity to generate carbon dioxide from a chemical reaction (e.g., baking soda and citric acid in water).

Connection

Teachers may

- Present lab safety cartoons depicting unsafe practices and ask students to identify the hazards.
- Identify the location of lab safety equipment (e.g., lab coats, safety glasses, first aid kits, fire blankets, fire extinguishers, eye wash, chemical shower, spill kits, SDS binder).
- Facilitate a discussion with students regarding the need for WHMIS standards.
- Organize lab stations with chemical bottles and relevant SDS. Ask students to identify hazardous, proper handling, and disposal techniques.

Students may

- Discuss how everyday life would be different without a particular chemical reaction (e.g., fuel combustion).
- Investigate Hazardous Household Product Symbols (HHPS) and compare with WHMIS symbols.
- Investigate how their local community collects and disposes of household hazardous wastes.

Consolidation

Students may

- Create a lab safety brochure to communicate WHMIS standards.
- Identify potential hazards, from WHMIS symbols on containers, for chemicals used in lab investigations. Determine and implement safe handling and disposal procedures.

Resources and Notes

Authorized

NL Science 10 (Teacher Resource [TR])

- TR-6-7
- BLM G-2

NL Science 10 (Student Resource [SR])

- pp. ix-xiii, 98-100, 182-183

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- WHMIS resources (websites)

Ionic and Molecular Compounds

Outcomes

Students will be expected to

11.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]

Focus for Learning

In Science 9, students investigated physical and chemical properties, distinguished between elements and compounds, and were introduced to molecular and ionic compounds and identified some common examples (CO_2, CH_4, H_2O, NaCl, $CaCO_3$).

In Science 1206, students should carry out an investigation to determine some observable properties of unknown compounds. Suggested compounds include sucrose, ethanol, starch, mineral oil, sodium chloride, ammonium chloride, copper(II) sulfate pentahydrate, iron(III) chloride, nickel(III) chloride, potassium chloride, and zinc sulfate (See TR-2-22, *NL Science 10*, for additional suggestions).

Students should

- follow provided procedures to determine their state at room temperature, solubility, solution colour, and solution conductivity for each unknown (SCO 8.0);
- organize and record observations in a personally created data table (SCO 11.0); and
- identify patterns in the properties and separate unknowns into two distinct groups (SCO 18.0).

Upon completion of the investigation, provide students the chemical names and formulas for the unknown compounds.

In addition to skill outcome 11.0, skill outcomes 7.0, 8.0, 14.0, 18.0, and 25.0 could be addressed and assessed. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Stemming from the investigation, students should distinguish between molecular and ionic compounds based on their composition, bonding, and common properties. They should also provide explanations for some compound properties (e.g., low boiling and melting points, relative softness, and poor heat and electrical conductivity of molecular compounds, high melting and boiling points, and electrical conductivity when melted or dissolved in water of ionic compounds).

Attitude

Encourage students to value processes for drawing conclusions. [GCO 4]

Sample Performance Indicators

1. Classify each unknown compound from the investigation as molecular or ionic and provide a rationale.
2. Compare and contrast bonds in molecular and ionic compounds.
3. Create a table to explain differences between molecular and ionic compounds.
4. Candle wax is soft to the touch and requires only a small amount of heat to melt. Would these observations lead to the conclusion that wax is molecular or ionic? Explain.

Ionic and Molecular Compounds

Sample Teaching and Assessment Strategies

The "What You Should Recall About..." sections of the *NL Science 10* student text (pp. 92-95) summarize the prerequisite knowledge required for the Science 1206 *Chemical Reactions* unit. Preassess student prior knowledge, reteaching as required.

Activation

Students may

- Conduct a book walk through *NL Science 10*, pp. 90-135, and identify key terms.

Connection

Teachers may

- Review chemical and physical properties of ionic and molecular compounds (i.e., melting and boiling points, state at room temperature, solubility, solution colour and conductivity).
- Introduce Lewis dot structures as a way to visualize the sharing of electrons in molecular compounds.
- Use chemistry tiles to enhance understanding of the formation of ionic compounds (BLM 3-11).
- Explicitly relate atomic structure to bond type and compound properties.

Students may

- Construct models of ionic (i.e., crystal lattice) and molecular compounds and relate their structure to their properties.
- Identify patterns in ion charges for groups on the periodic table.
- Create operational definitions for ionic and molecular compounds based on observations from their lab investigation.
- Distinguish between molecules and ions, molecular compounds and ionic compounds using Frayer models (BLM 3-10).
- De-construct chemical names and formulas of molecular compounds and ionic compounds and note similarities and differences in the elements which comprised them.

Consolidation

Students may

- Classify the unknown compounds from their lab investigation as ionic or molecular and include a rationale for each decision.
- Summarize the properties of ionic and molecular compounds.
- Compare data tables created by different groups and identify strengths and weaknesses.
- Discuss which properties might be most useful for classifying compounds as molecular or ionic.

Resources and Notes

Authorized

NL Science 10 (TR)

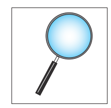
- TR-2-21 - 22
- BLMs G-12, 3-1, 3-2, 3-3, 3-9, 3-10, 3-11

NL Science 10 (SR)

- pp. 100-105

Note

The magnifying glass icon is used throughout the unit to indicate investigations.



Naming Chemical Compounds

Outcomes

Students will be expected to

42.0 name and write formulas for some common ionic and molecular compounds, using the periodic table and a list of ions [GCO 3]

43.0 describe the usefulness of scientific nomenclature systems [GCO 1]

Focus for Learning

Prerequisite knowledge required to name and write formulas for ionic and molecular compounds was addressed in Science 9. Preassess student knowledge of atomic structure, the periodic table, and energy level diagrams, reteaching as required.

In Science 1206, using a periodic table of ions and a list of polyatomic ions, students should name and write chemical formulas for

- binary ionic compounds,
- ionic compounds containing multivalent metals,
- ionic compounds containing polyatomic ions, and
- binary molecular compounds.

Note, the naming of hydrates, acids, and hydrocarbons is not an expectation of Science 1206.

Bodies such as the International Union of Pure and Applied Chemistry (IUPAC) create and uphold rules for the naming of elements and compounds based on their chemical composition. Prior to their use, chemicals were often given “trivial” names that emerged from their appearance, properties, production, or use. Using examples, such as ammonia, baking soda, hydrogen peroxide, laughing gas, limestone, ozone, and sugar, students should describe the usefulness of nomenclature systems to write formulas and predict properties.

Sample Performance Indicator

Complete the table by identifying each substance as molecular (M) or ionic (I) and providing the missing name or chemical formula.

M/I	Name	Chemical Formula
	potassium chloride	
		CCl_4
	dinitrogen pentoxide	
		$CuCl_2$
		$Ca(OH)_2$
	phosphorus	
	ammonium sulfate	
		Li_3PO_4
	hydrogen peroxide	
		Ni_2S_3
		F_2

Naming Chemical Compounds

Sample Teaching and Assessment Strategies

Activation

Students may

- Identify patterns that exist in names of ionic and molecular compounds.

Connection

Teachers may

- Explicitly connect the location of an element on the period table to its valence energy diagram and ion charge(s).
- Present the cross over method as a way to determine the chemical formula for an ionic compound.

Students may

- Tag articles in their STSE portfolio that exemplify the use of nomenclature systems.
- Examine representations of an ionic compound's crystal structure and relate to its chemical formula.
- Use molecular model kits to construct molecular compounds and relate their chemical formula and chemical name (Activity 3-2D, *NL Science 10*, p. 119).
- Conduct Internet research to find out the systematic name and formula of some chemicals given their trivial name (Activity 3-2F, *NL Science 10*, p. 123).

Consolidation

Students may

- Write the names of compounds when given their chemical formula and vice versa. Identify compounds as ionic or molecular.
- Design a chemical card game to apply knowledge of rules for naming and writing formulas for ionic compounds (Activity 3-2C, *NL Science 10*, p. 118).
- Create flash cards with the chemical names of molecular and ionic compounds on one side and their chemical formula on the reverse. Use the cards to practice naming and formula writing.
- Design and make a flowchart to represent the process of naming or writing formulas for compounds (Activity 3-2E, *NL Science 10*, p.122).

Extension

Teachers may

- Present rules for the naming of hydrates.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-2-26 - 36
- BLMs 3-11, 3-18, 3-19, 3-20, 3-21, 3-22, 3-23

NL Science 10 (SR)

- pp. 108-125

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Chemical naming resources (websites)

Chemical Reactions

Outcomes

Students will be expected to

44.0 represent chemical reactions and the conservation of mass using molecular models and balanced symbolic equations [GCO 3]

Focus for Learning

Students investigated and observed evidence of chemical changes in Science 9.

Begin treatment of SCO 44.0 by carrying out a directed investigation to analyze the mass of products and reactants in a chemical reaction (e.g., Investigation: 3-3B, *NL Science 10*, p. 133) and confirm the law conservation of mass.

Students should

- identify reactants and products in representations of chemical reactions (e.g., word, skeleton, and balanced chemical equations);
- state and apply the law of conservation of mass;
- use models (e.g., coloured paper clips) to balance chemical equations; and
- write balanced chemical equations for reactions from word and skeleton equations, and from written language.

Changing the subscripts of a chemical formula in order to balance a chemical equation, is a common student error. Correct the error by discussing examples of compounds where a small change in the subscripts makes a significant change in the chemical (e.g., water [H_2O] and hydrogen peroxide [H_2O_2]).

Students should understand that hydrogen, H_2(g), nitrogen, N_2(g), oxygen, O_2(g), fluorine, F_2(g), chlorine, Cl_2(g), bromine, Br_2(l), and iodine, I_2 (s), exist as diatomic elements and sulfur S_8, and phosphorus P_4 exist as polyatomic elements.

Equations could include substance states; solid, (s), liquid, (l), gas, (g), and aqueous solution, (aq).

Predicting products is not an expectation of Science 1206.

Sample Performance Indicators

1. Balance the following equations:
   - $Fe(s) + O_2(g) \rightarrow Fe_2O_3(s)$
   - $C_3H_8(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$
   - $AsCl_3(aq) + H_2S(aq) \rightarrow As_2S_3(s) + HCl(aq)$
   - $H_2SO_4(aq) + NaHCO_3(s) \rightarrow Na_2SO_4(aq) + CO_2(g) + H_2O(l)$
   - Zinc solid reacts with hydrochloric acid, HCl(aq), to produce a zinc chloride solution and hydrogen gas.
   - Liquid water is decomposed to form oxygen gas and hydrogen gas.
2. Represent a balanced chemical equation from question 1 using coloured paper clips.

Chemical Reactions

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Carry out a demonstration to review evidence of chemical changes. React, for example, a 10 cm^2 piece of aluminum foil, rolled into a ball, with 100 mL of 0.5 mol/L $CuCl_2(aq)$ in a 250 mL beaker (Launch Activity, *NL Science 10*, p. 139). This reaction is exothermic, produces a precipitate and a gas, and involves a distinct colour change.
- Present cellular respiration and photosynthesis as examples of important chemical reactions.

Connection

Teachers may

- Use a double pan balance to illustrate the law conservation of mass.

Students may

- Answer the following questions:
  - When an iron nail rusts (Fe_2O_3), it appears to get bigger. Does rusting follow the law of conservation of mass?
  - Burning wood results in a small amount of ash. Why is the mass of the wood not equal to the mass of the ash?
- Use coloured Legos™ or paper clips representing atoms of different elements, to help balance chemical equations. Discuss the limitations of the model used (Activity 3-3A, *NL Science 10*, p. 129).

Consolidation

Students may

- Use molecular model kits to represent balanced chemical reactions.
- Balance the following chemical equations:
  - $H_2O_2(aq) \rightarrow H_2O(l) + O_2(g)$
  - $Na(s) + CuS(s) \rightarrow Na_2S(s) + Cu(s)$
  - $H_2(g) + O_2(g) \rightarrow H_2O(l)$
  - $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$
  - $CH_4(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$
  - Solid potassium and aqueous magnesium chloride react to produce solid magnesium and aqueous potassium chloride.
  - Solid aluminum combines with oxygen gas to produce solid aluminum oxide.
- Create a “How to Balance a Chemical Reaction” instructional video.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-2-37 - 45
- BLM 3-26

NL Science 10 (SR)

- pp. 126-135

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Balancing chemical equations (websites)

Chemical Reactions

Outcomes

Students will be expected to

45.0 classify chemical reactions based on type [GCO 3]

16.0 describe and apply classification systems and nomenclatures used in the sciences [GCO 2]

44.0 represent chemical reactions and the conservation of mass using molecular models and balanced symbolic equations [GCO 3]

Focus for Learning

Chemists have developed a classification system for chemical reactions. The system helps them analyze familiar reactions and predict the products of new reactions. Note, predicting products is not an expectation of Science 1206.

Students should identify five chemical reaction types:

1. Formation reaction - a reaction in which two or more elements react to produce a compound.

$$A + B \rightarrow AB$$
$$Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

2. Decomposition reaction - a reaction in which a compound breaks down into two or more simpler compounds or elements.

$$AB \rightarrow A + B$$
$$2LiF(s) \rightarrow 2Li(s) + F_2(g)$$
$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

3. Single replacement reaction - a reaction in which one element takes the place of another element in a compound.

$$A + BX \rightarrow AX + B \text{ or } AX + Y \rightarrow AY + X$$
$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$
$$2NaBr(aq) + Cl_2(g) \rightarrow 2NaCl(aq) + Br_2(l)$$

4. Double replacement reaction - a reaction in which the positive ions of two different compounds exchange places, resulting in the formation of two new compounds.

$$AY + BX \rightarrow AX + BY$$
$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

5. Combustion reaction (limit to hydrocarbon combustion) - a reaction in which a compound, containing only the elements carbon and hydrogen, reacts with oxygen to produce carbon dioxide and water.

$$C_xH_y + O_2 \rightarrow CO_2 + H_2O$$
$$C_6H_{12}(aq) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

If the supply of oxygen is too low, students should recognize that incomplete combustion occurs, producing carbon (soot) and carbon monoxide, in addition to carbon dioxide and water.

