Physics, Grade 12, University Preparation (SPH4U)

2025-2026 Course Outline
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Revised by Amanda Cummings, OCT: August 2023
Developed from *The Ontario Curriculum Grade 11 and 12 Science (revised)*, published 2008

Credit Value: 1.0

Prerequisite Course: Physics, Grade 11, University Preparation (SPH3U)

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COURSE DESCRIPTION

This course enables students to deepen their understanding of physics concepts and theories. Students will continue their exploration of energy transformations and the forces that affect motion, and will investigate electrical, gravitational, and magnetic fields and electromagnetic radiation. Students will also explore the wave nature of light, quantum mechanics, and special relativity. They will further develop their scientific investigation skills, learning, for example, how to analyse, qualitatively and quantitatively, data related to a variety of physics concepts and principles. Students will also consider the impact of technological applications of physics on society and the environment.

Credit Value: 1.0

Prerequisite course: Physics, Grade 11, University Preparation (SPH3U)

Big ideas of this course:

Dynamics

- Forces affect motion in predictable and quantifiable ways.
- Forces acting on an object will determine the motion of that object.
- Many technologies that utilize the principles of dynamics have societal and environmental implications.

Energy and Momentum

- Energy and momentum are conserved in all interactions.
- Interactions involving the laws of conservation of energy and conservation of momentum can be analysed mathematically.
- Technological applications that involve energy and momentum can affect society and the environment in positive and negative ways.

Gravitational, Electric and Magnetic Fields

- Gravitational, electric, and magnetic forces act on matter from a distance.
- Gravitational, electric, and magnetic fields share many similar properties.
- The behaviour of matter in gravitational, electric, and magnetic fields can be described mathematically.
- Technological systems that involve gravitational, electric, and magnetic fields can have an effect on society and the environment.

The Wave Nature of Light

- Light has properties that are similar to the properties of mechanical waves.
- The behaviour of light as a wave can be described mathematically.
- Technologies that use the principles of the wave nature of light can have societal and environmental implications.

Revolutions in Modern Physics: Quantum Mechanics and Special Relativity

- Light can show particle-like and wave-like behaviour, and particles can show wavelike behaviour.
- The behaviour of light as a particle and the behaviour of particles as waves can be described mathematically.
- Time is relative to a person's frame of reference.
- The effects of relativistic motion can be described mathematically.
- New theories can change scientific thought and lead to the development of new technologies.

CURRICULUM EXPECTATIONS

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, analysing 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. Dynamics

- B1. analyse technological devices that apply the principles of the dynamics of motion, and assess the technologies' social and environmental impact;
- B2. investigate, in qualitative and quantitative terms, forces involved in uniform circular motion and motion in a plane, and solve related problems;
- B3. demonstrate an understanding of the forces involved in uniform circular motion and motion in a plane.

C. Energy and Momentum

- C1. analyse, and propose ways to improve, technologies or procedures that apply principles related to energy and momentum, and assess the social and environmental impact of these technologies or procedures;
- C2. investigate, in qualitative and quantitative terms, through laboratory inquiry or computer simulation, the relationship between the laws of conservation of energy and conservation of momentum, and solve related problems;
- C3. demonstrate an understanding of work, energy, momentum, and the laws of conservation of energy and conservation of momentum, in one and two dimensions.

D. Gravitational, Electric and Magnetic Fields

- D1. analyse the operation of technologies that use gravitational, electric, or magnetic fields, and assess the technologies' social and environmental impact;
- D2. investigate, in qualitative and quantitative terms, gravitational, electric, and magnetic fields, and solve related problems;
- D3. demonstrate an understanding of the concepts, properties, principles, and laws related to gravitational, electric, and magnetic fields and their interactions with matter.

E. The Wave Nature of Light

- E1. analyse technologies that use the wave nature of light, and assess their impact on society and the environment;
- E2. investigate, in qualitative and quantitative terms, the properties of waves and light, and solve related problems;
- E3. demonstrate an understanding of the properties of waves and light in relation to diffraction, refraction, interference, and polarization.

F. Revolutions in Modern Physics: Quantum Mechanics and Special Relativity

- F1. analyse, with reference to quantum mechanics and relativity, how the introduction of new conceptual models and theories can influence and/or change scientific thought and lead to the development of new technologies;
- F2. investigate special relativity and quantum mechanics, and solve related problems;
- F3. demonstrate an understanding of the evidence that supports the basic concepts of quantum mechanics and Einstein's theory of special relativity.

