# Outline of Course of Study

Faculty of Engineering Secondary School
Department of Engineering
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**Course reviser:** Kainia Cloutier
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**Course title:** Grade 11 Physics
**Grade**: 11
**Type:** University
**Ministry Course Code:** SPH3U
**Credit value:** 1.0 credit
**Ministry curriculum policy documents:**

- The Ontario Curriculum, Grades 11 and 12: Science 2008 (Revised)
- Ontario Schools, Kindergarten to Grade 12: Policy and Program Requirements, 2016
- Growing Success: Assessment, Evaluation, and Reporting in Ontario's Schools, Kindergarten to Grade 12, 2010

**Prerequisites and corequisites**: Science, Grade 10, Academic

## Course Description

This course develops students' understanding of the basic concepts of physics. Students will explore kinematics, with an emphasis on linear motion; different kinds of forces; energy transformations; the properties of mechanical waves and sound; and electricity and magnetism. Students will enhance their scientific investigation skills as they test laws of physics. In addition, they will analyze the interrelationships between physics and technology, and consider the impact of technological applications of physics on society and the environment.

## Resources

No textbook is required for this course. Students will be given access to all course material in class and will be given access to software for the course in order to continue their learning.

# Overall Curriculum Expectations

By the end of this course, students will:

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| **A. Scientific Investigation Skills and Career Exploration** | |
| A1 | demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analyzing and interpreting, and communicating); |
| A2 | identify and describe careers related to the fields of science under study, and describe the contributions of scientists, including Canadians, to those fields. |
| **B. Kinematics** | |
| B1 | analyze technologies that apply concepts related to kinematics, and assess the technologies' social and environmental impact; |
| B2 | investigate, in qualitative and quantitative terms, uniform and non-uniform linear motion, and solve related problems; |
| B3 | demonstrate an understanding of uniform and non-uniform linear motion, in one and two dimensions. |
| **C. Forces** | |
| C1 | analyze and propose improvements to technologies that apply concepts related to dynamics and Newton's laws, and assess the technologies' social and environmental impact |
| C2 | investigate, in qualitative and quantitative terms, net force, acceleration, and mass, and solve related problems |
| C3 | demonstrate an understanding of the relationship between changes in velocity and unbalanced forces in one dimension. |

| D. Energy and Society | |
|---|---|
| D1 | analyze technologies that apply principles of and concepts related to energy transformations, and assess the technologies' social and environmental impact |
| D2 | investigate energy transformations and the law of conservation of energy, and solve related problems |
| D3 | demonstrate an understanding of work, efficiency, power, gravitational potential energy, kinetic energy, nuclear energy, and thermal energy and its transfer (heat) |
| **E. Waves and Sound** | |
| E1 | analyze how mechanical waves and sound affect technology, structures, society, and the environment, and assess ways of reducing their negative effects |
| E2 | investigate, in qualitative and quantitative terms, the properties of mechanical waves and sound, and solve related problems |
| E3 | demonstrate an understanding of the properties of mechanical waves and sound and of the principles underlying their production, transmission, interaction, and reception |
| **F. Electricity and Magnetism** | |
| F1 | analyze the social, economic, and environmental impact of electrical energy production and technologies related to electromagnetism, and propose ways to improve the sustainability of electrical energy production |
| F2 | investigate, in qualitative and quantitative terms, magnetic fields and electric circuits, and solve related problems |
| F3 | demonstrate an understanding of the properties of magnetic fields, the principles of current and electron flow, and the operation of selected technologies that use these properties and principles to produce and transmit electrical energy |

# Outline of Course Content

| Unit 1: Lab Safety and Startup – 3 hours |
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| Students will be made aware of the safety equipment and procedures in the lab. They will review WHMIS, and analyze a MSDS for a common chemical. The students will start their ePortfolio.<br>STRAND: A1<br><u>Assessment of learning:</u><br>Lab Safety Assessment<br>Quiz: Significant Digits and Unit Conversions |

| Unit 2: Motion - 23 hours |
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| In this unit, students will develop an understanding of kinematics that will allow them to analyze the motion of an object. They will build a catapult and use it to hit a target.<br>STRAND: A1, B1, B2, B3, D1<br><u>Assessment of learning</u><br>Project: Catapult<br>Quiz: Solving Problems with Algebra |
| Unit 3: Forces - 18 hours |
| Students will learn Newton's Laws and apply them to describe the motion of an object. They will perform several short investigations to learn about applied forces, gravity, and friction. They will apply their knowledge by building a rocket balloon and delivering a payload.<br>They will talk about Canada's contribution to the International Space Station and other space programs and discuss possible careers related to the fields of science.<br>STRAND: A1, A2, C1, C2, C3<br><u>Assessment of learning</u><br>Project: Rocket payload<br>Quiz Newton's Second Law<br>Quiz: Friction and the Normal Force |
| Unit 4: Energy - 18 hours |
| The students will learn about work, energy, power, and the law of conservation of energy. They will learn about the concept of energy transfer and how this process always wastes some energy. They will perform an investigation with a small windmill and use it to lift a mass. They will then modify the windmill's blades to increase its power.<br>STRAND: A1, D1, D2, D3<br><u>Assessment of learning</u><br>Project: Windmill<br>Quiz: Work and Power<br>Quiz: Energy and Thermal Energy |
| Unit 5: Sound, Electricity, and Magnetism – 18 hours |