Student should

- represent different chemical reaction types using models (e.g., coloured disks, symbols, or Lego® blocks to represent elements or groups of atoms in reactants and products);
- classify chemical reactions according to reaction type; and
- balance complete hydrocarbon combustion reactions.

continued

Chemical Reactions

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present a "dancing model" of different reaction types:
  - two individual dancers form a pair as they dance (formation);
  - a dancing pair separate as they dance (decomposition);
  - a third individual "cuts in", interrupting a dancing pair and replaces one of the original dancers (single replacement); and
  - two dancing pairs switch partners (double replacement).

Connection

Students may

- Develop a classification system for chemical reactions using different coloured circles or symbols to represent different elements or groups of atoms in the reactants and products.
- Discuss whether formation and decomposition reactions are opposite processes.
- Compare the reactivity of copper, lead, silver, and zinc by conducting Activity 4-1B (*NL Science 10,* p. 146).

Consolidation

Students may

- Create a quick reference info-graphic to help classify reactions.
- Compare single and double replacement reactions, and complete and incomplete combustion, using a Venn diagram.
- Balance complete combustion reactions for butane, $C_4H_{10}(g)$, and hexane, $C_6H_{14}(g)$.
- Classify chemical reactions as formation, decomposition, single replacement, double replacement, or combustion.

Extension

Students may

- Explore predicting products based on chemical reaction type.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-2-46 - 58
- BLMs 4-1, 4-12

NL Science 10 (SR)

- pp. 140-153

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Reaction type resources (websites)

Chemical Reactions

Outcomes

Students will be expected to

45.0 classify chemical reactions based on type [GCO 3]

16.0 describe and apply classification systems and nomenclatures used in the sciences [GCO 2]

44.0 represent chemical reactions and the conservation of mass using molecular models and balanced symbolic equations [GCO 3]

Focus for Learning

Students should also conduct an investigation to observe different types of chemical reaction types (e.g., Investigation 4-1C, *NL Science 10*, pp.150-152).

In addition to SCO 16.0, the investigation provides an opportunity to address other skill outcomes (e.g., 14.0, 15.0, 26.0). Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Sample Performance Indicators

1. Classify the chemical equations according to reaction type:
   - $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$
   - $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
   - $N_2H_4(l) \rightarrow N_2(g) + 2H_2(g)$
   - $S(s) + O_2(g) \rightarrow SO_2(g)$
   - $2Fe(s) + 3CuSO_4(aq) \rightarrow 3Cu(s) + Fe_2(SO_4)_3(aq)$
2. Propane, C_3H_8, reacts with oxygen gas to produce carbon dioxide gas and water vapour. Write a balanced chemical equation for this complete combustion reaction.
3. Balance the following combustion reaction.

$$C_8H_{18}(l) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$$

Chemical Reactions

Sample Teaching and Assessment Strategies

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-2-46 - 58
- BLMs 4-1, 4-12

NL Science 10 (SR)

- pp. 138-153

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Reaction type resources (websites)

Acids and Bases

Outcomes

Students will be expected to

46.0 classify substances as acids, bases, or salts, based on their characteristics, name, and formula [GCO 3]

6.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making [GCO 2]

Focus for Learning

Students should classify substances as acids or bases based on their characteristic physical and chemical properties.

Property	Acid	Base
Taste	sour taste (lemon juice, vinegar)	bitter taste (coffee, baking soda)
Touch	many will burn skin	feels slippery and many will burn skin
Litmus indicator test	turns blue litmus red	turns red litmus blue
Reaction with metals	yes (most)	no (most)
Electrical conductivity	conducts electricity	conducts electricity
Solubility in water	yes (most)	varies
pH	< 7.0	> 7.0
Production of ions	hydrogen ions H^+ (aq)	hydroxide ions OH^- (aq)

While acidity is referenced in previous science curricula, the pH scale has not previously been addressed.

Different methods of identifying acids, bases, and neutral substances, and measuring pH should be explored (e.g., red, blue, and neutral litmus paper, pH paper, pH meter, indicator solutions such as phenolpthalein and universal indicator, natural indicators such as red cabbage juice and herbal teas). Students should recognize that the situational context determines which method is appropriate to use. To determine if an unknown lab spill is acidic or basic, for example, using litmus paper might be appropriate. A pH meter or pH paper might be appropriate to determine the pH of soil or aquarium water.

Additionally, students should conduct an investigation to explore how different properties can be used to identify unknown substances as acids or bases (e.g., Investigation 4-2B, *NL Science 10*, pp. 166-167). Note, students should never taste chemicals in the laboratory nor touch chemicals with their bare skin.

This investigation provides an opportunity to address and assess SCOs 7.0, 8.0, 9.0, 11.0, and 14.0. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

In addition to classifying substances as acids or bases based on their properties, students should recognize acids and bases from clues in their chemical formula and names. It is recommended that examples be limited to strong acids and strong bases.

continued

Acids and Bases

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Develop a list of acid and base properties by testing examples of acids and bases (e.g., citric acid, lemon juice, baking soda, liquid soaps) for solubility in water, electrical conductivity, reaction with metal, and reaction with litmus paper (red and blue), pH paper, and other indicator solutions. Measure pH with a pH meter as well.
- Present the pH scale and pH values of some common foods and substances.

Students may

- Investigate samples of various household items (e.g., soap, vinegar, water from various sources, shampoo, lemon juice, cleaning products, baking soda, soft drinks). Predict whether they are acidic, basic, or neutral and test them with litmus paper, pH paper, other indicators, and a pH meter to confirm predictions.
- View chemical formulas and names of various examples of acids and bases. Identify clues that can be used to recognize them.
- Provide examples of situations where the use of litmus paper would be appropriate and inappropriate for determining pH.
- Describe the logarithmic nature of the pH scale, using examples.

Consolidation

Students may

- Investigate unknown solutions to identify them as acids or bases on the basis of their reactions with Mg (s) ribbon, litmus paper, and other indicators.
- Compare acids and bases using a Venn diagram.
- Investigate the pH of water obtained from various sources (e.g., bottled sparkling water, bottled still water, distilled water, pond water, seawater, tap water, well water).

Extension

Students may

- Explore rules for the naming of acids.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-2-59 - 67

NL Science 10 (SR)

- pp. 154-162

Acids and Bases

Outcomes

Students will be expected to

46.0 classify substances as acids, bases, or salts, based on their characteristics, name, and formula [GCO 3]

6.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making [GCO 2]

Focus for Learning

In addition to acids and bases, SCO 46.0 references salts. Students should recognize chemical reactions between an acid and a base (i.e., neutralization reaction) as double replacement reactions, in which the ions switch places to form two new compounds, water and a salt. Students should balance neutralization reactions.

Sample Performance Indicators

1. Classify the following substances as acids or bases. Give reasons for the classification. All chemicals are aqueous.
   - H_2CO_3
   - KOH
   - $Ca(OH)_2$
   - HF
2. A substance tastes bitter and feels slippery. How might it react with red and blue litmus paper, and magnesium metal? What relative pH value would you expect if measured with a pH meter?
3. Balance the following neutralization reaction. Identify the acid, base, and salt in the reaction.

$$HBr(aq) + Al(OH)_3(aq) \rightarrow AlBr_3(aq) + H_2O$$

Acids and Bases

Sample Teaching and Assessment Strategies

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-2-59 - 67

NL Science 10 (SR)

- pp. 154-162

Neutralization Reactions

Outcomes

Students will be expected to

47.0 describe how neutralization involves tempering the effects of an acid with a base or vice versa [GCO 3]

48.0 describe the functioning of domestic and industrial technologies, using scientific principles [GCO 1]

Focus for Learning

Students should describe how, when an acid is added to a base or a base is added to an acid, the hydrogen (H^+) and hydroxide ions (OH^-) are removed from the solution, forming water molecules. Pure water has a pH of 7. As a result, the pH of the mixture approaches 7; becoming less acidic or less basic.

Neutralization reactions are a common reaction in everyday life. Students should identify and describe examples of domestic neutralization reactions, which include, but are not limited to

- antacid use to treat heartburn;
- neutralizing fish odours with lemon juice;
- using baking soda in the refrigerator to neutralize odours and in baking to react with acidic ingredients;
- using toothpaste to neutralize dietary acids that erode teeth;
- setting correct pH of water in aquariums, swimming pools, and hydroponic systems;
- liming lawns.

Neutralization reactions also have industrial applications which could be explored.

Students should explore the neutralization of acids in the environment; liming agricultural soils and acidic bodies of water. They should describe how calcium carbonate, $CaCO_3$, used in liming, reacts with and neutralizes environmental acids.

The issue of acid precipitation should be explored.

Attitude

Encourage students to show a continuing and more informed curiosity and interest in science and science-related issues. [GCO 4]

Sample Performance Indicators

1. The pH of oven cleaning products is 13. Following their use, vinegar, acetic acid, is often used to wipe down the inside of the oven. Describe the effects vinegar will have on the oven cleaner.
2. Calcium carbonate, $CaCO_3$, is the active ingredient in some antacid tablets. Using the balanced chemical reaction below, explain how the antacid tablet neutralizes the hydrochloric acid, HCl, produced by the stomach.

$$CaCO_3(s) + 2HCl(l) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Neutralization Reactions

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Simulate an acid or base spill in the lab. Provide relevant SDS and ask students to use them to identify proper clean-up and disposal procedures.

Students may

- View the contents of acid and base spill kits and reflect on the purpose of various items (i.e., neutralizing substances).

Connection

Students may

- Explore the tempering effects of acid-base reactions. Measure and record the pH of an acid and base using wide range pH paper or a pH meter. Combine the acid and base, in small increments, retesting the pH after each step.
- Tag articles in their STSE portfolio that describe the functioning of domestic and industrial technologies, using scientific principles.

Consolidation

Teachers may

- Provide balanced chemical reactions for neutralization reactions and ask students to identify the acid, base, and salt.

Students may

- Demonstrate the use of lime (i.e., calcium oxide) to neutralize a lake affected by acid precipitation. Combine the lime with water to produce calcium hydroxide, a base. Then, add it to dilute sulphuric acid (representing an acidic lake). Measure the pH of the individual reactants and product.
- Investigate the effectiveness of different antacids on simulated stomach acid.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-2-59 - 67

NL Science 10 (SR)

- pp. 162-169

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Acid precipitation resources (websites)

Chemistry Related Technologies

Outcomes	Focus for Learning
Students will be expected to	
49.0 identify examples where technologies were developed based on scientific understanding [GCO 1]	This outcome addresses one aspect of the relationship between science and technology; technology (i.e., products and processes) is developed based on scientific knowledge. Development of pharmaceuticals (products), for example, are based on knowledge of chemical reactions within the human body. Liming, to mitigate the effects of environmental acids, is a process based on knowledge of neutralization reactions. Students should identify examples of chemistry-related technologies (e.g., carbon monoxide detectors, catalytic converters, chemical heating pads, deicing salts, fireworks, fuels, household cleaners, pH meters, pH paper, personal hygiene products, pesticides, rust proofing compounds) and describe the scientific knowledge on which they are based.
50.0 compare examples of how society supports and influences science and technology [GCO 1]	Science and technology are expensive endeavours. Funding for research and development is provided by society through government agencies and other organizations. Society directs funding toward some research topics and away from others, thereby supporting science and technology and influencing the course of research. Government of Canada research into the health and environmental hazards caused by certain chemical substances (e.g., bisphenol A, phthalates, plastic microbeads, triclosan), is an example of how society supports scientific research. The emergence of the field of green chemistry is an example of how society influences science and technology. Students should identify and compare examples illustrating support and/or influence on science and technology.
23.0 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan [GCO 2]	Additionally, students should research chemistry-related, STSE issues or problems. Topics could include • societal use of antibacterial products, antibiotics, bottled water, deicing compounds, electric cells, fossil fuels, pesticides, products containing plastic microbeads, or single use plastics; • ocean acidification; • e-waste; and • oil spill remediation technologies.
51.0 defend a decision or judgment and demonstrate that relevant arguments can arise from different perspectives [GCO 1]	Based on their research, students should identify alternatives solutions to the problem, evaluate the strengths and weaknesses of each, and select one as the basis of a plan. They should develop and communicate their plan, recognizing multiple perspectives, and defend their decision or judgement. **Attitudes** Encourage students to • appreciate that the applications of science and technology can raise ethical dilemmas, and • acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research. [GCO 4]

Chemistry Related Technologies

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Facilitate a four corners activity related to a controversial issue or problem (e.g., pesticide use). Communicate statements (e.g., use of pesticides for lawn care should be banned) and ask students to make a judgement and move to a corner of the room representing their choice (i.e., strongly agree, agree, disagree, strongly disagree). Following each statement and subsequent movement, ask students to explain or defend their judgement. Discuss how individuals with these viewpoints could support and influence related science and technology.

Students may

- Participate in a book walk to identify chemistry related technologies (products and processes) and describe the scientific understanding on which they are based.
- Participate in a “convince me” activity where they are assigned a position on a controversial topic and collaboratively develop an evidence based, persuasive argument.
- Collect chemistry-related STSE articles for their portfolio and tag them as examples of
  - technologies based on scientific understanding,
  - how society supports and influences science and technology, and
  - defending a decision or judgement and demonstrating that relevant arguments arise from different perspectives.
- View the National Research Council of Canada’s website and explore their areas of research and development.
- Explore the principles of green chemistry.
- Research ocean acidification (i.e., causes, scientific understanding, environmental impacts, alternative solutions).
- Research waste-related environmental issues (e.g., e-waste, ship breaking yards).

Consolidation

Students may

- Create a science fair project (i.e., study) based on a chemistry-related issue or problem.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 134, 401

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- STSE content (websites)

Rates of Chemical Reactions

Outcomes

Students will be expected to

52.0 illustrate how factors such as heat, concentration, light, and surface area can affect chemical reactions [GCO 3]

2.0 design an experiment identifying and controlling major variables [GCO 2]

3.0 state a prediction and a hypothesis based on available evidence and background information [GCO 2]

8.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]

18.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]

29.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

Focus for Learning

Every chemical reaction proceeds at a definite rate under a specific set of conditions. Changing those conditions causes the reaction rate to speed up or slow down.