COURSE OUTLINE

Unit Number	Unit Name	Topics Covered	Instructional Hours	Overall Curriculum Expectations
1	Dynamics	Students will demonstrate an understanding that forces that affect motion in predictable and quantifiable ways. They will explore how forces acting on an object will determine the motion of that object. Finally, students will evaluate the possible societal and environmental implications of many technologies that utilize the principles of dynamics.	22	B1, B2, B3
2	Energy and Momentum	Students will demonstrate an understanding that energy and momentum are conserved in all interactions. They will explore ways interactions involving the laws of conservation of energy and conservation of momentum can be analysed mathematically. Students will also evaluate how technological applications that involve energy and momentum can affect society and the environment in positive and negative ways.	22	C1, C2, C3
3	Gravitational, Electric and Magnetic Fields	Students will demonstrate an understanding that gravitational, electric, and magnetic forces act on matter from a distance and share many similar properties. They will explore the ways the behaviour of matter in gravitational, electric, and magnetic fields can be described mathematically. Students will also evaluate the possible effects on society and the environment of technological systems that involve gravitational, electric, and magnetic fields.	22	D1, D2, D3
4	The Wave Nature of Light	Students will demonstrate an understanding that the properties of light are similar to the properties of mechanical waves. They will investigate how the behaviour of light as a wave can be described mathematically. Students will also evaluate the possible societal and environmental implications of technologies that use the principles of the wave nature of light.	22	E1, E2, E3
5	Revolutions in Modern Physics	Students will demonstrate an understanding of how light can show particle-like and wave-like behaviour, and particles can show wave-like behaviour. They will also explore ways to mathematically describe the behaviour of particles as waves.	22	F1, F2, F3

TOTAL INSTRUCTIONAL HOURS…….. 110 Hours

TEACHING AND LEARNING STATEGIES AND STRATEGIES FOR ASSESSMENT AND EVALUATION OF STUDENT PERFORMANCE

Students will follow a similar pattern of instructions in all units. To begin students will be involved in the exploration of an investigation of a concept. Then they will apply what they have learned in several real-life scenarios or applications of the concept. Students will see solutions to applications after they try to solve them for themselves. Then students will complete assignments where no solutions are provided and submit these for assessment. Finally, the unit ends with a test. A wide variety of instructional strategies are used to provide learning opportunities to accommodate a variety of learning styles, interests and ability levels. Seven scientific processes will form the heart of the teaching and learning strategies used:

- *Communicating:* To improve student success there will be several opportunities for students to share their understanding both in oral as well as written form.
- *Problem solving:* Scaffolding of knowledge, detecting patterns, making and justifying conjectures, guiding students as they apply their chosen strategy, directing students to use multiple strategies to solve the same problem, when appropriate, recognizing, encouraging, and applauding perseverance, discussing the relative merits of different strategies for specific types of problems.
- *Reasoning and proving:* Asking questions that get students to hypothesize, providing students with one or more numerical examples that parallel these with the generalization and describing their thinking in more detail.
- *Reflecting:* Modeling the reflective process, asking students how they know.
- *Selecting Tools and Computational Strategies:* Modeling the use of tools and having students use technology to help solve problems.
- *Connecting:* Activating prior knowledge when introducing a new concept in order to make a smooth connection between previous learning and new concepts, and introducing skills in context to make connections between particular manipulations and problems that require them.
- *Representing:* Modeling various ways to demonstrate understanding, posing questions that require students to use different representations as they are working at each level of conceptual development – concrete, visual or symbolic, allowing individual students the time they need to solidify their understanding at each conceptual stage.

Assessment Policy

In keeping with the Ministry of Education's document, Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools, 2010, this course will be presented to students with consideration of the overall and specific expectations established for the credit, the achievement chart in the appropriate curriculum policy document, and the guidelines for Assessment and Evaluation. The course contains both content standards (the knowledge and skills a student is expected to demonstrate throughout the course) and performance standards (the quality of student learning as reflected by the student's work toward achieving these skills).

To support student learning and to ensure that the assessment and evaluation encourage and promote student achievement as much as possible, course evaluations will be designed with a mind to being:

- balanced and equitable, with clear instructions and criteria;
- reflective of the overall and specific expectations for the course;
- ongoing and varied, allowing students to demonstrate achievement throughout the year;
- sure to include ongoing descriptive feedback giving students indications of goals and strategies for improvement; and
- supportive of student skills in assessing their own learning (for self-improvement) so that they can set personal goals and strategies (metacognition).

Assessment Types

This course will contain all three types of assessment recommended by the Ministry of Education.