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| The students will learn about waves and how sound is a mechanical wave in air. They will learn about the concept of resonance and how sounds can be amplified in an air column. They will investigate with air columns to determine the relationship between the length of an air column and the resonant length. The students will learn about electromagnetism, the laws that govern it, and how it can be used to create a simple DC motor. The activity will introduce them to many of the tools and materials that they will use to build the speaker, as well as an understanding of the fields that allow it to operate.<br>STRAND: A1, E1, E2, E3, F1, F2, F3<br><u>Assessment of learning</u><br>Project: Speaker<br>Quiz: Sound<br>Quiz: Electricity and Magnetism |
| Unit 6: Final Project – Mousetrap Car – 30 hours |
| As a final consolidation of learning, the students will put their physics and design skills to the challenge and create a mousetrap car.<br>STRAND: A1, B1, B2, B3, D3<br><u>Assessment of learning</u><br>Final project: Mousetrap car |

# Teaching & Learning Strategies

This course is intended to give high school students a good understanding of physics, as it is applied through projects. Our goal is to keep students engaged and curious by having them 'learn by doing.'

As it is common in science and engineering projects, group work will be a big part of this course. Group work will allow students to practice a variety of skills including: problem solving, organization, communication, and collaboration. Teachers will offer ongoing feedback and will regularly check for understanding through informal discussions and quizzes for assessment for learning.

Through peer feedback offered by students to students (assessment as learning), prototypes will be refined into their final design.

# Strategies for Assessment & Evaluation of Student Performance

Assessment, evaluation, and reporting of student achievement will be based on the policies and practices outlined in the following Ministry's policy document Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools, 2010.

Students will be evaluated based on the overall expectations of the course through the achievement charts in The Ontario Curriculum, Grades 11 and 12: Science, 2008 (Revised) (revised), as outlined in this document

The Ministry of Education's document Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools outlines policies for measuring and communicating achievement. Levels of achievement are defined as follows:

| Level | Percentage | Achievement |
|---|---|---|
| Level 1 | 50—59% | Represents achievement that falls much below the provincial standard. The student demonstrates the specified knowledge and skills with limited effectiveness. Students must work at significantly improving learning in specific areas, as necessary, if they are to be successful in the next grade/course |
| Level 2 | 60—69% | Represents achievement that approaches the provincial standard. The student demonstrates the specified knowledge and skills with some effectiveness. Students performing at this level need to work on identified learning gaps to ensure future success |
| Level 3 | 70—79% | Represents the provincial standard for achievement. The student demonstrates the specified knowledge and skills with considerable effectiveness. Parents of students achieving at level 3 can be confident that their children will be prepared for work in subsequent grades/courses. |
| Level 4 | 80—100% | Identifies achievement that surpasses the provincial standard. The student demonstrates the specified knowledge and skills with a high degree of effectiveness. However, achievement at level 4 does not mean that the student has achieved expectations beyond those specified for the grade/course. |

Seventy percent (70%) of the evaluation is based on daily classroom work and will be determined through a variety of methods, as outlined in the table below. Thirty percent (30%) of the evaluation will be based on a final design project which includes a prototype, presentation, and accompanying report. This final evaluation allows the student the opportunity to demonstrate comprehensive achievement of the overall expectations of the course.

Teachers will use “assessment for learning” and “assessment as learning” practices to help students identify: where they are in relation to the learning goals and what next steps they need to take to achieve the goals.

This ongoing feedback will help prepare students for “assessment of learning”, the process of collecting and interpreting evidence for the purpose of summarizing learning at a given point in time, to make judgments about the quality of student learning on the basis of established criteria, and to assign a value to represent that quality.