Students should design and conduct an investigation to study the effect of temperature, concentration of reactants, and surface area of reactants on reaction rate. The chemical reaction that occurs when Alka-seltzer® is placed in water, for example, could be investigated.

$$3NaHCO_3(s) + C_6H_8O_7(aq) \rightarrow 3H_2O(l) + 3CO_2(g) + Na_3C_6H_5O_7(aq)$$

They should

- design an experiment to test the effect of one factor on reaction rate, identifying and controlling major variables in their design (different groups should investigate different factors);
- state a prediction and hypothesis;
- operationally define temperature, concentration, surface area, and reaction rate in the context of their experiment;
- devise a procedure which includes the sampling method and necessary safety precautions;
- carry out and extend their procedure, where required;
- compile, organize, and display their data in appropriate formats;
- collect data from other groups;
- interpret data and infer relationships among variables; and
- create a formal write-up of their experiment (including a summary of class results).

In addition to the listed skill outcomes, this experiment provides opportunity to assess numerous other skills (e.g., 4.0, 5.0, 7.0, 11.0, 17.0, 20.0, 21.0, 22.0, 25.0, 26.0). Refer to the *Integrated Skills* unit for elaboration.

Students should provide examples to illustrate how heat, concentration, light, and surface area affect chemical reactions. Introduce collision theory to explain effects (i.e., reactant particles colliding with the correct orientation and sufficient energy to break their bonds).

Note, particle theory and kinetic energy were addressed in Science 7.

To illustrate how light can affect a chemical reaction, students should refer to the chemical reaction for photosynthesis.

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Endothermic and exothermic reactions are not addressed in Science 1206.

Attitude

Encourage students to work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas. [GCO 4]

Rates of Chemical Reactions

Sample Teaching and Assessment Strategies

Student reaction rate experiments could be used as a science fair project. In pairs, students could select different chemical reactions and design an experiment to test a factor affecting reaction rate. While similar, each project could be unique. This largely open inquiry experiment would allow for assessment of numerous skill outcomes.

Connection

Teachers may

- Demonstrate the reaction between magnesium metal and hydrochloric acid and show how changing the acid concentration and cutting the metal in smaller pieces changes the reaction rate. Student could then be asked to propose explanations for the differences in rate, leading to an introduction and discussion of collision theory.
- Discuss factors that affect combustion reactions (e.g., a burning wood fire).

Students may

- Provide and discuss reaction rate examples from their daily lives:
  - perishable food ripening and spoilage,
  - cooking times,
  - corrosion, and
  - pharmaceutical (chewable or coated tablets, slow release capsules).
- Compare how different groups operationally defined temperature, concentration of reactants, and surface area.
- Evaluate the reliability and adequacy of classmates' experimental data and data collection methods (i.e., number of defined levels of the independent variable, number of trials, data treatments, number of significant figures for measured values).
- View video of classmates carrying out experiments to assess how well variables were controlled.

Consolidation

Students may

- Create a formal lab report for their designed experiment.

Extension

Students may

- Explore how the use of catalysts increase the rate of a chemical reaction.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-2-68 - 73

NL Science 10 (SR)

- pp. 170-177

Chemistry Related Careers

Outcomes

Students will be expected to

53.0 identify and describe science- and technology-based careers related to the science they are studying [GCO 1]

Focus for Learning

Students should explore science- and technology-based careers. The scope could be limited to chemistry based careers or broadened to include careers related to weather dynamics, motion, and sustainability.

Students should use research inquiry tools and techniques to collect information regarding the skills and knowledge required for a specific chemistry-related career and communicate that information in a format of their choosing.

Chemistry-related careers in industry, academia, government, non-profit, and entrepreneurship sectors could be explored.

Cross-curricular connections could be made to Career Development courses.

Attitude

Encourage students to consider further studies and careers in science- and technology-related fields. [GCO 4]

Chemistry Related Careers

Sample Teaching and Assessment Strategies

Activation

Students may

- Brainstorm a list of careers to which the study of chemistry contributes.

Connection

Teachers may

- Invite guest speakers working in chemistry-related careers to present (i.e., face to face or virtually) about the knowledge and skills used in their jobs, their educational background, and career path.

Students may

- View chemistry-related career profiles on relevant career information websites (e.g., explorecuriocity.org)
- View the *Science At Work* features (*NL Science 10*, pp. 80-81, 180-181, 266-267, 350-351) and discuss how the featured careers relate to the study of weather dynamics, chemistry, motion, and sustainability.
- Prepare advance questions for guest speakers.

Consolidation

Students may

- Choose a chemistry-related career and research the required education, qualifications, and job responsibilities. Communicate this information to classmates in a personally selected format.
- Interview an individual working in a chemistry-related career and creatively communicate the details of the interview with classmates.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 80-81, 180-181, 266-267, 350-351.

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Career resources (websites)

Section Three: Specific Curriculum Outcomes

Unit 3: Motion

Focus

The concept of motion becomes of great interest to students as they approach the age for obtaining a driver's license. Students should be provided with opportunities to investigate the principles of kinematics in everyday situations. If students are provided with a variety of examples of motion to investigate, they will begin to develop an understanding of the concepts of displacement, velocity, and acceleration.

This unit emphasizes the nature of science and technology and provides further opportunities to address skill outcomes related to designing and carrying out investigations.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

- 38.0 describe examples of Canadian contributions to science and technology
- 40.0 relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary studies
- 54.0 identify possible areas of further study related to science and technology
- 55.0 distinguish between scientific questions and technological problems
- 62.0 describe the historical development of a technology
- 63.0 evaluate the role of continued testing in the development and improvement of technologies
- 64.0 analyze natural and technological systems to interpret and explain their structure and dynamics
- 65.0 evaluate the design of a technology and the way it functions on the basis of identified criteria such as safety, cost, availability, and impact on everyday life and the environment

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

- 3.0 state a prediction and a hypothesis based on available evidence and background information
- 4.0 design an experiment and identify specific variables
- 5.0 formulate operational definitions of major variables
- 7.0 develop appropriate sampling procedures
- 9.0 use instruments effectively and accurately for collecting data
- 10.0 estimate quantities
- 18.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
- 19.0 compare theoretical and empirical values and account for discrepancies
- 20.0 evaluate the relevance, reliability, and adequacy of data and data collection methods
- 21.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
- 26.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

56.0 describe quantitatively the relationship among motion variables.
57.0 analyze mathematically the relationship among displacement, velocity, and time
58.0 analyze graphically the relationship among displacement, velocity, and time for uniform motion
59.0 distinguish between instantaneous and average velocity
60.0 analyze graphically the relationship among displacement, velocity, and time for non-uniform motion
61.0 describe quantitatively the relationship among velocity, time, and acceleration

GCO 4 (Attitudes): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- value the contributions to scientific and technological development made by individuals from many societies and cultural backgrounds
- consider further studies and careers in science- and technology-related fields
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations
- use factual information and rational explanations when analyzing and evaluating
- value the processes for drawing conclusions
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

SCO Continuum

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Science 8	Science 1206	Physics 2204
Fluids	*Motion*	
• describe the motion of objects in terms of balanced and unbalanced forces	• describe quantitatively the relationship among motion variables • analyze mathematically the relationship among displacement, velocity, and time • analyze graphically the relationship among displacement, velocity, and time for uniform and non-uniform motion • distinguish between instantaneous and average velocity • describe quantitatively the relationship among velocity, time, and acceleration	• use vectors to represent force, velocity, and acceleration • analyze quantitatively the horizontal and vertical motion of a projectile • identify the frame of reference for a given motion • apply Newton's laws of motion • analyze quantitatively two-dimensional motion in a horizontal plane and a vertical plane • describe uniform circular motion • explain quantitatively circular motion using Newton's laws

Suggested Unit Plan

The *Motion* unit follows *Chemical Reactions* and is the second consecutive physical science unit. It is the final physics-related unit of the common K-10 Science program.

Unit content is foundational for Physics 2204.

<table>
<tr><th colspan="2">September</th><th colspan="2">October</th><th colspan="2">November</th><th colspan="2">December</th><th colspan="2">January</th><th colspan="2">February</th><th colspan="2">March</th><th colspan="2">April</th><th colspan="2">May</th><th colspan="2">June</th></tr>
<tr><td colspan="5">Weather Dynamics</td><td colspan="5">Chemical Reactions</td><td colspan="5">Motion</td><td colspan="5">Sustainability of Ecosystems</td></tr>
<tr><td colspan="20">Skills Integrated Throughout</td></tr>
</table>

Motion in Daily Life

Outcomes

Students will be expected to

4.0 design an experiment and identify specific variables [GCO 2]

5.0 formulate operational definitions of major variables [GCO 2]

Focus for Learning

To initiate the *Motion* unit, students should engage in an open inquiry investigation to determine how fast an object is moving using unconventional methods and tools. With limited teacher direction, students should, in pairs or small groups,

- select a moving object to measure (e.g., ball, marble, pencil, skateboard, roll of ticker tape, toy car);
- identify and operationally define variables needed to determine speed (i.e., distance, time);
- devise and carry out a procedure to measure required variables, detailing the data collection techniques employed; and
- calculate speed.

Teachers should limit the measurement tools and materials made available for student use. Uncalibrated materials (e.g., lengths of string, sticks), seldom used tools (e.g., sand timer, trundle wheel), and non-SI unit measurement tools (e.g., metre stick calibrated in inches) should be included. Students may use mobile device stopwatches to measure time.

Students should communicate their procedure and results. Limiting materials and teacher direction should result in varied methods being used to calculate speed.

This initial investigation provides opportunity to discuss

- designing experiments (SCO 4.0);
- operationally defining variables (SCO 5.0);
- evaluating and selecting appropriate instruments for collecting data (SCO 6.0);
- developing appropriate sampling procedures (SCO 7.0),
- evaluating the relevance, reliability, and adequacy of data and data collection methods (SCO 20.0); and
- identifying and explaining sources of error and measurement uncertainty and expressing results in a form that acknowledges the degree of uncertainty (SCO 21.0).

Refer to the *Integrated Skills* unit for elaboration of these skills.

Throughout the unit, as knowledge outcomes are addressed (i.e., motion variables, uniform and non-uniform motion, acceleration) and skill outcomes are developed through investigations, refer back to this initial investigation experience.

Attitude

Encourage students to work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas. [GCO 4]

Motion in Daily Life

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present video of races (e.g., horse races, Olympic track events, cycling races) and ask students which objects are moving the fastest.

Students may

- Participate in running races to determine who is the fastest.

Connection

Teachers may

- Ask students to orally describe how they would determine the speed of a skateboarder, including the measurements they would take.
- Facilitate a discussion regarding the variables required to determine speed, appropriate measurement tools, SI units, appropriate sampling procedures, accuracy and precision in measurement, and the role of estimation.

Students may

- Demonstrate how they determined the speed of their moving object and compare their method to those used by other groups.
- Compare and evaluate the measurement tools used by different groups in their speed investigations.

Consolidation

Students may

- After completion of their speed investigation and class discussion, revise their investigation, making changes to improve the reliability and adequacy of their distance and time measurements.
- Repeat the speed investigation following their improved procedure and using appropriate measurement tools.

Resources and Notes

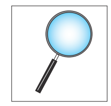
Authorized

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/teaching-and-learning-strategies.html
  - Determining Speed

Note

The magnifying glass icon is used throughout the unit to indicate investigations.



Motion in Daily Life

Outcomes

Students will be expected to

40.0 relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary studies [GCO 1]

54.0 identify possible areas of further study related to science and technology [GCO 1]

55.0 distinguish between scientific questions and technological problems [GCO 1]

Focus for Learning

Prior to this course, students' investigation of motion has been limited. In Science 1206, students investigate motion along a straight line (i.e., uniform and non-uniform one-dimensional motion).

The study of motion is part of the scientific discipline of physics. Motion-related applications, however, also relate to other science disciplines (e.g., astronomy, geomatics, kinesiology, mechanical engineering) and reinforce the interconnected nature of science.

Students should recognize and describe examples of motion in their daily lives.

Throughout the unit, students should engage with real-world applications of motion (i.e., STSE content) and make connections to physics and other science disciplines. They could connect a study of the efficiency of the gait of polar bears, for example, to the disciplines of biology, climate change, kinesiology, and physics. Automobile designs could be related to studies in aerodynamics, ergonomics, kinematics, mathematics, and environmental science.

Although the terms science and technology are often used interchangeably, they have different purposes. The goal of science is the pursuit of knowledge (i.e., finding answers to scientific questions). The goal of technology is to solve problems and improve human life.

When engaging with STSE content, students should distinguish scientific questions from technological problems. They should identify, for example, "What is the effect of a headwind on the velocity of a vehicle?" as a scientific question and "How could the design of a vehicle be modified to take into account a headwind?" as a technological problem.

Attitude

Encourage students to consider further studies and careers in science- and technology-related fields. [GCO 4]

Sample Performance Indicator

Classify the following as scientific questions or technological problems

- How can a fishing boat be modified to hold a larger catch?
- How does changing the dimple pattern of a golf ball affect its flight pattern?

Motion in Daily Life

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Activate prior motion-related knowledge by facilitating a game of “Simon Says” or charades focused on types of motion.

Students may

- View images depicting examples of motion in daily life (*NL Science 10,* pp. 192-195) and describe them.

Connection

Teachers may

- Annotate the back of images depicting motion with the scientific disciplines and interdisciplinary fields to which they relate. Cut each image into several pieces and randomly distribute them to students. Ask students to locate classmates with the missing parts of their image, reform it, and discuss how the annotations on the back relate to the image.

Students may

- Generate a list of science disciplines and interdisciplinary fields.
- Create a concept map of applications of motion-related studies. Continue to add to the map as new applications are identified.
- Brainstorm careers related to the study of motion.
- Collect motion-related STSE articles for their portfolio and tag whether they include a scientific question and/or technological problem.

Consolidation

Teachers may

- Present and throw a paper airplane and ask students to identify possible factors affecting its motion. Factors may be grouped into general areas of study.
- Present a motion-related product (e.g., skateboard) and ask students to identify scientific questions to investigate and potential problems or issues users may experience with the product.