Assessment *for* learning

The teacher will gather information about student's skill and understanding in order to plan teaching activities to maximize student achievement. In addition, the teacher will give feedback on work which is designed to help the student direct his/her efforts to particular skills or content so that he/she can improve his/her results. These assessments are generally not completed for marks, but rather for feedback, and include such things as checklists, student reflections, practice activities, and sample questions.

Assessment *as* learning
The student will be asked to demonstrate progress in developing skills and understanding of content in a way which allows him/her to set goals, reflect on work, and determine strategies for progress. These assessments may or may not be evaluated for marks and may include such things as small tests, quizzes, brief presentations, student reflections and self and peer-assessed activities.

Assessment *of* learning
The student will be asked to demonstrate that he/she has acquired the skills taught and has developed a strong understanding of the content and performance standards related to the topic. These assessments are done in preparation for moving forward to new content and performance standards or in completion of the course itself. These are assessed for marks and are used to record and report what has been learned. They include such things as unit tests, presentations, assignments, projects, and exams.

All assessments are designed to fit into one or more of the Grade 9-12 Science Achievement Chart categories: Knowledge and Understanding, Thinking, Communication, and Application (see Appendix 1).

Learning Skills & Work Habits
The development of learning skills and work habits is needed for success in school and in life. In addition to their assessment based on the achievement chart, student success also reflects a variety of specific learning skills, through which students complete course work and assessments. These learning skills are not assigned grades based on the achievement chart, or a numeric grade, but are rather indicated on the student report card using levels (excellent, good, satisfactory, needs improvement). This indicates to the student which learning skills should receive increased effort by the student in order to improve his/her learning, and which skills are helping the student achieve their academic success. The learning skills are behaviours considered essential and integral to student learning and to the evaluation of a student's achievement as he/she progresses through each course and grade. The six learning skills are listed below; for a full description, see Appendix 2.

- Responsibility
- Organization
- Independent Work
- Collaboration
- Initiative
- Self-Regulation

<u>Assessment Structure</u>
Student achievement is communicated formally to students and parents by means of the Provincial Report Card. The report card provides a record of the student's achievement of the curriculum expectations in the form of a percentage grade. The percentage grade represents the quality of the student's overall achievement of the expectations for the course and reflects the corresponding level of achievement as described in the achievement chart. A final grade is recorded, and a credit is granted and recorded if the student's grade is 50% or higher.

The final grade in the course is determined as follows:

Term Work *	70%
Final Examination	30%
Final Grade	100%

*Term work is based on evaluations conducted throughout the course. This portion of the grade will reflect the student's most consistent level of achievement throughout the course, although special consideration may be given to more recent evidence of achievement.

Achievement Chart Categories

There are four categories into which student evaluations are divided: Knowledge and Understanding, Thinking, Communication, and Application. This means that a student's evaluated work will contain marks in all, or some, of these categories as indicated by the teacher and based on the teacher's professional judgment. Students are evaluated according to the criteria established for the course, not according to the achievement of other students. Achievement of level 3 in these categories represents the provincial standard.

There are four levels of student achievement, Levels 1-4 (as well as the possibility that a student's work can be evaluated as below level 1).

See full achievement chart for Science Grade 9-12 in Appendix 1.

CONSIDERATIONS FOR PROGRAM PLANNING

Instructional approaches

> *A much more effective way to learn is for students to be actively involved in thinking and discussing during both class and investigation activities, with the goal of having the students develop a deep understanding of scientific concepts.*
>
> Kathleen Falconer et al., Effect of Reformed Courses in Physics and Physical Science on Student Conceptual Understanding (American Educational Research Association, April 2001), p. 1

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

> *Differentiated Instruction is responsive instruction. It occurs as teachers become increasingly proficient in understanding their students as individuals, increasingly comfortable with the meaning and structure of the disciplines they teach, and increasingly expert at teaching flexibly in order to match instruction to student need with the goal of maximizing the potential of each learner in a given area.*
>
> Carol Ann Tomlinson, Fulfilling the Promise of the Differentiated Classroom (ASCD, 2003), pp. 2–3

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 en- courage 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 supports 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 Science Programs for Students with Special Education Needs

Classroom teachers are the key educators of students who have special education needs. They have a responsibility to help all students learn, and they work collaboratively with special education resource teachers, where appropriate, to achieve this goal. Special Education Transformation: The Report of the Co-Chairs with the Recommendations of the Working Table on Special Education, 2006 endorses a set of beliefs that should guide program planning for students with special education needs in all disciplines. These beliefs are as follows:

- 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.