# Achievement chart: Science, Grade 9 to 12

| **Categories** | **50–59% (Level 1)** | **60–69% (Level 2)** | **70–79% (Level 3)** | **80–100% (Level 4)** |
|---|---|---|---|---|
| **Knowledge and Understanding –** Subject-specific content acquired in each course (knowledge), and the comprehension of its meaning and significance (understanding) | | | | |
| | The student: | | | |
| **Knowledge of content** (e.g., facts, terminology, definitions, safe use of equipment and materials) | demonstrates limited knowledge of content | demonstrates some knowledge of content | demonstrates considerable knowledge of content | demonstrates thorough knowledge of content |
| **Understanding of content** (e.g., concepts, ideas, theories, principles, procedures, processes) | demonstrates limited understanding of content | demonstrates some understanding of content | demonstrates considerable knowledge of content | demonstrates thorough knowledge of content |
| **Category** | **50–59% (Level 1)** | **60–69% (Level 2)** | **70–79% (Level 3)** | **80–100% (Level 4)** |
| **Thinking –** The use of critical and creative thinking skills and inquiry, research, and problem-solving skills and/or processes | | | | |
| | The student: | | | |
| **Use of initiating and planning skills and strategies** (e.g., formulating questions, identifying the problem, developing hypotheses, selecting strategies and resources, developing plans) | uses initiating and planning skills and strategies with limited effectiveness | uses initiating and planning skills and strategies with some effectiveness | uses initiating and planning skills and strategies with considerable effectiveness | uses initiating and planning skills and strategies with a high degree of effectiveness |
| **Use of processing skills and strategies** (e.g., performing and recording, gathering evidence and data, observing, manipulating | uses processing skills and strategies with limited effectiveness | uses processing skills and strategies with some effectiveness | uses processing skills and strategies with considerable effectiveness | uses processing skills and strategies with a high degree of effectiveness |

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| materials and using equipment safely, solving equations, proving) | | | | |
| **Use of critical/creative thinking processes, skills and strategies** (e.g., analysing, interpreting, problem solving, evaluating, forming and justifying conclusions on the basis of evidence) | uses critical/ creative thinking processes, skills, and strategies with limited effectiveness | uses critical/ creative thinking processes, skills, and strategies with some effectiveness | uses critical/ creative thinking processes, skills, and strategies with considerable effectiveness | uses critical/ creative thinking processes, skills, and strategies with a high degree of effectiveness |
| **Category** | **50–59% (Level 1)** | **60–69% (Level 2)** | **70–79% (Level 3)** | **80–100% (Level 4)** |
| **Communication –** The conveying of meaning through various forms | | | | |
| | The student: | | | |
| **Expression and organization of ideas and information** (e.g., clear expression, logical organization) **in oral, visual, and written forms** (e.g., diagrams, models) | expresses and organizes ideas and information with limited effectiveness | expresses and organizes ideas and information with some effectiveness | expresses and organizes ideas and information with considerable effectiveness | expresses and organizes ideas and information with a high degree of effectiveness |
| **Communication for different audiences** (e.g., peers, adults) **and purposes** (e.g., to inform, to persuade) **in oral, visual, and written forms** | communicates for different audiences and purposes with limited effectiveness | communicates for different audiences and purposes with some effectiveness | communicates for different audiences and purposes with considerable effectiveness | communicates for different audiences and purposes with a high degree of effectiveness |
| **Use of conventions vocabulary, and terminology of the discipline in oral, visual, and written forms** (e.g., standards, formulae, scientific notation, SI units) | uses conventions, vocabulary, and terminology with limited effectiveness | uses conventions, vocabulary, and terminology with some effectiveness | uses conventions, vocabulary, and terminology with considerable effectiveness | uses conventions, vocabulary, and terminology with a high degree of effectiveness |
| **Category** | **50–59% (Level 1)** | **60–69% (Level 2)** | **70–79% (Level 3)** | **80–100% (Level 4)** |
| **Application –** The use of knowledge and skills to make connections within and between various contexts | | | | |
| | The student: | | | |
| **Application of knowledge and skills** (e.g.,concepts, processes, safe use of equipment, scientific investigation skills) **in familiar contexts** | applies knowledge and skills in familiar contexts with limited effectiveness | applies knowledge and skills in familiar contexts with some effectiveness | applies knowledge and skills in familiar contexts with considerable effectiveness | applies knowledge and skills in familiar contexts with a high degree of effectiveness |
| **Transfer of knowledge and skills** (e.g., concepts, processes, safe use of equipment scientific investigation skills) **to unfamiliar contexts** | transfers knowledge and skills to unfamiliar contexts with limited effectiveness | transfers knowledge and skills to unfamiliar contexts with some effectiveness | transfers knowledge and skills to unfamiliar contexts with considerable effectiveness | transfers knowledge and skills to unfamiliar contexts with a high degree of effectiveness |

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|---|---|---|---|---|
| **Making connections between science, technology, society, and the environment** (e.g., assessing the impact of science on technology, people and other living things, and the environment) | makes connections between science, technology, society, and the environment with limited effectiveness | makes connections science, technology, society, and the environment with some effectiveness | makes connections between science, technology, society, and the environment with considerable effectiveness | makes connections between science, technology, society, and the environment with a high degree of effectiveness |
| **Proposing courses of practical actions to deal with problems relating to science, technology, society, and the enviroment** | proposes courses of practical action of limited effectiveness | proposes courses of practical action of some effectiveness | proposes courses of practical action of considerable effectiveness | proposes highly effective courses of practical action |

Note: A student whose achievement is below 50% at the end of a course will not obtain a credit for the course.