Students may

- View motion-related articles and videos and identify scientific questions or technological problems contained within them.
- Choose a personal activity related to motion and identify possible areas of study related to science and technology.

Resources and Notes

Authorized

NL Science 10 (Teacher Resource [TR])

- TR-3-5

NL Science 10 (Student Resource [SR])

- pp. 192-195, 242, 266-267

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Motion-related STSE resources (websites)

Accuracy and Precision

Outcomes

Students will be expected to

9.0 use instruments effectively and accurately for collecting data
[GCO 2]

10.0 estimate quantities
[GCO 2]

21.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
[GCO 2]

Focus for Learning

In the initial investigation, students used standard and non-standard tools and instruments to determine the speed of a moving object. In this investigation, students explore certainty in measurement. They should use appropriate instruments, with varying degrees of precision, to collect data (e.g., measure the length of a lab bench) and express measured values with the appropriate number of significant figures (i.e., all digits that can be read with certainty plus one estimated digit).

Students should distinguish between accuracy and precision, and suggest ways to improve them. A metre stick graduated in centimetres, for example, is less precise than one measured in millimetres. To improve accuracy, measurements should be repeated a minimum of three times, and the average measurement should be used. Averaged measurements are more accurate than any of the individual measurements.

Students should identify the number of significant figures in given values and follow provided rules (See Appendix A) when performing calculations using these values. They should use scientific notation when appropriate. Note, scientific notation has not previously been addressed in science or mathematics courses.

Teachers should ensure that both random and systematic error (including parallax) are addressed.

In addition to skill outcomes 9.0, 10.0, and 21.0, exploration and use of measurement instruments provides an opportunity to address SCO 7.0 (i.e., develop appropriate sampling procedures). Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Sample Performance Indicator

Select an appropriate measuring instrument and calculate the area of your science textbook. Express all measurements and calculated values using the correct number of significant figures.

Accuracy and Precision

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Provide a collection of analog measurement tools and instruments (e.g., ammeter, calliper, force meters, rulers, stopwatches, thermometers, triple beam balance, trundle wheel, voltmeter) for students to explore. Ask them to identify what the tool or instrument measures, its unit of measurement, and degree of precision.

Students may

- Develop a list of tools and instruments that could be used to measure distance.

Connection

Teachers may

- Present videos describing uncertainty in measurements.

Students may

- Discuss the following questions:
  - What is the difference between a centimetre, metre, and kilometre? Give an example of when each is used.
  - On a driver's license, why is mass not reported in milligrams?
  - What are the SI units for distance, time, and speed?

Consolidation

Students may

- Use appropriate measuring instruments to calculate the height of a door frame and the area of a desk top. Express measurements and calculated values to the correct number of significant figures.
- Perform reaction time activities (e.g., starting and stopping a stopwatch, catching a dropped metre stick), taking repeated measurements and averaging results.

Resources and Notes

Authorized

NL Science 10 (TR)

- BLMs G-16, G-17, G-18, G- 19

NL Science 10 (SR)

- pp. 382-386, 394-396

Appendices

- Appendix A

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Error and uncertainty in measurement (websites)

Describing One-Dimensional Motion

Outcomes

Students will be expected to

56.0 describe quantitatively the relationship among motion variables
[GCO 3]

57.0 analyze mathematically the relationship among displacement, velocity, and time
[GCO 3]

Focus for Learning

Students should

- define the terms position ($\vec{d}$), distance (d), displacement ($\Delta\vec{d}$), and reference point;
- distinguish between vector quantities and scalar quantities;
- describe one-dimensional motion using position, distance, and displacement; and
- solve problems to determine the position, distance, and displacement of moving objects.

Problems encountered should

- involve adding and subtracting vector quantities algebraically;
- expose students to directions represented in a variety of formats (e.g., right/left, up/down, forward/backward, east/west); and
- include examples requiring unit conversion.

Students may use diagrams to aid understanding of problems. However, drawing vector diagrams is not an expectation of Science 1206.

Students should

- define the terms speed (v) and velocity ($\vec{v}$), and identify them as scalar and vector quantities respectively;
- define uniform motion;
- define average speed and average velocity; and
- use the following to solve for a missing variable when given the other variables, or a means of finding them.

$$\text{average speed} = \frac{\text{total distance travelled}}{\text{total elapsed time}}, \quad v_{ave} = \frac{d}{t}$$

$$\text{average velocity} = \frac{\text{displacement}}{\text{time interval}}, \quad \vec{v}_{ave} = \frac{\Delta\vec{d}}{\Delta t}, \quad \vec{v}_{ave} = \frac{\vec{d}_2 - \vec{d}_1}{\Delta t}$$

Teachers should model and encourage the rearrangement of formulas in problem solving. Students should apply provided rules for use of significant figures in all calculations (See Appendix A).

Sample Performance Indicators

1. Compare distance and displacement, and speed and velocity.
2. You take 16 steps[N], followed by 23 steps[S], and then 68 steps[N]. What is the total distance travelled? What is your displacement?
3. If you walk to school at a speed of 1.6 m/s and it takes 9.0 minutes, what is the distance from your home to school?
4. Fence posts around a pasture are 2.5 m apart. A goat starts running west beside the fence. When it passes the fifth post 9.0 s have elapsed. It passes the eleventh post at 11.5 s. What is the goat's average velocity?

Describing One-Dimensional Motion

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Ask students to sit in pairs. Give one person a simple diagram with lines and shapes, and the other a blank sheet of paper. Sitting back to back, ask the student with the diagram to describe to his/her partner how to draw the diagram. Following the activity, discuss the importance of accurately describing the starting point and the length, direction, and shape of line segments.

Students may

- Give directions to a blindfolded partner on how to locate something in the room.

Connection

Teachers may

- Use number lines to distinguish distance from displacement. Floor tiles may be used as a kinesthetic number line.

Students may

- Use Frayer models to distinguish between distance and displacement, speed, and velocity.
- Use a sticky note to denote the reference point on a metre stick. Place a small object at various locations on the metre stick and determine its position relative to the reference point.

Consolidation

Teachers may

- Ask a student to travel the length of a hallway using different motions at different intervals (e.g., walking, hopping, crawling, running). Using a timing device and metre sticks, ask the remaining students to measure distance and time for each motion and calculate the student's average speed.

Students may

- Create problems related to displacement, speed, and velocity on index cards with the problem on one side and the solution on the other. Participate in a quiz-quiz-trade activity using the cards.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-3-10 - 21
- TR 3-59 - 61

NL Science 10 (SR)

- pp. 198-217, 256 - 258

Appendices

- Appendix A

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Motion variables resources (websites)

Describing One-Dimensional Motion

Outcomes

Students will be expected to

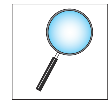
56.0 describe quantitatively the relationship among motion variables [GCO 3]

26.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]

10.0 estimate quantities [GCO 2]

21.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty [GCO 2]

Focus for Learning



Students should use appropriate instruments (e.g., ticker tape and recording timer, motion sensor connected to a computer) to investigate slow and fast uniform motion and use their results to construct position-time graphs (e.g., Investigation 5-2A, *NL Science 10*, p. 214).

They should follow provided procedures to collect position and time data for slow motion and fast motion (e.g., pull ticker tape through a recording timer, push a dynamics cart away from a motion sensor). Students should compile and organize their data into tables, graph the data in a scatter plot, and draw a line of best fit. Note, direct instruction regarding drawing a line of best fit may be required.

Students should analyze and interpret position-time graphs; estimating values through interpolation and extrapolation, and comparing steepness of the lines of best fit. They should identify and explain sources of error (i.e., random or systematic) and uncertainty and apply significant figure rules when expressing measurements.

Position-time graphs may be used to further elaborate the concepts of uniform and non-uniform motion. Additionally, teachers may discuss the significance of the slope of the best fit line and use unit analysis to relate slope and average velocity.

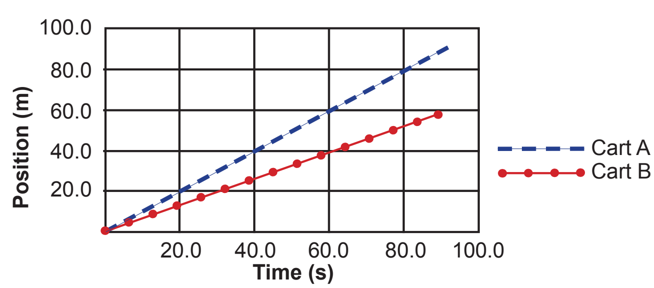
In addition to SCOs 10.0, 21.0 and 26.0, skill outcomes 8.0, 9.0, 11.0, 17.0, and 18.0 may be assessed. Refer to the *Integrated Skills* unit for elaboration.

Cross curricular connections may be made to the Mathematics 1201 *Relations and Functions* unit.

Attitude

Encourage students to use factual information and rational explanations when analyzing and evaluating. [GCO 4]

Sample Performance Indicators



1. Which cart is moving the fastest?
2. At what time is the position of Cart A 50 m?
3. Estimate the position of Cart B at 100 s.

Describing One-Dimensional Motion

Sample Teaching and Assessment Strategies

Activation

Students may

- View ticker tapes and interpret dot patterns.

Connection

Teachers may

- Instruct students on how to mark time on ticker tape and measure distance between time intervals.
- Instruct students on how to connect motion sensors to data collection devices and configure their data collection device to collect data and display a position-time graph.
- Discuss potential issues with precision, accuracy, and random and systematic error.
- Distribute sample position-time graphs to students on small cards. Using a Think-Pair-Share strategy, students should identify position at specific times, and distance and displacement for various time intervals, then pair and share analysis with a classmate to confirm interpretation.

Students may

- Consider different types of graphs and select the most appropriate type to represent motion data.
- Practice graphing position-time data (Activity 5-3A, *NL Science 10*, p. 220).
- Identify variables that should be controlled to achieve uniform motion.
- Brainstorm ways to minimize error in data and data collection.
- Compare lines of best fit drawn by hand with computer-generated lines for the same data set.

Consolidation

Teachers may

- Provide position-time data. Ask students to create an appropriate graph with a line of best fit.

Students may

- View position-times graphs depicting the motion of multiple objects on the same graph and compare and describe their motion.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-3-22 - 24

NL Science 10 (SR)

- pp. 214-215, 388-393

Graphically Analyzing Uniform Motion

Outcomes

Students will be expected to

58.0 analyze graphically the relationship among displacement, velocity, and time for uniform motion [GCO 3]

Focus for Learning

Given position-time graphs representing uniform motion, students should

- describe the motion qualitatively (e.g., the object moves with a constant speed to the right); and
- determine an object's position at a given time, the distance and displacement for a given time interval, and speed and velocity from the slope.

Students should analyze position-time graphs that have

- different initial positions;
- positive, negative, and zero slopes;
- an object moving from a positive position to a negative position, or vice versa; and
- an object that makes a series of constant velocity movements (limit to three segments).

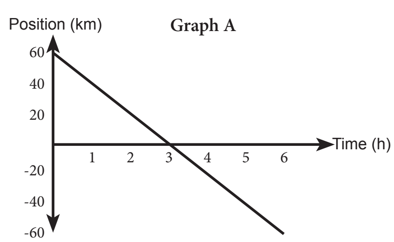
Additionally, given velocity-time graphs representing uniform motion, students should

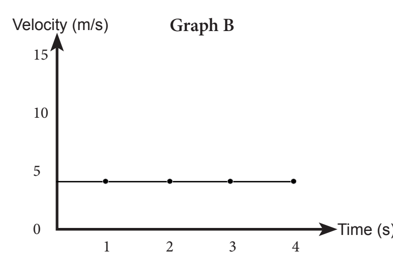
- interpret the graph to determine velocity; and
- determine displacement by calculating the area under the graph (Limit to graphs with positive y values and limit calculations to the to addition of two areas).

Students should analyze velocity-time graphs that have

- positive and negative velocities,
- positive and negative displacements, and
- an object that makes a series of constant velocity movements (limit to three segments).

Sample Performance Indicators





1. How would you determine velocity for each graph?
2. Calculate the resultant displacement for Graph B.

Graphically Analyzing Uniform Motion

Sample Teaching and Assessment Strategies

The graph in Activity 6-1D (*NL Science 10*, p. 244) is an example of an object that makes a series of constant velocity movements.

Connection

Teachers may

- Present sets of position-time data. Ask students to identify those that represent uniform motion.
- Use motion sensors to generate position-time and velocity-time graphs for various uniform motions.
- Use unit analysis to establish the relationship between slope of the best fit line and velocity.

Students may

- Practice drawing best fit lines and calculating slope.
- Practice performing area under the graph calculations for uniform motion graphs.
- Graph the motion of runners on the same position-time graph to analyze the relationship between displacement, velocity, and time (Activity 5-3B, *NL Science 10*, p. 223).

Consolidation

Students may

- Use a recording timer and ticker tape to investigate the motion of a toy car undergoing uniform motion (Investigation 5-3C, *NL Science 10*, pp. 224-225).
- Solve problems to determine the velocity or displacement of an object undergoing uniform motion requiring calculations from position-time and velocity-time graphs.
- Construct a position-time graph for a described motion (e.g., Jan walks 60 m[N] to the corner store in 60 s. She stays at the store for 60 s then runs the 60 m[S] back to her house in 20 s. From the position-time graph construct the corresponding velocity-time graph.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-3-26 - 39

NL Science 10 (SR)

- pp. 218-229

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Graphical analysis of motion resources (websites)

Introducing Non-Uniform Motion

Outcomes

Students will be expected to

59.0 distinguish between instantaneous and average velocity
[GCO 3]

3.0 state a prediction and a hypothesis based on available evidence and background information.
[GCO 2]

18.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
[GCO 2]

Focus for Learning

Students should

- define non-uniform motion;
- identify position-time graphs of non-uniform motion;
- distinguish between line and curve of best fit;
- distinguish between instantaneous velocity and average velocity;
- calculate average velocities for various time intervals; and
- calculate instantaneous velocities, using the tangent method, from position-time graphs.