- Successful instructional practices are founded on evidence-based research, tempered by experience.
- Classroom teachers are key educators for a student's literacy and numeracy development.
- 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.

In any given classroom, students may demonstrate a wide range of strengths and needs. Teachers plan programs that recognize this diversity and give students performance tasks that respect their particular abilities so that all students can derive the greatest possible benefit from the teaching and learning process. The use of flexible groupings for instruction and the provision of ongoing assessment are important elements of programs that accommodate a diversity of learning needs.

In planning science courses for students with special education needs, teachers should begin by examining the current achievement level of the individual student, the strengths and learning needs of the student, and the knowledge and skills that all students are expected to demonstrate at the end of the course, in order to determine which of the following options is appropriate for the student:

- no accommodations or modifications; or
- accommodations only; or
- modified expectations, with the possibility of accommodations; or
- alternative expectations, which are not derived from the curriculum expectations for a course and which constitute alternative programs and/or courses.

If the student requires either accommodations or modified expectations, or both, the relevant information, as described in the following paragraphs, must be recorded in his or her Individual Education Plan (IEP).

Students Requiring Accommodations Only

Some students are able, with certain accommodations, to participate in the regular course curriculum and to demonstrate learning independently. Accommodations allow access to the course without any changes to the knowledge and skills the student is expected to demonstrate. The accommodations required to facilitate the student's learning must be identified in his or her IEP. A student's IEP is likely to reflect the same accommodations for many, or all, subjects or courses. Providing accommodations to students with special education needs should be the first option considered in program planning. Instruction based on principles of universal design and differentiated instruction focuses on the provision of accommodations to meet the diverse needs of learners. There are three types of accommodations:

- Instructional accommodations are changes in teaching strategies, including styles of presentation, methods of organization, or use of technology and multimedia.
- Environmental accommodations are changes that the student may require in the class- room and/or school environment, such as preferential seating or special lighting.
- Assessment accommodations are changes in assessment procedures that enable the student to demonstrate his or her learning, such as allowing additional time to complete tests or assignments or permitting oral responses to test questions.

If a student requires "accommodations only" in science courses, assessment and evaluation of his or her achievement will be based on the appropriate course curriculum expectations and the achievement levels outlined in this document.

Students Requiring Modified Expectations

Some students will require modified expectations, which differ from the regular course expectations. For most students, modified expectations will be based on the regular course curriculum, with changes in the number and/or complexity of the expectations. Modified expectations represent specific, realistic, observable, and measurable achievements and describe specific knowledge and/or skills that the student can demonstrate independently, given the appropriate assessment accommodations. It is important to monitor, and to reflect clearly in the student's IEP, the extent to which expectations have been modified. As noted in section 7.12 of the ministry's policy document Ontario Secondary

Schools, Grades 9 to 12: Program and Diploma Requirements, 1999, the principal will determine whether achievement of the modified expectations constitutes successful completion of the course and will decide whether the student is eligible to receive a credit for the course. This decision must be communicated to the parents and the student. When a student is expected to achieve most of the curriculum expectations for the course, the modified expectations should identify how the required knowledge and skills differ from those identified in the course expectations. When modifications are so extensive that achievement of the learning expectations (knowledge, skills, and performance tasks) is not likely to result in a credit, the expectations should specify the precise requirements or tasks on which the student's performance will be evaluated and which will be used to generate the course mark recorded on the Provincial Report Card. Modified expectations indicate the knowledge and/or skills the student is expected to demonstrate and have assessed in each reporting period.

The student's learning expectations must be reviewed in relation to the student's progress at least once every reporting period and must be updated as necessary. If a student requires modified expectations in science courses, assessment and evaluation of his or her achievement will be based on the learning expectations identified in the IEP and on the achievement levels outlined in this document. If some of the student's learning expectations for a course are modified but the student is working towards a credit for the course, it is sufficient simply to check the IEP box on the Provincial Report Card. If, however, the student's learning expectations are modified to such an extent that the principal deems that a credit will not be granted for the course, the IEP box must be checked and the appropriate statement from the Guide to the Provincial Report Card, Grades 9–12, 1999 (page 8) must be inserted. The teacher's comments should include relevant information on the student's demonstrated learning of the modified expectations, as well as next steps for the student's learning in the course.