# Considerations for Program Planning

## Instructional Approaches

Students come to secondary school with a natural curiosity developed throughout the elementary grades. They also bring with them individual interests and abilities as well as diverse personal and cultural experiences, all of which have an impact on their prior knowledge about science, technology, the environment, and the world they live in. Effective instructional approaches and learning activities draw on students' prior knowledge, capture their interest, and encourage meaningful practice both inside and outside the classroom. Students will be engaged when they are able to see the connection between the scientific concepts they are learning and their application in the world around them and in real-life situations.

Students in a science class typically demonstrate diversity in the ways they learn best. It is important, therefore, that students have opportunities to learn in a variety of ways – individually, cooperatively, independently, with teacher direction, through hands-on experiences, and through examples followed by practice. In science, students are required to learn concepts and procedures, acquire skills, and learn and apply scientific processes, and they become competent in these various areas with the aid of instructional and learning strategies that are suited to the particular type of learning. The approaches and strategies teachers use will vary according to both the object of the learning and the needs of the students.

In order to learn science and to apply their knowledge and skills effectively, students must develop a solid understanding of scientific concepts. Research and successful classroom practice have shown that an inquiry approach, with emphasis on learning through concrete, hands-on experiences, best enables students to develop the conceptual foundation they need. When planning science programs, teachers will provide activities and challenges that actively engage students in inquiries that honour the ideas and skills students bring to them, while further deepening their conceptual understandings and essential skills.

Students will investigate scientific concepts using a variety of equipment, materials, and strategies. Activities are necessary for supporting the effective learning of science by all students. These active learning opportunities invite students to explore and investigate abstract scientific ideas in rich, varied, and hands-on ways. Moreover, the use of a variety of equipment and materials helps deepen and extend students' understanding of scientific concepts and further extends their development of scientific investigation skills.

All learning, especially new learning, should be embedded in well-chosen contexts for learning – that is, contexts that are broad enough to allow students to investigate initial understandings, identify and develop relevant supporting skills, and gain experience with varied and interesting applications of the new knowledge. In the secondary science curriculum, many of these contexts come from the Relating Science to Technology, Society, and the Environment (STSE) expectations. Such rich contexts for learning enable students to see the "big ideas" of science. This understanding of "big ideas" will enable and encourage students to use scientific thinking throughout their lives. As well, contextualized teaching and learning provides teachers with useful insights into their students' thinking, their understanding of concepts, and their ability to reflect on what they have done. This insight allows teachers to provide support to help enhance students' learning.

# Health and Safety in Science

Teachers must model safe practices at all times and communicate safety expectations to students in accordance with school board and Ministry of Education policies and Ministry of Labour regulations. Teachers are responsible for ensuring the safety of students during classroom activities and also for encouraging and motivating students to assume responsibility for their own safety and the safety of others. Teachers must also ensure that students have the knowledge and skills needed for safe participation in science activities.

To carry out their responsibilities with regard to safety, it is important for teachers to have:

- concern for their own safety and that of their students;
- the knowledge necessary to use the materials, equipment, and procedures involved in science safely;
- knowledge concerning the care of living things – plants and animals – that are brought into the classroom;
- the skills needed to perform tasks efficiently and safely.

Students demonstrate that they have the knowledge, skills, and habits of mind required for safe participation in science activities when they:

- maintain a well-organized and uncluttered work space;
- follow established safety procedures;
- identify possible safety concerns;
- suggest and implement appropriate safety procedures;
- carefully follow the instructions and example of the teacher;
- consistently show care and concern for their own safety and that of others.

Various kinds of health and safety issues can arise when learning involves field trips. Out- of-school field trips can provide an exciting and authentic dimension to students' learning experiences. They also take the teacher and students out of the predictable classroom environment and into unfamiliar settings. Teachers must preview and plan these activities carefully to protect students' health and safety.

# Planning Technological Education Programs for Students with Special Education Needs

Classroom teachers have a duty to ensure that all students in their class have the opportunity to learn and succeed regardless of their special education needs. *Special Education Transformation: The Report of the Co-Chairs with the Recommendations of the Working Table on Special Education, 2006* promotes a set of beliefs that should guide program planning for students with special education. These beliefs include:

- All students can succeed.
- Universal design and differentiated instruction are effective and interconnected means of meeting the learning or productivity needs of any group of students.
- Each student has his or her own unique patterns of learning.
- Classroom teachers need the support of the larger community to create a learning environment that supports students with special education needs.
- Fairness is not sameness.