Students should, in pairs or small groups, perform a guided inquiry investigation of non-uniform motion. They should

- investigate the motion of an object rolling down an inclined plane;
- predict the shape of the position-time graph for the rolling object;
- select and use instruments (e.g., ticker-tape and recording timer, motion sensors, slow motion video) appropriately and effectively to collect position and time data;
- create a position-time graph and draw a curve of best fit;
- draw tangent lines at selected times and calculate slope (i.e., instantaneous velocity);
- compile instantaneous velocity and time data in a table;
- construct a velocity-time graph; and
- draw a line of best fit for the velocity-time graph and calculate slope.

Introduce the concept of acceleration ($\vec{a}$), referencing data obtained from this investigation. Students should define acceleration and relate it to the slope of a velocity-time graph.

This investigation provides an opportunity to assess numerous skill outcomes 3.0, 4.0, 5.0, 6.0, 8.0, 7.0, 9.0, 10.0, 11.0, 17.0, 18.0, 21.0, 22.0, 25.0, 26.0, and 29.0. Refer to the *Integrated Skills* unit for elaboration.

Attitude

Encourage students to confidently evaluate evidence and consider alternative perspectives, ideas, and explanations. [GCO 4]

Introducing Non-Uniform Motion

Sample Teaching and Assessment Strategies

The non-uniform motion investigation could be modelled after Investigation 6-2B (*NL Science 10*, pp. 252-253). Note, however, that this investigation does not use thee tangent method to calculate instantaneous velocities.

Activation

Teachers may

- Present video of track events. Ask students to comment on changes in velocity of specific individuals during the race.

Students may

- Analyze a position-time graph depicting changes in velocity (Launch Activity 6, *NL Science 10*, p. 231) and describe the motion of the object during different time intervals.

Connection

Teachers may

- Demonstrate how to draw tangent lines from points on non-linear position-time graphs. Relate the slope of the tangents to instantaneous velocities.

Students may

- Distinguish instantaneous and average velocity from instantaneous and average speed using driving to school as an example.
- Provide examples of non-uniform motion from daily life.
- Practice drawing curves of best fit.
- Classify examples of instantaneous and average velocity (or speeds)
  - a plane on autopilot at 255 m/s[S],
  - a triathlete's speed for an entire race is 10.0 km/h,
  - a highway radar records the car's speed as 65 km/h,
  - cruise control for a car driving east is set at 110.0 km/h, and
  - a jogger runs 2.0 m/s for 1.0 h.

Consolidation

Students may

- Compare position-time graphs for uniform and non-uniform motion, including slope.
- Compare velocity-time graphs for uniform and non-uniform motion.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-3-52 - 58

NL Science 10 (SR)

- pp. 246-249, 252-253

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Instantaneous velocity resources (websites)

Graphical Analysis of Non-Uniform Motion

Outcomes

Students will be expected to

60.0 analyze graphically the relationship among displacement, velocity, and time for non-uniform motion [GCO 3]

Focus for Learning

Given position-time graphs representing non-uniform motion, students should

- describe the motion qualitatively (e.g., the object speeds up to the right); and
- determine an object's position, distance, displacement, average velocity, and instantaneous velocity (using tangent method).

Students should analyze position-time graphs of non-uniform motion that have

- different initial positions;
- increasing and decreasing slopes;
- an object moving from a positive position to a negative position, or vice versa; and
- an object that makes a series of velocity changes (limit to two changes [three sections]).

Additionally, given velocity-time graphs representing non-uniform motion, students should

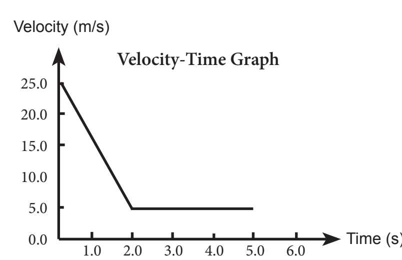
- describe the depicted motion qualitatively (e.g., the object speeds up to the right);
- interpret the graph to determine acceleration from slope; and
- determine displacement by calculating the area under the graph (Limit to graphs with positive y values and limit calculations to the to addition of two areas).

Students should analyze velocity-time graphs of non-uniform motion that have

- positive and negative velocities;
- positive, negative, and zero resultant displacements; and
- an object that makes a series of constant velocity movements (limit to two changes [three sections]).

Teachers should always assume uniform acceleration.

Sample Performance Indicator



1. Calculate area under the graph to determine displacement.
2. Determine acceleration for each segment of the graph.

Graphical Analysis of Non-Uniform Motion

Sample Teaching and Assessment Strategies

The graph in Launch Activity 6 (*NL Science 10*, p. 231) is an example of an object that makes a series of velocity changes.

Connection

Teachers may

- Present examples of position-time graphs depicting non-uniform motion and ask students to identify similarities.

Students may

- Use an online interactive simulator (e.g., The Moving Man) to explore position, velocity, and acceleration and the resulting position-time and velocity-time graphs.
- View a position-time or velocity-time graph and attempt to recreate the graph by moving an object in front of a motion sensor.
- Create velocity-time graphs using mobile device applications.

Consolidation

Teachers may

- Create a set of non-uniform motion position-time graphs and a matching set of corresponding velocity-time graphs on index cards. Distribute all graphs to students and ask them to find their match.

Students may

- Construct a graph from a provided set of data for non-uniform motion.
- Create a quick reference guide for graphical analysis. Include sketches of position-time and velocity-time graphs and descriptions of the motion represented.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-3-40 - 54

NL Science 10 (SR)

- pp. 233-249

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Graphical analysis of motion resources (websites)
- The Moving Man simulator (website)

Calculating Acceleration

Outcomes

Students will be expected to

61.0 describe quantitatively the relationship among velocity, time, and acceleration [GCO 3]

Focus for Learning

Students should use the following equations to solve for a missing variable when given the other variables.

$$\text{average acceleration} = \frac{\text{change in velocity}}{\text{change in time}}$$

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

Assume acceleration is constant.

Teachers should model and encourage the rearrangement of formulas in problem solving. Students should apply provided rules for use of significant figures in all calculations (See Appendix A).

Sample Performance Indicators

1. Starting from rest, a skateboarder accelerates down a hill. After 3.8 s she reaches a velocity of 8.75 m/s. What was her average acceleration? Assume downhill is the positive direction.
2. An object moving north at 14 m/s experiences an acceleration of 2.0 m/s^2[N]. What is the velocity of the object after accelerating for 4.0 s?
3. A car travelling at 15 m/s accelerates at a rate of -1.02 m/s^2. How long does it take the car to stop?

Calculating Acceleration

Sample Teaching and Assessment Strategies

Connection

Students may

- Practice solving acceleration problems (*NL Science 10*, p.262).

Consolidation

Teachers may

- Use exit cards to formatively assess students' abilities to solve acceleration problems, sketch position-time and velocity-time graphs from a description of motion, and describe motion from position-time and velocity-time graphs.

Students may

- Create a set of acceleration problems and solutions; recording individual problems on one side of an index card with its solution on the other side. Use the cards in a Quiz, Quiz, Trade activity to solving acceleration problems.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-3-59 - 65

NL Science 10 (SR)

- pp. 256-263

Appendices

- Appendix A

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Acceleration resources (websites)

Acceleration Due to Gravity

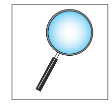
Outcomes

Students will be expected to

7.0 develop appropriate sampling procedures [GCO 2]

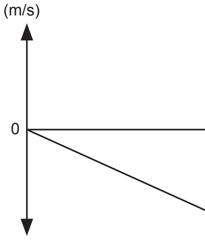
19.0 compare theoretical and empirical values and account for discrepancies [GCO 2]

Focus for Learning



Students should

- devise a procedure that will allow them to determine acceleration due to gravity (g) for a chosen object;
- select appropriate instruments (e.g., ticker tape and recording timers, motion sensors, stopwatches) and develop appropriate sampling procedures to collect data;
- carry out procedures, using instruments effectively and accurately to collect position-time data;
- compile and organize position-time data in an appropriate table and display it in a position-time graph with a curve of best fit;
- calculate instantaneous velocity at specific times using the tangent method;
- compile velocity-time data in an appropriate table;
- display velocity-time data in an appropriate graph;



- interpret the trend from the velocity-time graph and calculate acceleration (i.e., slope of the line of best fit);
- determine the percentage error of their measured value for g using the equation

$$\%\text{ error} = \frac{|\text{theoretical value} - \text{empirical value}|}{\text{empirical}} \times 100\%$$

  where the accepted value of g is -9.81m/s^2;
- evaluate the relevance, reliability, and adequacy of data and data collection methods;
- identify and explain sources of error and uncertainty in measurements and account for discrepancies; and
- describe changes they would make to their procedure in order to improve accuracy.

This investigation provides another opportunity to assess numerous skill outcomes 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 25.0, 26.0, and 29.0. Refer to the *Integrated Skills* unit for elaboration.

Attitude

Encourage students to value the processes for drawing conclusions. [GCO 4]

Acceleration Due to Gravity

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Facilitate an investigation to determine if mass affects how quickly an object falls. This can be done by dropping two objects of similar shape but different mass (e.g., die and a sugar cube, marble and a ball bearing, golf ball and a table tennis ball). By dropping the objects onto metal pans, timing differences can be heard.
- Present videos of objects falling inside a vacuum.

Connection

Teachers may

- Discuss percentage error and its meaning.

Consolidation

Students may

- Compare their percentage error value with those of other groups and account for discrepancies observed.

Extension

Students may

- View an online demonstration of how to use video analysis of a falling flashing light to develop a position versus time graph for acceleration. Use the video data to find instantaneous velocity from tangents drawn at various intervals along the position-time graph and construct a velocity-time graph to determine acceleration due to gravity and compare it with the theoretical value.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-3-54 - 55

NL Science 10 (SR)

- pp. 250-251

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Acceleration due to gravity resources (websites)
- Video analysis of acceleration demonstration (video)

Motion Technologies

Outcomes

Students will be expected to

62.0 describe the historical development of a technology [GCO 1]

63.0 evaluate the role of continued testing in the development and improvement of technologies [GCO 1]

Focus for Learning

SCOs 62.0 and 63.0 illustrate aspects of the nature of technology.

Students should select a transportation technology of interest (e.g., airplane, ATV, automobile, bicycle, canoe, helicopter, jet skis, kayak, motorcycle, scooter, skateboard, skis, snowboard, snowmobile, spacecraft, submarine) and use research inquiry to investigate and describe the historical development of the technology.

Technology is developed through an engineering design process to meet identified needs or wants or to solve a practical problem. As the needs and wants of society change, new technologies are developed and existing technologies are modified to better meet those needs and wants (e.g., autonomous vehicles, electric vehicles). Students should recognize the critical role that continued testing plays in the engineering design process and the development and improvement of technologies. The development of autonomous vehicles and improvement of vehicle safety through crash testing are suggested contexts.

64.0 evaluate the design of a technology and the way it functions on the basis of identified criteria such as safety, cost, availability, and impact on everyday life and the environment [GCO 1]

There are different ways to analyze technologies (e.g., risk-benefit analysis, life cycle analysis) to determine their costs, benefits, and risks. Students should use research inquiry to evaluate the design and functioning of a transportation-related technology (e.g., autonomous vehicles, electric vehicles, ride share/car share programs). Their evaluation of the technology should focus on safety, cost, availability, impact on society, and impact on the environment. This STSE outcome highlights technology's impact on society and the environment.

65.0 analyze natural and technological systems to interpret and explain their structure and dynamics [GCO 1]

In science and technology, the word 'system' refers to a group of interacting parts that work together to do a job. In this unit the focus is on technological systems. Students should select a transportation-related technology of interest and analyze one of its systems. Complex technologies are comprised of many different systems. If students select automobiles, for example, they could analyze the braking system, electrical system, engine system, exhaust system, fuel supply system, safety system, steering system, suspension system, or transmission system. Their analysis should focus on identifying the parts of the system and explaining how they work together.

Students should recognize that changes made to one part of a system affects the whole system and the other systems with which it interacts. This notion reinforces the need for continued testing in the development and improvement of technologies.

Attitude

Encourage students to show concern for safety and accept the need for rules and regulations. [GCO 4]

Motion Technologies

Sample Teaching and Assessment Strategies

While positioned toward the end of the *Motion* unit, this series of STSE outcomes may be addressed earlier in conjunction with outcomes 40.0, 54.0, and 55.0.

Connection

Teachers may

- Present images representing the historical development of snowmobiles (or another transportation technology). Ask students to sequence images on a relative time line and discuss how the technology has changed over time.
- Present images of “penny-farthing” bicycles and model using a risk-benefit analysis to evaluate its design and functioning.

Students may

- Analyze the historical development of sneakers.
- Take apart a ball point pen (or similar mechanical device). Identify the parts and organize them into systems.
- Consider the safety of flying cars and suggest design elements that may make them safer to operate.
- Investigate the importance of crash test dummies in vehicle testing and safety.

Consolidation

Students may

- Research and evaluate the design and functioning of bicycles using a risk-benefit analysis with respect to safety, cost, availability, societal impact, and environmental impact. Communicate your findings in an appropriate format.
- Analyze the structure and dynamics of bicycle subsystems (i.e., aerodynamics, brakes and steering, drivers and gears, structural frame, wheels).
- Research a variety of different cars online and evaluate them with respect to safety, cost, and environmental impact.
- Suggest improvements to a current motion-related technology.

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 216, 254

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Motion technologies resources (websites)

Canadian Contributions

Outcomes

Students will be expected to

38.0 describe examples of Canadian contributions to science and technology [GCO 1]

Focus for Learning

Canadian scientists and technologists have contributed to many areas of motion. Students should engage in research inquiry to describe examples of Canadian contributions to motion-related science and technology and communicate findings to their peers. Examples include, but are not limited to, the

- Avro Arrow aircraft,
- Canadarm and Canadarm2,
- Confederation Bridge,
- Jolly Jumper, and
- snowmobile.

Attitude

Encourage students to value the contributions to scientific and technological development made by individuals from many societies and cultural backgrounds. [GCO 4]

Canadian Contributions

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Present images of Canadian contributions to motion-related science and technology for discussion.