Program considerations for English language learners

Ontario schools have some of the most multilingual student populations in the world. The first language of approximately 20 per cent of the students in Ontario's English-language schools is a language other than English. Ontario's linguistic heritage includes several Aboriginal languages and many African, Asian, and European languages. It also includes some varieties of English – also referred to as dialects – that differ significantly from the English required for success in Ontario schools. Many English language learners were born in Canada and have been raised in families and communities in which languages other than English, or varieties of English that differ from the language used in the classroom, are spoken. Other English language learners arrive in Ontario as newcomers from other countries; they may have experience of highly sophisticated educational systems, or they may have come from regions where access to formal schooling was limited.

When they start school in Ontario, many of these students are entering a new linguistic and cultural environment. All teachers share in the responsibility for these students' English language development. English language learners (students who are learning English as a second or additional language in English-language schools) bring a rich diversity of background knowledge and experience to the classroom. These students' linguistic and cultural backgrounds not only support their learning in their new environment but also become a cultural asset in the classroom community. Teachers will find positive ways to incorporate this diversity into their instructional programs and into the classroom environment.

Most English language learners in Ontario schools have an age-appropriate proficiency in their first language. Although they need frequent opportunities to use English at school, there are important educational and social benefits associated with continued development of their first language while they are learning English. Teachers need to encourage parents to continue to use their own language at home in rich and varied ways as a foundation for language and literacy development in English. It is also important for teachers to find opportunities to bring students' languages into the classroom, using parents and community members as a resource.

During their first few years in Ontario schools, English language learners may receive support through one of two distinct programs from teachers who specialize in meeting their language-learning needs:

- English as a Second Language (ESL) programs are for students born in Canada or new- comers whose first language is a language other than English or is a variety of English significantly different from that used for instruction in Ontario schools.
- English Literacy Development (ELD) programs are primarily for newcomers whose first language is a language other than English or is a variety of English significantly different from that used for instruction in Ontario

schools, and who arrive with significant gaps in their education. These students generally come from countries where access to education is limited or where there are limited opportunities to develop language and literacy skills in any language. Some Aboriginal students from remote communities in Ontario may also have had limited opportunities for formal schooling, and they also may benefit from ELD instruction.

In planning programs for students with linguistic backgrounds other than English, teachers need to recognize the importance of the orientation process, understanding that every learner needs to adjust to the new social environment and language in a unique way and at an individual pace. For example, students who are in an early stage of English-language acquisition may go through a "silent period" during which they closely observe the interactions and physical surroundings of their new learning environment. They may use body language rather than speech or they may use their first language until they have gained enough proficiency in English to feel confident of their interpretations and responses. Students thrive in a safe, supportive, and welcoming environment that nurtures their self-confidence while they are receiving focused literacy instruction. When they are ready to participate in paired, small-group, or whole-class activities, some students will begin by using a single word or phrase to communicate a thought, while others will speak quite fluently.

With exposure to the English language in a supportive learning environment, most young children will develop oral fluency quite quickly, making connections between concepts and skills acquired in their first language and similar concepts and skills presented in English. However, oral fluency is not a good indicator of a student's knowledge of vocabulary or sentence structure, reading comprehension, or other aspects of language proficiency that play an important role in literacy development and academic success. Research has shown that it takes five to seven years for most English language learners to catch up to their English-speaking peers in their ability to use English for academic purposes. Moreover, the older the children are when they arrive, the more language knowledge and skills they have to catch up on, and the more direct support they require from their teachers.

Responsibility for students' English-language development is shared by the classroom teacher, the ESL/ELD teacher (where available), and other school staff. Volunteers and peers may also be helpful in supporting English language learners in the language class- room. Teachers must adapt the instructional program in order to facilitate the success of these students in their classrooms. Appropriate adaptations include:

- modification of some or all of the subject expectations so that they are challenging but attainable for the learner at his or her present level of English proficiency, given the necessary support from the teacher;
- use of a variety of instructional strategies (e.g., extensive use of visual cues, graphic organizers, and scaffolding; previewing of textbooks; pre-teaching of key vocabulary; peer tutoring; strategic use of students' first languages);
- use of a variety of learning resources (e.g., visual material, simplified text, bilingual dictionaries, and materials that reflect cultural diversity);
- use of assessment accommodations (e.g., granting of extra time; use of oral interviews, demonstrations or visual representations, or tasks requiring completion of graphic organizers or cloze sentences instead of essay questions and other assessment tasks that depend heavily on proficiency in English).

When learning expectations in any course are modified for an English language learner (whether the student is enrolled in an ESL or ELD course or not), this information must be clearly indicated on the student's report card.

Although the degree of program adaptation required will decrease over time, students who are no longer receiving ESL or ELD support may still need some program adaptations to be successful.