Teachers are encouraged to develop their program plan in accordance with their students' diversity of strengths and abilities. This can be achieved through a myriad of ways including: assessing each student's prior knowledge and skills, providing ongoing assessment, and allowing for flexible groupings. By assessing each student's current achievement level and weighing that against the course expectations, the teacher can determine if the student will be requiring any combination of: accommodations, modified expectations, or alternative expectations. If the student requires accommodations, modified expectations, or both, the information must be recorded in their Individual Education Plan (IEP).

## Students Requiring Accommodations Only

Accommodations that are required by students must be identified on their IEP. Differentiated instruction and universal design lend themselves well to providing accommodations for students. Students will still be evaluated on the curriculum course expectations and achievement levels communicated by the Ministry.

There are three types of accommodations:

- Instructional accommodations: Teachers change the way in which lessons are taught including integrating technology and using different styles of presentation.
- Environmental accommodations: This includes a change in the learning environment whether it be classroom seating by location or group, or lighting.
- Assessment accommodations: These allow students to demonstrate their learning in a different way. For instance, they may be given the opportunity to give oral answers to written questions or they may be given more time to complete an assignment or test.

## Students Requiring Modified Expectations

Modified expectations that are required by students must be identified on their IEP. For the most part, these expectations will be based on the regular course expectations but the number and/or complexity will differ. Modified expectations are specific, realistic, and measurable achievements that the student can demonstrate independently, given assessment accommodations.

It is the principal who will decide whether the achievement of the modified expectations constitutes successful completion of the course and whether the student is eligible to receive a credit for the course; this decision must be communicated to the student and their parents.

When course expectations are not extensively modified and it is expected that the student can achieve most of them, the modified expectations should determine how the required knowledge and skills differ from those identified in the course expectations. In the case, if the student is working toward a credit for the course, the IEP box must be checked on the Provincial Report Card.

With extensive modifications to expectations such that achievement of them is not expected to result in a credit, the expectations should identify the precise requirements or tasks on which the student's performance will be evaluated and which will be used to determine the student's mark on the Provincial Report Card. The IEP box must be checked and the appropriate statement from the *Guide to the Provincial Report Card, Grades 9-12, 1999* (p. 8) must be added. Modified expectations must be reviewed in relation to the student's progress at least once each reporting period, and must be updated as necessary.

# Program Considerations for English Language Learners

Schools in Ontario have a very diverse and multicultural student population, such that 20% of students have a language other than English as their first language. These English language learners may be recent immigrants or refugees while others may be born in Canada into a family whose primary home language is either not English or is an English dialect differing significantly from the English taught in Ontario schools. Teachers must be mindful that many of these students are entering a new linguistic and cultural environment at school.

During their first few years in an Ontario school, English language learners pay receive support through English as a Second Language (ESL) programs or English Literacy Development (ELD) programs. ELD programs are primarily for newcomers who arrive with significant gaps in their education, often due to limited opportunities (in terms of education and literacy) in their home country.

It is important that teachers recognize the orientation process whereby English language learners adapt to a new social environment and language. Some may be very quiet at first, using body language rather than speech and/or limited verbal communication to convey their thoughts. These students thrive in a safe, supportive, and welcoming environment. As the students learn to speak English, it is important to note that oral fluency is not a good indicator of the student's literacy development and vocabulary.

It is the shared responsibility of the classroom teacher, the ESL/ELD teacher (where available), and other school staff to help in the development of students' English. Volunteers and peers may also provide significant support. Teachers are required to adapt their instruction to facilitate the success of their English language learner students. These adaptations may include:

- Modifying some or all course expectations such that they are challenging yet achievable given the student's English proficiency
- Using a variety of instruction strategies, such as visual cues, pre-teaching vocabulary, offering peer tutoring
- Using a variety of learning resources, such as bilingual dictionaries, visual material, simplified text

- Modifying assessments, such as giving extra time, offering the choice of demonstrating skills/knowledge orally or in writing, assigning cloze sentences instead of essays

When learning expectations are modified for an English language learner, it must be clearly indicated on their report card.

# Environmental Education

As noted in *Shaping Our Schools, Shaping Our Future: Environmental Education in Ontario Schools*, environmental education "is the responsibility of the entire education community. It is a content area and can be taught. It is an approach to critical thinking, citizenship, and personal responsibility, and can be modelled. It is a context that can enrich and enliven education in all subject areas and offer students the opportunity to develop a deeper connection with themselves, their role in society, and their interdependence on one another and the earth's natural systems" (p. 10).