Consolidation

Teachers may

- Facilitate a cooperative jigsaw activity describing examples of Canadian contributions to motion-related science and technology. Students should leave home groups to investigate their assigned example. They should eventually return to their home group and collectively share what was learned.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-3-61 - 62

NL Science 10 (SR)

- p. 262

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Canadian motion-related technologies (websites)

Section Three: Specific Curriculum Outcomes

Unit 4: Sustainability of Ecosystems

Focus

Students receive an abundance of conflicting information from media and literature on the need to protect the environment as well as the need to remain competitive in an increasingly technological world. A focus on the dynamic equilibrium within ecosystems provides students with opportunities to explore the interdependence of species and the relationships between organisms and their physical environment. As students develop these understandings, they are better able to make informed decisions about the sustainability of ecosystems.

This unit emphasizes the social and environmental contexts of science and technology.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

- 37.0 identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology
- 51.0 defend a decision or judgment and demonstrate that relevant arguments can arise from different perspectives
- 72.0 propose a course of action on social issues related to science and technology, taking into account human and environmental needs
- 75.0 explain how a paradigm shift can change scientific world views
- 76.0 describe how Canadian research projects in science and technology are funded
- 77.0 describe the importance of peer review in the development of scientific knowledge
- 78.0 compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

- 2.0 design an experiment identifying and controlling major variables
- 3.0 state a prediction and a hypothesis based on available evidence and background information
- 5.0 formulate operational definitions of major variables
- 6.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making
- 13.0 select and integrate information from various print and electronic sources or from several parts of the same source
- 14.0 select and use apparatus and materials safely
- 16.0 describe and apply classification systems and nomenclature used in the sciences
- 17.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
- 25.0 communicate questions, ideas and intentions, and receive, interpret, understand, and respond to the ideas of others
- 27.0 identify multiple perspectives that influence a science related decision or issue

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

66.0 explain why ecosystems with similar characteristics can exist in different geographical locations
67.0 explain various ways in which natural populations are kept in equilibrium and relate this equilibrium to the resource limits of an ecosystem
68.0 illustrate and explain the cycling of matter through biotic and abiotic components of an ecosystem by tracking carbon, nitrogen, and oxygen
69.0 describe how soil composition and fertility can be altered and how these changes could affect an ecosystem
70.0 describe the mechanisms of bioaccumulation, and explain its potential impact on the viability of and diversity of consumers at all trophic levels
71.0 analyze the impact of external factors on an ecosystem
73.0 explain how the biodiversity of an ecosystem contributes to its sustainability
74.0 explain why different ecosystems respond differently to short-term stresses and long-term changes

GCO 4 (Attitudes): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not
- show a continuing and more informed curiosity and interest in science and science-related issues
- use factual information and rational explanations when analyzing and evaluating
- work collaboratively in planning and carrying out investigations, as well as generating and evaluating ideas
- have a sense of personal and shared responsibility for maintaining a sustainable environment
- project the personal, social, and environmental consequences of proposed actions
- want to take action for maintaining a sustainable environment.

SCO Continuum

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Science 7	Science 1206	Biology 2201
Interactions Within Ecosystems	*Sustainability of Ecosystems*	*Interactions Among Living Things*
• explain how biological classification takes into account the diversity of life on Earth • identify the roles of producers, consumers, and decomposers in a local ecosystem, and describe their diversity and interactions • describe conditions essential to growth and reproduction of plants and microorganisms in an ecosystem and relate them to various aspects of the human food supply • describe how energy is supplied to, and how it flows through, a food web • describe how matter is recycled in an ecosystem through interactions among plants, animals, fungi, and microorganisms • describe interactions between biotic and abiotic factors • identify signs of ecological succession in a local ecosystem	• explain why ecosystems with similar characteristics can exist in different geographical locations • explain various ways natural populations are kept in equilibrium and relate this equilibrium to the resource limits of an ecosystem • illustrate and explain the cycling of matter through biotic and abiotic components of an ecosystem • describe how soil composition and fertility can be altered and how these changes could affect an ecosystem • describe the mechanisms of bioaccumulation, and explain its potential impact on the viability of and diversity of consumers at all trophic levels • analyze the impact of external factors on an ecosystem • explain how the biodiversity of an ecosystem contributes to its sustainability • explain why different ecosystems respond differently to short-term stresses and long-term changes	• compare Canadian biomes in terms of climate, vegetation, physical geography, and location • describe population growth and explain factors that affect population growth • analyze interactions within and between populations • evaluate Earth's carrying capacity, considering human population growth and its demands on natural resources • use the concept of the energy pyramid to explain the production, distribution, and use of food resources

Suggested Unit Plan

The *Sustainability of Ecosystems* unit is the final unit of Science 1206. It is the final life science unit of the common K-10 Science program.

Unit content is foundational for Biology 2201.

September	October	November	December	January	February	March	April	May	June
Weather Dynamics		**Chemical Reactions**			**Motion**		**Sustainability of Ecosystems**		
Skills Integrated Throughout									

Components of Sustainable Ecosystems

Outcomes

Students will be expected to

16.0 describe and apply classification systems and nomenclature used in the sciences [GCO 2]

Focus for Learning

In Science 7, students studied ecosystems, their biotic and abiotic components, and the interrelationships among them. They described how ecosystems are organized and how energy is supplied to, and flows through them. Activate students' prior knowledge of ecosystem-related terminology (e.g., ecology, biotic factor, abiotic factor, organism, species, population, community, habitat, niche, producer, consumer, decomposer, herbivore, carnivore, omnivore, food chain, food web).

In Science 1206, the focus is on the sustainability of ecosystems.

Students should

- describe sustainable ecosystems as ecosystems capable of withstanding pressure and giving support to a variety of organisms;
- describe animals, plants, microorganism, and their interactions (i.e., symbiosis, predation, competition) as biotic components of ecosystems;
- describe non-living factors (e.g., light, nutrients, oxygen, pH, soil, water) as abiotic components of ecosystems; and
- describe how biotic interactions and abiotic characteristics affect sustainability.

Throughout the unit, where possible, learning should focus on local ecosystems and include terrestrial, freshwater, and ocean ecosystems.

Under appreciating the importance of abiotic components in sustaining life is a common student misconception.

Attitude

Encourage students to value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not. [GCO 4]

Sample Performance Indicators

1. View an image of a local terrestrial or aquatic ecosystem and describe the biotic and abiotic components of the ecosystem.
2. Select a biotic interaction (i.e., symbiosis, predation, competition) and describe how it affects sustainability.
3. Select an abiotic characteristic (i.e., water, oxygen, light, nutrients, soil) and describe how it affects sustainability.

Components of Sustainable Ecosystems

Sample Teaching and Assessment Strategies

The “What You Should Recall About...” sections of *NL Science 10* (pp. 278-281) summarize the prerequisite knowledge required for the Science 1206 *Sustainability of Ecosystems* unit. Preassess students’ prior knowledge, reteaching as required.

Activation

Students may

- Create an ‘ecosystem’ concept map from prior knowledge.
- Brainstorm what is needed to sustain species within an ecosystem.

Connection

Students may

- Visit and observe local ecosystems; identifying abiotic and biotic factors.
- Kinesthetically create and analyze food webs for local aquatic and terrestrial ecosystems.
- Engage in a book walk through unit 4 (NL Science 10, pp. 276-355) to identify new terminology.
- Participate in a jigsaw cooperative learning activity to examine how various biotic interactions and abiotic characteristics affect sustainability.

Consolidation

Teachers may

- Provide images of local and terrestrial ecosystems. Given an image or description of an ecosystem, students should identify the biotic and abiotic components and describe how biotic interactions and abiotic characteristics affect sustainability.

Students may

- Engage in an ecosystem field study to identify the biotic factors and abiotic conditions of a local terrestrial or aquatic ecosystem.

Resources and Notes

Authorized

NL Science 10 (Teacher Resource [TR])

- TR-4-7 - 13

NL Science 10 (Student Resource [SR])

- pp. 278-281, 284-287

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/teaching-and-learning-strategies.html
    - Activating Prior Knowledge of Ecology
    - Coastal Monitoring Program

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Sustainable ecosystem resources (websites)

Different Geographic Locations Can Sustain Similar Ecosystems

Outcomes

Students will be expected to

66.0 explain why ecosystems with similar characteristics can exist in different geographical locations [GCO 3]

Focus for Learning

Students should recognize that different geographic locations can sustain similar ecosystems. Boreal forest ecosystems, for example, are found across Canada as well as across large regions in Russia, Finland, and Scandinavia. Students should explain that this phenomenon occurs because these diverse geographic locations have similar combinations of abiotic characteristics (e.g., latitude, elevation, climate, hours of sunlight, soil type, nutrient levels).

Abiotic characteristics determine the type and abundance of plants, and other photosynthetic organisms, that can survive. The plants, in turn, determine the diversity and abundance of animals, fungi, and other species that can inhabit the location. As a result, diverse geographic locations can sustain similar communities of species adapted to the particular combination of abiotic factors.

The term biome may be introduced to refer to a group of similar ecosystems. Local biomes include boreal forest, tundra, freshwater, and various marine biomes.

Note, comparing the characteristics of different biomes is not an expectation of Science 1206. Canadian biomes are compared in Biology 2201.

Sample Performance Indicator

Explain why polar bears can inhabit diverse geographical locations such as Greenland, Alaska, northern Russia, and the north coast of Labrador.

Different Geographic Locations Can Sustain Similar Ecosystems

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Provide information regarding abiotic characteristics of unidentified geographic regions. Ask students to predict the dominant flora and fauna found there and the expected level of biodiversity.
- Present images of ecosystems found online. Ask students to predict the possible geographic locations of the image. Use an image search engine to identify the exact location of the image.

Students may

- Identify different geographic locations which might have similar combinations of abiotic characteristics.
- View a map depicting the locations of tropical rain forests or deserts. Explain why this biome is only found in these locations.
- Identify different geographic locations that might have similar characteristics to the Grand Banks marine ecosystem.

Consolidation

Students may

- View images of the ranges of specific plants or animals (e.g., snowshoe hare, larch). Explain why they are found in these areas but not others.
- Explain why polar bears can inhabit diverse geographical locations such as Greenland, Alaska, northern Russia, and the north coast of Labrador.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-4-14 - 16

NL Science 10 (SR)

- pp. 288-289

Populations and Sustainability

Outcomes

Students will be expected to

67.0 explain various ways in which natural populations are kept in equilibrium and relate this equilibrium to the resource limits of an ecosystem [GCO 3]

Focus for Learning

In Science 7, students defined the terms species, population, and community. In Science 1206, students relate natural populations to ecosystem sustainability.

Students should

- define equilibrium as a state of balance in which there is no net change over time;
- relate equilibrium to natural populations;
- define limiting factor and describe abiotic and biotic examples;
- distinguish between density-independent and density-independent factors;
- explain how limiting factors maintain population equilibrium;
- define carrying capacity;
- interpret graphs depicting changes in populations over time; and
- define a species' ecological niche.

Human populations are not a focus of Science 1206. Human population growth is addressed in Biology 2201.

17.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

Additionally, students should engage in a predator-prey simulation to investigate how predation and prey availability limit population growth (e.g., Investigation 7-2D, *NL Science 10,* p. 302).

Students should, in small collaborative groups,

- compile and organize prey and predator data, for each generation, in a data table;
- display their data in a graph (the number of generations is the independent variable); and
- analyze and interpret changes in predator and prey populations over time.

Students should recognize predation and prey availability as limiting factors that keep natural populations in equilibrium.

In addition to SCO 17.0, evidence may be collected to assess SCOs 11.0 and 18.0. Refer to the *Integrated Skills* unit for elaboration of theses outcomes.

Attitude

Encourage students to use factual information and rational explanations when analyzing and evaluating. [GCO 4]

Sample Performance Indicators

1. Explain how factors such as decreased oxygen supply, low food supply, disease, predators, and limited physical space may affect the population size of trout in a pond.
2. Refer to Activity 7-2A (*NL Science 10,* p. 295). Plot the population data for the three bird species on separate graphs and draw lines of best fit. Identify which bird population is in equilibrium.

Populations and Sustainability

Sample Teaching and Assessment Strategies

Activation

- Facilitate kinesthetic predator-prey games. Following play, discuss the role predation in ecosystem sustainability.

Connection

Teachers may

- Present graphs depicting changes in the population of an organism over time. Ask students to identify if the population trend is increasing, decreasing, or maintaining equilibrium.

Students may

- Analyze and interpret population graphs of organisms from local ecosystems.
- Investigate factors affecting the balance of a managed moose population (Investigation 7-2C, *NL Science 10*, p. 301).
- Select a local organism and create a list of potential limiting factors.
- Discuss the implications of reintroducing a predator to an area (e.g., introducing the Labrador wolf to Newfoundland).

Consolidation

Students may

- Explain what is meant by the following statement. “Population size is dependent on the resources available”.
- Personally create data tables to organize data compiled from predator-prey simulations.
- Compare their predator-prey graphs to those of classmates and suggest explanation for any discrepancies observed.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-4-17 - 28
- BLM 7-7

NL Science 10 (SR)

- pp. 292-296, 301-302

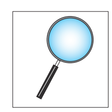
Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Limiting factor and population resources (websites)
- Predator-prey simulations (websites)

Note

The magnifying glass icon is used throughout the unit to indicate investigations.



Cycles and Sustainability

Outcomes

Students will be expected to

68.0 illustrate and explain the cycling of matter through biotic and abiotic components of an ecosystem by tracking carbon, nitrogen, and oxygen
[GCO 3]

Focus for Learning

In Science 7, students illustrated and explained how matter cycles through producers, consumers, and decomposers in an ecosystem. In Science 1206, students should

- analyze a general model of a nutrient cycle, depicting nutrient stores and flows, and explain how nutrients cycle through biotic and abiotic components (e.g., Activity 7-3A, *NL Science 10*, p. 305);
- define the processes of photosynthesis and cellular respiration;
- explain the cycling of carbon and oxygen through ecosystems (Note, carbon and oxygen should be treated as a combined cycle);
- define the processes of denitrification and nitrification; and
- illustrate and explain the nitrogen cycle.

Treatment should include nutrient cycling in aquatic ecosystems.

Students' ability to explain the cycling of matter should be emphasized over their ability to illustrate cycles.

Students should recognize that sustainable ecosystems depend on the availability and balance of essential nutrients. They should describe human activities affecting each cycle and recognize that these activities result in nutrient imbalances.