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 natural and human factors that influence Earth's climate.
- An understanding of the effects of human activity on the environment can develop as students consider the impact of their actions (e.g., taking part in tree planting at a local park, walking or biking to school instead of riding in the car, packing a litterless lunch) on their local environment.
- Systems thinking can be developed as students understand what a system is and how changing one part of it (e.g., introducing zebra mussels into a local lake or non-native invasive plants into a wetland) can affect the whole system.

Antidiscrimination Education

The implementation of antidiscrimination principles in education influences all aspects of school life. It promotes a school climate that encourages all students to work to attain high standards, affirms the worth of all students, and helps students strengthen their sense of identity and develop a positive self-image. It encourages staff and students alike to value and show respect for diversity in the school and the wider society. It requires schools to adopt measures to provide a safe environment for learning, free from harassment, violence, and expressions of hate.

Antidiscrimination education encourages students to think critically about themselves and others in the world around them in order to promote fairness, healthy relationships, and active, responsible citizenship.

Schools have the responsibility to ensure that school–community interaction reflects the diversity in the local community and wider society. Consideration should be given to a variety of strategies for communicating and working with parents and community members from diverse groups, in order to ensure their participation in such school activities as plays, concerts, and teacher interviews. Families new to Canada, who may be unfamiliar with the Ontario school system, or parents of Aboriginal students may need special outreach and encouragement in order to feel comfortable in their interactions with the school.

Antidiscrimination Education and Science

The science program provides students with access to materials that reflect diversity with respect to gender, race, culture, and ability. Diverse groups of people involved in scientific activities and careers should be prominently featured. In planning the science program, teachers should consider issues such as access to laboratory experiences and equipment. Laboratory benches and lighting should be adjustable and appropriate for students with physical disabilities. Equipment and materials can also be adapted in ways that make them accessible to all students.

The examples used to illustrate knowledge and skills, and the practical applications and topics that students explore as part of the learning process, should vary so that they appeal to both boys and girls and relate to students' diverse backgrounds, interests, and experiences.

In many instances, variations in culture and location (whether rural, urban, or suburban) can be found in a single classroom. Students living in apartment buildings will have different access to plants and animals than students living in a rural setting or on a First Nation reserve. There may be cultural sensitivities for some students in areas such as the use of biological specimens. For example, a number of religions have prohibitions regarding pigs. Although it is impossible to anticipate every contingency, teachers should be open to adjusting their instruction, if feasible, when concerns are brought to their attention.

It is important that learning activities include opportunities for students to describe, study, or research how women and men from a variety of backgrounds, including Aboriginal peoples, have contributed to science, used science to solve problems in their daily life and work, or been affected by scientific processes or phenomena. The calendar systems of various cultures or the use that Aboriginal peoples have made of medicinal plants might be considered. Students might examine the impact of climate change on different regions and cultures around the world, as well as the impact of technologies or technological processes in use in different countries in relation to the food chain, the environment, or the ozone layer. Expectations in the curriculum encourage students to look at the perspectives and world views of various cultures, including Aboriginal cultures, as they relate to scientific issues.

Access to computers should be monitored and a range of software applications provided. A problem-solving approach can benefit students who are having difficulties with materials or equipment. Because access to equipment at home will vary, it is important to offer challenges for or support to students whose levels of prior knowledge differ.

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.

As they work to achieve the STSE expectations, students are frequently asked to identify the implications of an action, activity, or process. As they gather information from a variety of sources, they need to be able to interpret what they are reading, to look for instances of bias, and to determine why that source might express that particular bias.

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.

In 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 Investigation (Inquiry/Research)

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.

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 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 practise 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, news- papers, 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.

<u>Skills of Scientific Investigation (inquiry and research)</u>

The goal of science education is more than just providing students with a knowledge of facts. Mastery of the subject can no longer be evaluated solely in terms of students' ability to recall specialized terminology, memorize isolated facts, or repeat a theory. Rather, students must be given opportunities to learn through investigation. In doing so, they can practice and become proficient in various scientific investigation skills. These skills not only develop critical thinking

and allow students to extend their understanding of science; they are also useful in students' everyday lives and will help them in pursuing their postsecondary goals, whether in science or some other area of endeavour.

Initially, students become aware of and familiar with each new skill. With emerging understanding, students reflect on and practice aspects of these skills when conducting investigations. As their knowledge and confidence grow, students begin to implement the skills more fully. Through repeated use, they are able to increase and refine their understanding of and proficiency in each skill. Finally, once they become proficient, they can extend skills, incorporating them into other areas of study as well as everyday activities.