The increased emphasis on relating science to technology, society, and the environment (STSE) within this curriculum document provides numerous opportunities for teachers to integrate environmental education effectively into the curriculum. The STSE expectations provide meaningful contexts for applying what has been learned about the environment, for thinking critically about issues related to the environment, and for considering personal action that can be taken to protect the environment. Throughout the courses and strands, teachers have opportunities to take students out of the classroom and into the world beyond the school, to observe, explore, and investigate. One effective way to approach environmental literacy is through examining critical inquiry questions related to students' sense of place, to the impact of human activity on the environment, and/or to systems thinking. This can be done at numerous points within the science curriculum.

The following are some examples:

- A sense of place can be developed as students investigate the geological history of their region.
- An understanding of the effects of human activity on the environment can be developed as students consider the impact of their actions (e.g., the use of household chemicals, the consumption of electricity, the acquisition of new electronic devices and the disposal of used ones) on the local and global environment.
- Systems thinking can be developed as students extend their understanding of various kinds of systems (e.g., bodily systems; our solar system; Earth systems; mechanical systems) and the interdependence of their components.

# Equity and Inclusion Education in Science Education

The Faculty of Engineering Secondary School abides by the University of Ottawa's Violence Prevention Policy and Prevention of Harassment and Discrimination Policy. These policies encourage staff and students to show respect for diversity in the school and the wider society. The policies aim to provide a safe learning environment, free from violence, harassment, and discrimination.

Differentiated instruction will be at the core of curriculum planning. By assessing each individual student's abilities, background, interests and learning styles, teachers can design their lessons based on the needs of their diverse students. The course content (what is being taught), process (how it is taught), and product (how students demonstrate their learning) will be designed in relation to the students' needs. Differentiated instruction offers students a choice from a range of activities or allows them to select their own projects; by giving students the power to choose their own topic, they can select something that most interests them and become more invested in the project.

# Critical Thinking and Critical Literacy in Science

Critical thinking is the process of thinking about ideas or situations in order to understand them fully, identify their implications, and/or make a judgement about what is sensible or reasonable to believe or do. Critical thinking includes skills such as questioning, predicting, hypothesizing, analysing, synthesizing, examining opinions, identifying values and issues, detecting bias, and distinguishing between alternatives.

Students use critical thinking skills in science when they assess, analyse, and/or evaluate the impact of something on society and the environment; when they form an opinion about something and support that opinion with logical reasons; or when they create personal plans of action with regard to making a difference. In order to do these things, students need to examine the opinions and values of others, detect bias, look for implied meaning in their readings, and use the information gathered to form a personal opinion or stance.

In developing the skills of scientific investigation (inquiry/research skills), students must ask appropriate questions to frame their research, interpret information, and detect bias. Depending on the topic, they may be required to consider the values and perspectives of a variety of groups and individuals.

Critical literacy is the capacity for a particular type of critical thinking that involves looking beyond the literal meaning of a text to determine what is present and what is missing, in order to analyse and evaluate the text's complete meaning and the author's intent. Critical literacy goes beyond conventional critical thinking by focusing on issues related to fairness, equity, and social justice. Critically literate students adopt a critical stance, asking what view of the world the text advances and whether they find this view acceptable. I

n science, students who are critically literate are able, for example, to read or view reports from a variety of sources on a common issue. They are able to assess how fairly the facts have been reported, what biases might be contained in each report and why that might be, how the content of the report was determined and by whom, and what might have been left out of the report and why. These students would then be equipped to produce their own interpretation of the issue

# Literacy, Mathematical Literacy, and Inquiry/Research Skills

Literacy, mathematical literacy, and investigation skills are critical to students' success in all subjects of the curriculum and in all areas of their lives. Many of the activities and tasks that students undertake in the science curriculum involve the literacy skills related to oral, written, and visual communication. Communication skills are fundamental to the development of scientific literacy, and fostering students' communication skills is an important part of the teacher's role in the science curriculum.

When reading in science, students use a different set of skills than they do when reading fiction or general non-fiction. They need to understand vocabulary and terminology that are unique to science, and must be able to interpret symbols, charts, diagrams, and graphs. In addition, as they progress through secondary school, it becomes critically important for them to have the ability to make sense of the organization of science textbooks, scientific journals, and research papers. To help students construct meaning from scientific texts, it is essential that teachers of science model and teach the strategies that support learning to read while students are reading to learn in science.

Writing in science employs special forms and therefore also requires specific and focused learning opportunities. Students use writing skills to describe and explain their observations, to support the process of critically analysing information in both informal and formal contexts, and to present their findings in written, graphic, and multimedia forms.