Students should define eutrophication and explain its effects on aquatic ecosystems.

Note, nutrient cycles may be referred to as biogeochemical cycles. This alternate term illustrates the interdisciplinary nature of the study of nutrient cycles (SCO 40.0).

Sample Performance Indicators

1. Explain how the processes of photosynthesis and cellular respiration relate to the cycling of oxygen and carbon in ecosystems.
2. Explain how oxygen and carbon dioxide cycle in aquatic ecosystems.
3. Explain how nitrification returns nitrogen to the atmosphere.
4. Create a sketch of the nitrogen cycle and explain how nitrogen is cycled through an ecosystem.
5. Describe how widespread, human use of agricultural fertilizer affects aquatic ecosystems.

Cycles and Sustainability

Sample Teaching and Assessment Strategies

Use of Activity 7-3B: A Nutrient Cycle Travel Log (*NL Science 10*, p. 313) is strongly suggested as an anchor activity to illustrate the movement of carbon, oxygen, and nitrogen through ecosystems. Activity notes and blackline masters are provided in the *NL Science 10* teacher resource. Following the activity, students should compare their passport with those of others travelling as the same nutrient.

Activation

Teachers may

- Engage student groups in placemat activities to elicit prior knowledge of nutrients (i.e., carbon, oxygen, nitrogen).
- Revisit the water cycle from the *Weather Dynamics* unit to introduce the cycling of matter through ecosystems.

Connection

Teachers may

- Present online images of various nutrient cycles (i.e., general nutrient cycles, nitrogen, carbon, oxygen, carbon/oxygen). Ask students to
  - compare multiple illustrations of the same cycle, and
  - analyze and interpret a representative cycle for each nutrient.
- Present videos explain the cycling on carbon, oxygen, and nitrogen through ecosystems.
- Discuss carbon taxes and cap and trade systems.

Students may

- Illustrate the process of eutrophication in a flow chart.

Consolidation

Students may

- Describe how human activities impact the carbon cycle.
- Explain the importance of bacteria to the nitrogen cycle.
- Compare the processes of nitrification and denitrification using a Venn diagram.

Extension

Students may

- Investigate the cycling of phosphorus, or other nutrients, through ecosystems.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-4-29 - 40
- BLM 7-10, 7-11, 7-12

NL Science 10 (SR)

- pp. 304-308, 313

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Nutrient cycles resources (websites and videos)
- Human activities influencing nutrient cycles (websites)

Soil Composition and Fertility

Outcomes

Students will be expected to

69.0 describe how soil composition and fertility can be altered and how these changes could affect an ecosystem
[GCO 3]

2.0 design an experiment identifying and controlling major variables
[GCO 2]

3.0 state a prediction and a hypothesis based on available evidence and background information
[GCO 2]

5.0 formulate operational definitions of major variables
[GCO 2]

14.0 select and use apparatus and materials safely
[GCO 2]

25.0 communicate questions, ideas, and intentions, and receive, interpret, understand, and respond to the ideas of others
[GCO 2]

Focus for Learning

Students should describe ways soil composition (i.e., minerals [sand, silt, clay], air, water, and organic matter) and fertility (i.e., nutrients) can be altered. Alterations include

- amending soils by adding sand, silt, clay, peat, manure, compost;
- irrigating, mulching, aerating, and tilling soils;
- fertilizing, growing legumes or other cover crops; and
- adding chemicals to alter pH.

Students should describe how altering soil composition and fertility could affect an ecosystem, making connections to nutrient cycles (e.g., manuring and composting add organic matter to the soil which bacteria breakdown to produce nitrates that can be taken up by plants). Note, human activities, related to agriculture, may also result in unintended consequences, such as soil erosion, soil compaction, nutrient depletion, toxicity, and eutrophication of aquatic ecosystems.

Treatment may be extended to include hydroponics and aquaponics.

Additionally, students should design and conduct an experiment to investigate the effects of altering a personally-selected aspect of soil composition or fertility. Students could investigate, for example, the effects of

- fertilizer type (i.e., percentages of primary nutrients) or amount on plant growth;
- fertilizer amount on the growth of algae in water;
- pH on plant growth;
- growing legumes on nitrogen levels in soils;
- mulch type or amount on soil water retention; or
- sand percentage in soils on drainage.

The focus should be students' ability to design and carry out a controlled experiment. This open investigation could be used as a science project.

In addition to skill outcomes 2.0, 3.0, 5.0 and 14.0, teachers may assess SCOs 1.0, 6.0, 7.0, 8.0, 9.0, 11.0, 17.0, 18.0, 20.0, 21.0, 22.0, 24.0, 26.0, and 29.0. If students are expected to conduct background research, SCOs 12.0 and 13.0 may also be assessed. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Attitude

Encourage students to work collaboratively in planning and carrying out investigations, as well as generating and evaluating ideas.
[GCO 4]

Soil Composition and Fertility

Sample Teaching and Assessment Strategies

Activation

Students may

- List what plants require in order to grow.

Teachers may

- Display samples of soil with different characteristics and discuss which would be best for optimal plant growth.

Connection

Teachers may

- Invite local farmers or avid gardeners to present to the class on methods they use to alter soil composition and fertility.

Students may

- Compare the composition of soil samples obtained from various local ecosystems.
- Use soil testing kits to determine pH and nitrogen, phosphorus, and potassium levels for local soil samples.
- Explore methods historically used to alter soils in Newfoundland and Labrador (e.g., harvesting seaweed to use as fertilizer).
- Examine how the use of cover crops improves soil composition and fertility.
- Discuss how crop rotation may help sustain nutrient levels in agricultural soils.

Consolidation

Teachers may

- Facilitate a class mini-conference where student groups present their research question, procedure, and findings to classmates and respond to participant's questions.

Students may

- Investigate how adding varying amounts of liquid fertilizer affects the growth of algae in bottles of water (algae may be introduced by adding drops of pond water or water from an aquarium).
- Communicate their research using a formal lab report (*NL Science 10,* p. 381).
- Evaluate the design of their experiments and make suggestion for improvement.
- Examine how agriculture-related toxins are affecting Arctic ecosystems.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-4-34 - 35

NL Science 10 (SR)

- p. 314

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Amending soil composition and fertility resources (websites)

Bioaccumulation and Biomagnification

Outcomes

Students will be expected to

70.0 describe the mechanisms of bioaccumulation, and explain its potential impact on the viability of and diversity of consumers at all trophic levels
[GCO 3]

Focus for Learning

In Science 7, students described how matter flowed through food chains and food webs. Treatment, however, did not include references to trophic levels.

In Science 1206, students should

- recognize categories of organisms, such as primary producers, primary consumers, secondary consumers, tertiary consumers, and quaternary consumers, as trophic levels;
- describe the process of bioaccumulation;
- identify examples of bioaccumative and toxic substances (e.g., DDT, PCBs, mercury, PAHs);
- describe the process of biomagnification; and
- explain the impacts of bioaccumulation and biomagnification on consumers at different trophic levels.

Students should explore relevant examples illustrating the impacts of specific bioaccumative and toxic substances on higher order consumers. This exploration may also be used to address, in part, SCO 71.0; analyzing the impact of external factors on ecosystems.

Note, use of energy pyramids to explain resource flow in ecosystems is not an expectation of Science 1206. Energy pyramids are addressed in Biology 2201.

Attitude

Encourage students to show a continuing and more informed curiosity and interest in science and science-related issues. [GCO 4]

Sample Performance Indicator

A bioacculative and toxic substance is leaking into a freshwater ecosystem and is absorbed by phytoplankton. Using the food chain below, describe the processes of bioaccumulation and biomagnification and explain the potential impacts on the stickleback, brown trout, and osprey.

phytoplankton → zooplankton → stickleback → brown trout → osprey

Bioaccumulation and Biomagnification

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Present food chains and webs for local terrestrial and aquatic ecosystems. Ask students to classify organisms according to trophic level.
- Present case studies related to bioaccumulation and biomagnification for students to explore.

Students may

- Create a two-tab foldable to differentiate between bioaccumulation and biomagnification.
- Discuss at which trophic level organisms are most affected by biomagnification.

Consolidation

Students may

- Investigate the bioaccumulation of mercury, DDT, PCBs, and plasticizers (e.g., phthlates, BPA).

Resources and Notes

Authorized

NL Science 10 (SR)

- pp. 309-312

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Bioaccumulation and biomagnification resources (websites)

Factors That Affect the Sustainability of Ecosystems

Outcomes

Students will be expected to

71.0 analyze the impact of external factors on an ecosystem [GCO 3]

13.0 select and integrate information from various print and electronic sources or from several parts of the same source [GCO 2]

Focus for Learning

Students should investigate and analyze the impact of external factors (e.g., changing climate, human activities [deforestation, draining wetlands, industry, introduction of non-native species, overexploitation, pollution]) on the sustainability of local ecosystems (e.g., Arctic, freshwater, forests, oceans). Students should

- select a local ecosystem;
- use research inquiry to identify external factors affecting the ecosystem;
- collect and analyze information on their topic; and
- compile and display their information, in an appropriate format, to communicate how their selected ecosystem is impacted by external factors.

Skill outcomes 1.0, 12.0, 13.0, 17.0, 22.0, 24.0, and 26.0 may be assessed. Refer to the *Integrated Skills* unit for elaboration.

Note, climate change effects were previously investigated in unit 1.

The term ecosystem services may be introduced to describe the benefits sustainable ecosystems provide organisms.

72.0 propose a course of action on social issues related to science and technology, taking into account human and environmental needs [GCO 1]

27.0 identify multiple perspectives that influence a science related decision or issue [GCO 2]

51.0 defend a decision or judgment and demonstrate that relevant arguments can arise from different perspectives [GCO 1]

Investigating external threats to local ecosystems should lead to discussions regarding the social and environmental contexts of science and technology.

Students should examine real-world or fictitious, science-related decisions or issues (e.g., considering the establishment of a marine protected area in the Laurentian channel, creating a development plan to preserve a wetland while allowing for some urban development, deciding whether to remove soil from proposed hydroelectric reservoirs, deciding whether to permit fracking in western Newfoundland). Students should

- identify multiple perspectives influencing the decision or issue;
- propose a course of action, taking into account social and environmental needs; and
- develop, present, and defend a position or course of action.

Evidence may also be collected to assess skill outcomes 23.0, 25.0, 26.0, 28.0, and 29.0. Refer to the *Integrated Skills* unit for elaboration.

Attitude

Encourage students to project the personal, social, and environmental consequences of proposed actions. [GCO 4]

Factors That Affect the Sustainability of Ecosystems

Sample Teaching and Assessment Strategies

Students' investigation of the impact of external factors on local ecosystems may be facilitated as a cooperative jigsaw activity. The local ecosystems investigated could comprise the expert groups. Following investigation, students would communicate their expert learning to members of their home group.

Connection

Teachers may

- Present local, environment-related decisions or issues for students to research and discuss.

Students may

- Consider the ecosystem services provided by various local ecosystems (e.g., Arctic, freshwater, forests, oceans).
- Investigate invasive species that are of special concern in Newfoundland and Labrador.
- Explore the role of restoration ecologists in renewing degraded ecosystems.
- Investigate beekeeping operations and colony collapse disorder. Identify factors affecting sustainability.

Consolidation

Teachers may

- Facilitate a class debate of a contentious environment-related issue or decision. Assign specific perspectives to individual students. Ask them to develop arguments consistent with their perspective.

Students may

- Investigate overexploitation of freshwater and ocean species (e.g., cod, shrimp, Atlantic salmon).

Extension

- Students may investigate the great Pacific garbage patch or electronic waste in Guiyu, China.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-4-43 - 47

NL Science 10 (SR)

- pp. 289, 320-326

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Ecosystem threats (websites)
- Case studies (websites)
- Marine protected areas resources (websites)

Biodiversity and Sustainability

Outcomes

Students will be expected to

73.0 explain how the biodiversity of an ecosystem contributes to its sustainability [GCO 3]

74.0 explain why different ecosystems respond differently to short-term stresses and long-term changes [GCO 3]

Focus for Learning

Sustainable ecosystems are capable of withstanding pressure and give support to a variety of organisms.

Students should

- define biodiversity and resilience,
- examine evidence of the relationship between resilience and biodiversity,
- explain how ecosystems with greater biodiversity are more resilient to stress,
- distinguish between and provide examples of short-term stresses and long-term changes, and
- explain how different ecosystems respond to stress and change.

Treatment should include discussion regarding the importance of protecting ecosystems, biodiversity, and endangered, threatened, and vulnerable species.

Sample Performance Indicators

1. Graph the resilience data contained within Investigation 8-1D (*NL Science 10*, p. 332). Explain the relationship between resilience and biodiversity.
2. Arctic ecosystems are believed to be less biodiverse than ecosystems at lower latitudes. What affect might this have on the resilience of Arctic ecosystems?

Biodiversity and Sustainability

Sample Teaching and Assessment Strategies

Use of Investigation 8-1D: Resilience of a Grassland Ecosystem (*NL Science 10*, p. 332) is strongly suggested as an anchor investigation to illustrate how species diversity affects the resilience of an ecosystem.

Activation

Students may

- Brainstorm a list of species that inhabit a local ecosystem.

Connection

Students may

- Predict the level of biodiversity in ecotones (i.e., transition zones between two ecosystems) and discuss its role in ecosystem resilience.
- Discuss the resilience and sustainability of monculture lawns.
- Discuss how overexploitation of a species (e.g., Atlantic cod) can threaten biodiversity.
- Identify personal actions they might undertake to protect biodiversity.

Consolidation

Students may

- Describe how stresses may impact an ecosystem with low biodiversity differently than one with high biodiversity.
- Describe how a forest ecosystem may respond to a wind storm, insect infestation, and large scale logging project.
- Describe how a wetland ecosystem may respond to an abnormally dry summer and ATV use.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-4-47 - 51

NL Science 10 (SR)

- pp. 327-333

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Biodiversity resources (websites)

Shifting Perspectives on Ecosystems

Outcomes

Students will be expected to

75.0 explain how a paradigm shift can change scientific world views [GCO1]

37.0 identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology [GCO 1]

76.0 describe how Canadian research projects in science and technology are funded [GCO 1]

77.0 describe the importance of peer review in the development of scientific knowledge [GCO 1]

Focus for Learning

Students should

- explain what is meant by a paradigm shift;
- recognize that society is currently in the midst of a paradigm shift related to how we understand sustainability and the importance of ecosystem services, biodiversity, and maintaining sustainable ecosystems;
- identify the role that images of Earth, taken from space, played in initiating the paradigm shift;
- explain how society's views about the sustainability are changing; and
- provide evidence of the paradigm shift at the local, provincial, national, and international levels.