Four Broad Areas of Scientific Investigation

Students learn to apply scientific investigation skills in four broad areas: initiating and planning; performing and recording; analysing and interpreting; and communicating.

Skills in these four areas are not necessarily performed sequentially. See Appendix 3 for an illustration of how investigation may begin in any one of the areas, and students will tend to move back and forth among the areas as they practise and refine their skills. Students should reflect on their questions, procedures, and findings, and should be prepared to modify them as they proceed through an investigation. In addition, each investigation is unique and will require a particular mix and sequence of skills.

The Role of Information and Communications Technology in Science

Information and communications technology (ICT) provide 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 dissections 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.

ICT tools are also useful for teachers in their teaching practice, both for whole class instruction and for the design of curriculum units that contain varied approaches to learning to meet diverse student needs.

The Ontario Skills Passport and Essential Skills

Teachers planning programs in science need to be aware of the purpose and benefits of the Ontario Skills Passport (OSP). The OSP is a bilingual, web-based resource that enhances the relevance of classroom learning for students and strengthens school–work connections. The OSP provides clear descriptions of Essential Skills such as Reading Text, Writing, Computer Use, Measurement and Calculation, and Problem Solving and includes an extensive database of occupation-specific workplace tasks that illustrate how workers use these skills on the job. The Essential Skills are transferable, in that they are used in virtually all occupations. The OSP also includes descriptions of important work habits, such as working safely, being reliable, and providing excellent customer service. The OSP is designed to help employers assess and record students' demonstration of these skills and work habits during their cooperative education placements. Students can use the OSP to assess, practise, and build their Essential Skills and work habits and transfer them to a job or further education or training.

The skills described in the OSP are the Essential Skills that the Government of Canada and other national and international agencies have identified and validated, through extensive research, as the skills needed for work, learning,

and life. These Essential Skills provide the foundation for learning all other skills and enable people to evolve with their jobs and adapt to workplace change.

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, present 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.

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 understand 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.)

APPENDIX 1 – ACHIEVEMENT CHART

ACHIEVEMENT CHART: SCIENCE, GRADES 9–12

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 understanding of content	demonstrates thorough understanding of content
Thinking and Investigation – 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 materials and using equipment safely, solving equations, proving)*	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
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
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/or 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