*Scientists...take meticulous notes to form hypotheses, document observations, conduct experiments, and solve problems. Writing for them is much more than data collection; it is exploring, revising, and thinking on paper. Writing helps them learn facts, work out what the facts mean, and use facts to make new discoveries and refine old theories.*

Laura Robb, *Teaching Reading in Social Studies, Science and Math* (2003), p. 59

Oral communication skills are fundamental to the development of scientific literacy and are essential for thinking and learning. Through purposeful talk, students not only learn to communicate information but also explore and come to understand ideas and concepts; identify and solve problems; organize their experience and knowledge; and express and clarify their thoughts, feelings, and opinions.

To develop their oral communication skills, students need numerous opportunities to listen to information and talk about a range of subjects in science. The science program provides opportunities for students to engage in various oral activities in connection with expectations in all the strands, such as brainstorming to identify what they know about the new topic they are studying, discussing strategies for solving a problem, presenting and defending ideas or debating issues, and offering critiques of models and results produced by their peers.

Students' understanding is revealed through both oral and written communication. It is not always necessary for science learning to involve a written communication component. Whether students are talking or writing about their scientific learning, teachers can ask questions that prompt students to explain their thinking and reasoning behind a particular solution, design, or strategy, or to reflect on what they have done.

Understanding science also requires the use and understanding of specialized terminology. In all science courses, students are expected to use appropriate and correct terminology, and are encouraged to use language with care and precision in order to communicate effectively.
The Ministry of Education has facilitated the development of materials to support literacy instruction across the curriculum. Helpful advice for integrating literacy instruction in senior science courses may be found in *Think Literacy: Cross-Curricular Approaches, Grades 7–12, 2003*.

The science program also builds on, reinforces, and enhances mathematical literacy. For example, clear, concise communication in science often involves using diagrams, tables, graphs, calculations, and equations to represent quantitative data. Many components of the science curriculum emphasize students' ability to interpret data and information presented in a variety of forms (e.g., symbols, graphs, tables). In addition, physics, chemistry, earth and space science, and biology provide rich problem-solving situations that require students to apply, and help them develop and extend, mathematical knowledge and thinking.

Investigations are at the heart of learning in science. In science courses, students will have multiple opportunities to develop their ability to ask questions and conduct inquiries and research as they plan and carry out investigations. They will practice using a variety of inquiry and research skills that they need to carry out their investigations and will learn how to determine the most appropriate methods to use in a particular inquiry or research activity. Students will also learn how to locate relevant information in a variety of print and electronic sources, including books and articles, scientific periodicals, manuals, newspapers, websites, databases, tables, diagrams, and charts. As they advance through the courses, students will be expected to distinguish between primary and secondary sources, to use these sources in appropriate ways and with increasing sophistication, and to assess their validity and relevance.

# The Ontario First Nation, Métis, Inuit Education Policy Framework

The Ontario First Nation, Métis, and Inuit Education Policy Framework is based on the vision that all First Nation, Métis and Inuit students in Ontario will have the knowledge, skills and confidence they need to successfully complete their secondary education to pursue postsecondary education or training and/or to enter the workforce. They will have the traditional and contemporary knowledge, skills, and attitudes required to be socially contributive, politically active, and economically prosperous citizens of the world. All students in Ontario will have knowledge and appreciation of contemporary and traditional First Nation, Métis, and Inuit traditions, cultures, and perspectives.

The Faculty of Engineering Secondary School abides by the goals stated in the Ontario First Nation, Métis, and Inuit Education Policy Framework to provide a supportive and safe environment for all FNMI students. These goals include:

- Increase the level of student achievement
- Reduce gaps in student achievement
- Increase the levels of public confidence

For example, the school will strive to develop awareness among teachers of the learning styles of First Nation, Métis, and Inuit students and instructional methods designed to enhance the learning of students, such as incorporating meaningful First Nation, Métis, and Inuit cultural perspectives and activities when planning instruction, and implementing strategies for developing critical and creative thinking.

The First Nation, Métis, and Inuit students will also have access to the support, activities and resources offered by the uOttawa Indigenous Resource Centre Mashkawazìwogaming. For example, students can have access to student mentoring from a university student, individual or group meeting with and Elder in residence, and social and cultural events to participate in, if they wish to.

The Faculty of Engineering Secondary School, as part as the University of Ottawa also supports the uOttawa Indigenous Action Plan Framework for 2019-2024 which is designed to facilitate the inclusion of First Nation, Métis, and Inuit students and support the specific needs of the indigenous community.

# The Role of Information and Communications Technology in Science

Information and communications technology (ICT) provides a range of tools that can significantly extend and enrich teachers' instructional strategies and support students' learning in science. Computer programs can help students collect, organize, and sort the data they gather and to write, edit, and present multimedia reports on their findings. ICT can also be used to connect students to other schools, at home and abroad, and to bring the global community into the local classroom. Technology also makes it possible to use simulations – for instance, when field studies on a particular topic are not feasible or dis- sections are not acceptable.