Scientific research provides crucial information to society. Research findings are used by citizens, governments, and businesses to make decisions about policy and legislation related to sustainability.

Students should

- investigate to determine how science research projects are funded (e.g., Activity 8-2A, *NL Science 10,* p. 338*);* and
- recognize that research projects are funded by governments, through universities and research councils, corporations, and to a lesser extent by philanthropists, non-profit foundations, professional organizations, and crowdsourcing.

Identifying funders of scientific research is important when evaluating the potential for bias. Was the provided funding unrestricted or could the funder have influenced the research?

Peer-reviewed journals provide a trusted form of science communication. Readers can trust that the scientific research published in the journal has been reviewed by experts and meets certain standards of scientific quality. Once published, others may attempt to replicate, challenge, or extend the findings. It is through this process that scientific knowledge develops.

Attitude

Encourage students to have a sense of personal and shared responsibility for maintaining a sustainable environment. [GCO 4]

Shifting Perspectives on Ecosystems

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Use optical illusions to illustrate how individuals may hold different views or ways of thinking.

Connection

Teachers may

- Discuss the predictive power of theories.
- Provide examples of science-related paradigm shifts:
  - from geocentrism to heliocentrism,
  - from spontaneous generation to biogenesis, and
  - from fixed continents to continental drift.

  Discuss the role technological innovation played in these shifts.

Students may

- Discuss why it takes time and effort to change a paradigm.
- Tag articles in their STSE portfolio that illustrate how scientific understanding was enhanced or revised as a result of the invention of a new technology.

Consolidation

Students may

- Discuss environmental policies and legislation that are outcomes of the paradigm shift related to the sustainability of ecosystems.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-4-52 - 55

NL Science 10 (SR)

- pp. 334-340

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/science-1206/resource-links.html

- Images of Earth from space (websites)
- Paradigm shift resources (websites)

Sustainable Development

Outcomes

Students will be expected to

78.0 compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology [GCO 1]

6.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making [GCO 2]

Focus for Learning

Sustainable development must balance the risks of technologies with the benefits.

Students should

- analyze information about the risks and benefits of a specific technology (i.e., product or process); and
- personally decide whether the benefits outweigh the risks.

Technologies analyzed could include

- aquaculture,
- antibiotic use in livestock farming,
- herbicides or pesticides,
- hydroelectric power generation,
- microbead (plastic) use in hygiene products, and
- sonar and seismic testing.

Evidence may be collected to assess skill outcomes 6.0, 12.0, 13.0, 22.0, 25.0, 27.0, and 28.0. Refer to the *Integrated Skills* unit for elaboration.

Attitude

Encourage students to want to take action for maintaining a sustainable environment. [GCO 4]

Sustainable Development

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Provide information regarding controversial, technological products and processes for students to analyze the risks and benefits of their use.

Students may

- Tag articles in their STSE portfolio that compare the risks and benefits to society of applying scientific knowledge or introducing a technology

Consolidation

Teachers may

- Facilitate a class debate regarding the risks and benefits to society and the environment of use of specific technologies.

Students may

- Complete Activity 8-2B (*NL Science 10,* p. 341*)* to compare the risks and benefits of the use of atrazine, an agricultural herbicide.

Resources and Notes

Authorized

NL Science 10 (TR)

- TR-4-55 - 58

NL Science 10 (SR)

- pp. 341-346

Appendix A: Scientific Conventions

Scientific Conventions

Scientific information should be communicated according to accepted scientific conventions. These conventions include significant figures, formulas, units, and data (graphs, diagrams, tables). The Department of Education and Early Childhood Development follows the conventions below for public exams.

Significant Figures

Any number used in a calculation should contain only figures that are considered reliable; otherwise, time and effort are wasted. Figures that are considered reliable are called significant figures. Scientific calculations generally involve numbers representing actual measurements. In a measurement, significant figures in a number consist of:

Figures (digits) definitely known + one estimated figure (digit)

They are often expressed as “all of the digits known for certain plus one that is uncertain”.

Significant Figure Rules

1. All non-zero digits are significant.
2. Zero rules
   - Trailing zeros (i.e., at the end to the right) of a measurement may or may not be significant:
     - If it represents a measured quantity, it is significant (e.g., 25.0 cm - the zero is significant; the decimal is clearly indicated).
     - If immediately to the left of the decimal, it is not significant (e.g., 250 cm or 2500 cm - zeros are not significant; both have 2 significant digits as there is uncertainty whether zeros are measured values).
     - If the trailing zeros in 250 cm and 2500 cm are significant, the measurements must be written in scientific notation (e.g., 2.50×10^2 cm or 2.500×10^3 cm - zeros are significant). Note: Scientific notation is not part of the K-12 mathematics program.
   - A zero, between two non-zero digits in a measurement, is significant (e.g., 9.04 cm - the zero is significant).
   - Leading zeros (i.e., at the beginning to the left) are never significant (i.e., they do not represent a measured quantity), they merely locate the decimal point (e.g., 0.46 cm and 0.07 kg - the zeros are not significant).
3. Rounding with Significant Figures

   In reporting a calculated measured quantity, rounding an answer to the correct number of significant figures is important if the calculated measurement is to have any meaning. The rules for rounding are listed below.
   - If the figure to be dropped is less than 5, eliminate it:
     - rounding 39.949 L to three significant figures results in 39.9 L
     - rounding 40.0 g to two significant figures results in 4.0×10^1 g
   - If the figure to be dropped is greater than or equal to 5, eliminate it and raise the preceding figure by 1:
     - rounding 39.949 L to four significant figures results in 39.95 L
     - rounding 39.949 L to two significant figures results in 4.0×10^1 L

4. Multiplying and Dividing with Significant Figures

   In determining the number of significant figures in a measurement that is calculated by multiplying or dividing, the measurement with the least number of significant figures should be identified. The final calculated measurement should contain the same number of significant figures as the measurement with the least number of significant figures.

   $$2.1 \text{ cm} \times 3.24 \text{ cm} = 6.8 \text{ cm}^2$$

   Since 2.1 cm contains two significant figures and 3.24 contains three significant figures, the calculated measurement should contain no more than two significant figures.

5. Adding and Subtracting with Significant Figures

   In determining the number of significant figures when adding or subtracting, the final calculation should be rounded to the same precision as the least precise measurement.

   $$42.56 \text{ g} + 39.460 \text{ g} + 4.1 \text{ g} = 86.1 \text{ g}$$

   Since 4.1 g has only one decimal place, the calculated measurement must be rounded to one decimal place.

6. Performing a Series of Calculations with Mixed Operations

   When a series of calculations is performed, it is important to remember that multiplication/division and addition/subtraction are governed by separate significant figure rules. Rounding only occurs at the last step.

   When calculations involve both of these types of operations, the rules must be followed in the same order as the operations. Rounding still only occurs at the last step of the calculation.

   $$\frac{(0.428 + 0.0804)}{0.009800}$$

   The addition is first, 0.428 + 0.0804 = 0.5084. Following the rules for addition/subtraction, the answer should have three significant figures, but rounding is the last step. Therefore, 0.5084 is used in the next step, 0.5084 ÷ 0.009800 = 51.87755. Following the rules for multiplication/addition, the answer should have four significant figures (but rounding is the last step). The sum of the numerator has three significant figures, and the denominator has four, so the final answer is rounded to three significant figures, 51.9.

   In problems requiring multiple calculations (e.g., calculating final velocity and then using that value to calculate time), it is recommended that rounding only occur in the final calculation. Also, to improve accuracy and consistency, an extra digit should be carried in all intermediate calculations. Students may find it helpful to write the extra digit as a subscript (e.g., 39.5_4 [3 significant figures + 1 extra].

7. Calculating with Exact Numbers

   Sometimes numbers used in a calculation are exact rather than approximate. This is true when using defined quantities, including many conversion factors, and when using pure numbers. Pure or defined numbers do not affect the accuracy of a calculation. You may think of them as having an infinite number of significant figures. Calculating with exact numbers is important when dealing with conversions or calculating molar ratios in chemistry.

8. Scientific Constants

   Treat scientific constants as significant digits because they are rounded values (i.e., actual measured or defined values have many decimal places [e.g., the speed of light constant, 3.00×10^8 m/s, is a rounded value based on the defined value, 299 792 458 m/s]).

9. Significant Figures in Logarithms

   When determining the number of significant figures from a logarithm function, only the digits to the right of the decimal should be counted as significant figures.

   - What is the pH of a sample of orange juice that has 2.5×10^{-4} mol/L hydronium ions?
     The measurement 2.5×10^{-4} mol/L has two significant figures. The power of ten indicates where the decimal is located (i.e. 0.00025). The pH of the sample is $-\log(2.5 \times 10^{-4}) = 3.602\ 059$. The digit to the left of the decimal is derived from the power of ten, therefore, it is not significant. Only two digits to the right of the decimal are significant. The answer should be recorded as 3.60.
   - What is the hydronium ion concentration of orange juice with pH = 2.25?
     The pH value, 2.25, has two significant figures. The hydronium ion concentration is equal to the antilogs of -2.25. This value is 0.0056234 mol/L, which, when rounded to two significant figures, becomes 0.0056 mol/L or 5.6×10^{-3} mol/L.

Formulas and Units

A constructed response question that requires numerical calculations often uses formulas or equations as the starting point to its solution. Proper use of formulas and units in science indicates a thorough understanding of the logic to solve a problem. For any solution that requires the mathematical manipulation of a formula, the formula should be stated at the beginning, followed by workings that clearly indicate the mathematical computations necessary to find the solution.

For most cases in science, a SI unit follows a measured value because it describes the value. Three exceptions to this are pH, equilibrium constants, and index of refraction. The final answer of a solution for a constructed response question that requires the mathematical manipulation of a formula always has a unit with the value. The workings of a solution that lead to the final answer do not have to show units.

Data

Data is generally presented in the form of graphs, tables, and drawings. When these formats are used several scientific conventions should be followed.

Graphs

Graphs represent relationships between numerical information in a pictorial form. Two kinds of graphs are commonly used in science courses in Newfoundland and Labrador:

- Line graph
  - used to display the relationship between continuous data
  - demonstrates a progression of values or shows how one variable changes in relation to another variable (e.g., growth of a child with age)

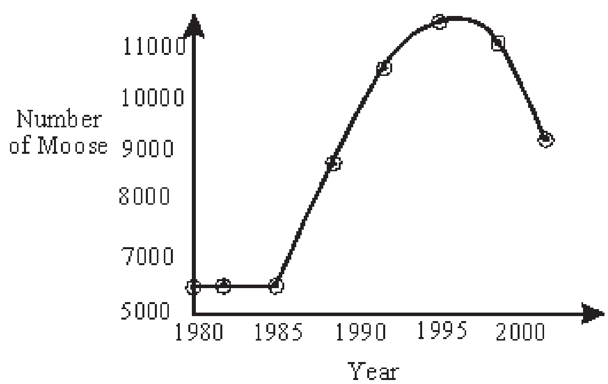
  Note: When equations are graphed, a line or curve of best-fit must be drawn.

- Bar graph
  - used to display discrete or discontinuous data
  - consists of parallel bars whose lengths are proportional to quantities given in a set of data. The items compared are plotted along the horizontal axis and appropriate measurement is plotted along the vertical axis (e.g., populations of different types of protists in a lake).

Graphing Rules:

1. The graph must have a title. The title represents the relationship between the two variables.
2. The independent variable is on the horizontal *x*-axis.
3. The dependent variable is on the vertical *y*-axis.
4. Each axis is specifically labelled with units (if applicable) according to the variable it represents and values are provided with equal increments. The scale does not have to be the same on both axes, but the scales must accommodate the ranges of the two variables (i.e., the graph line or series of bars must fill ≥ 75% of the available space).
   Note: It is not necessary that both axes start at zero. See example below.
5. When data are plotted, a circle should be placed around each point to indicate a degree of error. The graph may show exact numbers or a general relationship. A best-fit line or curve must be used in line and scatter graphs.
6. A legend may be used to identify individual lines on a multi-line graph.

Moose Population in Newfoundland and Labrador (1980 - 2000)



Tables

Tables represent numerical or textual information in an organized format. They show how different variables are related to one another by clearly labelling data in a horizontal or vertical format. As with graphs, tables must have a title that represents the relationship between the variables.

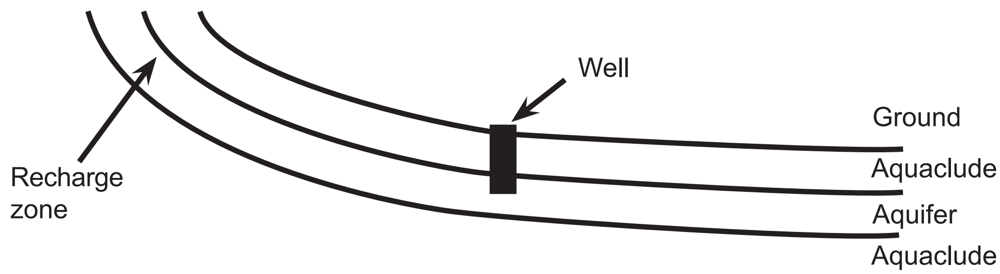
Moose Populations in Newfoundland and Labrador (1980 - 2000)

Year	Number of Moose
1980	5789
1985	6057
1990	8823
1995	11 156
2000	9315

Drawings

Biological drawings that indicate a scale are not required. Diagrams, however, may often be used to aid explanations. These should be clear and properly labelled to indicate important aspects of the diagram.

Geological Conditions Necessary for an Artesian Well



September 2018
ISBN: 978-1-55146-679-8