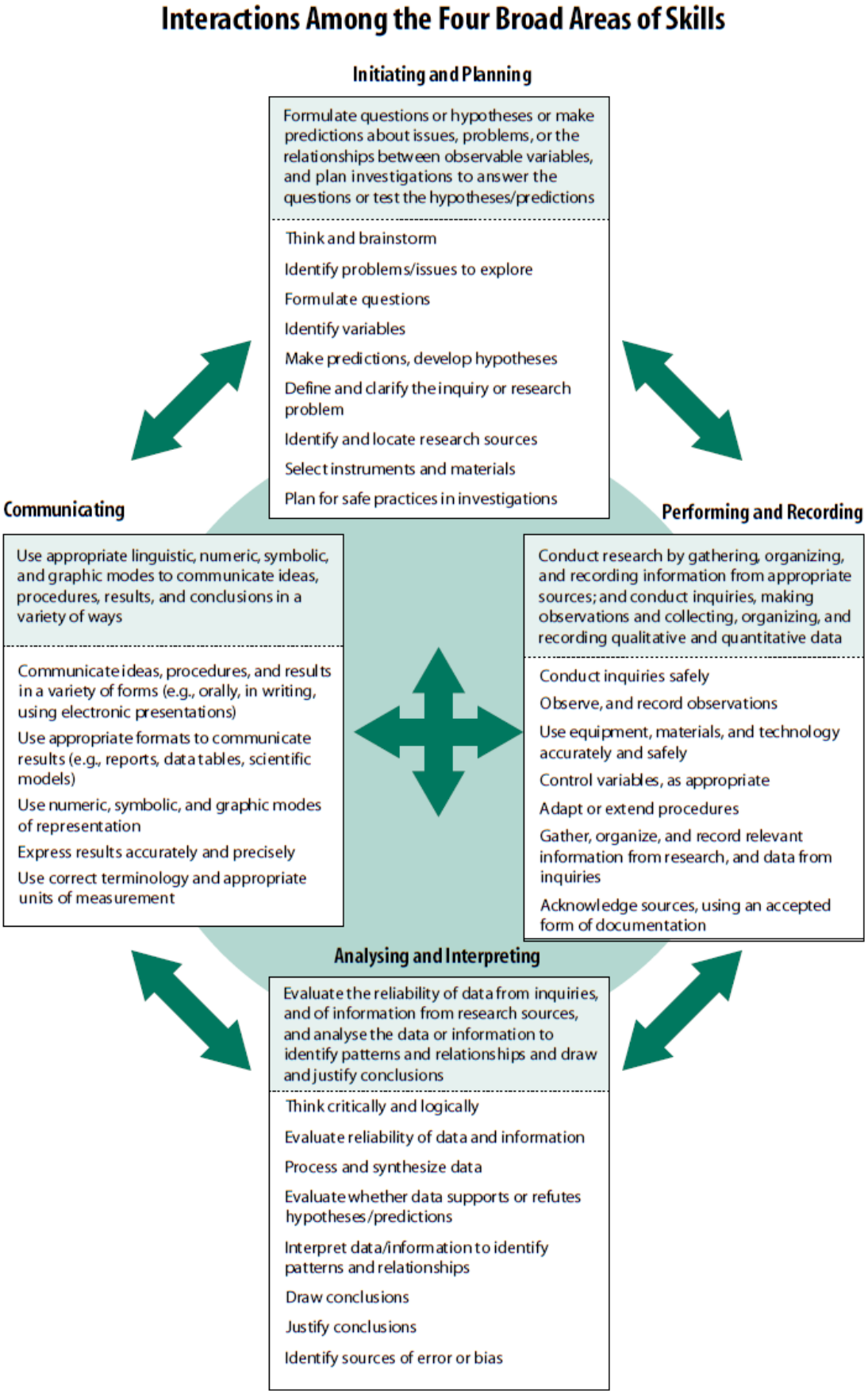
Categories	50–59% (Level 1)	60–69% (Level 2)	70–79% (Level 3)	80–100% (Level 4)
Communication (*continued*)				
	The student:			
Communication for different audiences *(e.g., peers, adults)* **and purposes** *(e.g., to inform, to persuade)* **in oral, visual, and/or written forms**	communicates for different 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/or written forms *(e.g., symbols, formulae, scientific notation, SI units)*	uses conventions, vocabulary, and terminology of the discipline with limited effectiveness	uses conventions, vocabulary, and terminology of the discipline with some effectiveness	uses conventions, vocabulary, and terminology of the discipline with considerable effectiveness	uses conventions, vocabulary, and terminology of the discipline with a high degree of effectiveness
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 and 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 and 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
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 between 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 action to deal with problems relating to science, technology, society, and the environment	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

APPENDIX 2 - LEARNING SKILLS & WORK HABITS

LEARNING SKILLS AND WORK HABITS IN GRADES 1 TO 12

Learning Skills and Work Habits	Sample Behaviours
Responsibility	The student: • fulfils responsibilities and commitments within the learning environment; • completes and submits class work, homework, and assignments according to agreed-upon timelines; • takes responsibility for and manages own behaviour.
Organization	The student: • devises and follows a plan and process for completing work and tasks; • establishes priorities and manages time to complete tasks and achieve goals; • identifies, gathers, evaluates, and uses information, technology, and resources to complete tasks.
Independent Work	The student: • independently monitors, assesses, and revises plans to complete tasks and meet goals; • uses class time appropriately to complete tasks; • follows instructions with minimal supervision.
Collaboration	The student: • accepts various roles and an equitable share of work in a group; • responds positively to the ideas, opinions, values, and traditions of others; • builds healthy peer-to-peer relationships through personal and media-assisted interactions; • works with others to resolve conflicts and build consensus to achieve group goals; • shares information, resources, and expertise and promotes critical thinking to solve problems and make decisions.
Initiative	The student: • looks for and acts on new ideas and opportunities for learning; • demonstrates the capacity for innovation and a willingness to take risks; • demonstrates curiosity and interest in learning; • approaches new tasks with a positive attitude; • recognizes and advocates appropriately for the rights of self and others.
Self-regulation	The student: • sets own individual goals and monitors progress towards achieving them; • seeks clarification or assistance when needed; • assesses and reflects critically on own strengths, needs, and interests; • identifies learning opportunities, choices, and strategies to meet personal needs and achieve goals; • perseveres and makes an effort when responding to challenges.

APPENDIX 3 – SKILLS OF SCIENTIFIC INVESTIGATION (INQUIRY AND RESEARCH)



APPENDIX 4 - RESOURCE LIST

The Ontario Curriculum Grade 11 and 12 Science (revised), published 2008