Whenever appropriate, therefore, students should be encouraged to use ICT to support and communicate their learning. For example, students working individually or in groups can use computers and portable storage devices, CD-ROM and DVD technologies, and/or Internet websites to gain access to science institutions in Canada and around the world. Students can also use digital or video cameras to record laboratory inquiries or findings on field trips, or for multimedia presentations on scientific issues.
Although the Internet is a powerful learning tool, all students must be made aware of issues of privacy, safety, and responsible use, as well as of the potential for abuse of this technology, particularly when it is used to promote hatred.

## The Ontario Skills Passport and Essential Skills

The Ontario Skills Passport (OSP) is a web-based service that can track students' Essential Skills (such as reading, writing, and problem solving) and work habits (such as working safely and being reliable). These skills and work habits are easily transferable from school to work and are useful for employers looking to assess potential candidates for cooperative education placements. The OSP is also useful for students looking to assess, build, document, and track their skills through their educational, professional, and personal experiences. More information about the OSP can be found on the ministry website, skills.edu.gov.on.ca.

## Career Education

Ongoing scientific discoveries and innovations coupled with rapidly evolving technologies have resulted in an exciting environment in which creativity and innovation thrive, bringing about new career opportunities. Today's employers seek candidates with strong critical-thinking and problem-solving skills and the ability to work cooperatively in a team – traits that are developed through participation in the science program. Through science courses, students will develop a variety of important capabilities, including the ability to identify issues, conduct research, carry out experiments, solve problems, pre- sent results, and work on projects both independently and as a team. Students are also given opportunities to explore various careers related to the areas of science under study and to research the education and training required for these careers (see the expectations in the first strand of every course in the program, "Scientific Investigation Skills and Career Exploration").
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## Cooperative Education and Other Forms of Experiential Learning

Cooperative education and other forms of experiential learning, such as job shadowing, field trips, and work experience, enable students to apply the skills they have developed in the classroom to real-life activities in the world of science and innovation. Cooperative education and other workplace experiences also help to broaden students' knowledge of employment opportunities in a wide range of fields, including laboratory technology and research, health care, veterinary science, and horticulture. In addition, students develop their understanding of workplace practices, certifications, and the nature of employer– employee relationships.
Teachers of science can support their students' learning by maintaining links with community-

based organizations to ensure that students have access to hands-on experiences that will reinforce the knowledge and skills they have gained in school.

Students who choose a science course as the related course for two cooperative education credits are able, through this packaged program, to meet the OSSD compulsory credit requirements for groups 1, 2, and 3.

Health and safety issues must be addressed when learning involves cooperative education and other workplace experiences. Teachers who provide support for students in workplace learning placements need to assess placements for safety and ensure that students under- stand the importance of issues relating to health and safety in the workplace. Before taking part in workplace learning experiences, students must acquire the knowledge and skills needed for safe participation. Students must understand their rights to privacy and confidentiality as outlined in the Freedom of Information and Protection of Privacy Act. They have the right to function in an environment free from abuse and harassment, and they need to be aware of harassment and abuse issues in establishing boundaries for their own personal safety. They should be informed about school and community resources and school policies and reporting procedures with respect to all forms of abuse and harassment.

Policy/Program Memorandum No. 76A, "Workplace Safety and Insurance Coverage for Students in Work Education Programs" (September 2000), outlines procedures for ensuring the provision of Health and Safety Insurance Board coverage for students who are at least 14 years of age and are on placements of more than one day. (A one-day job shadowing or job twinning experience is treated as a field trip.) Teachers should also be aware of the minimum age requirements outlined in the Occupational Health and Safety Act for persons to be in or to be working in specific workplace settings. All cooperative education and other workplace experiences will be provided in accordance with the ministry's policy document *Cooperative Education and Other Forms of Experiential Learning: Policies and Procedures for Ontario Secondary Schools, 2000*.

# Planning Program Pathways and Programs Leading to a Specialist High Skills Major

Science courses are well suited for inclusion in some programs leading to a Specialist High Skills Major (SHSM) or in programs designed to provide pathways to particular apprenticeship or workplace destinations. In some SHSM programs, science courses can be bundled with other courses to provide the academic knowledge and skills important to particular industry sectors and required for success in the workplace and postsecondary education, including apprenticeship. Science courses may also be combined with cooperative education credits to provide the workplace experience required for some SHSM programs and for various program pathways to apprenticeship and workplace destinations. (SHSM programs would also include sector-specific learning opportunities offered by employers, skills-training centres, colleges, and community organizations.)