Catholic District School Board Writing Partnership

Science

Course Profile

Physics

Grade 12
College Preparation
SPH4C

• *for teachers by teachers*

This sample course of study was prepared for teachers to use in meeting local classroom needs, as appropriate. This is not a mandated approach to the teaching of the course. It may be used in its entirety, in part, or adapted.

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Course Overview
Physics, SPH4C, Grade 12, College Preparation

Policy Document: *The Ontario Curriculum, Grades 11 and 12, Science, 2001.*
Prerequisite: Grade 10 Science, Academic or Applied

Course Description

This course develops students' understanding of the basic concepts of physics. Students will explore these concepts as they relate to mechanical, electrical, fluid (hydraulic and pneumatic), and communications systems, as well as to the operation of commonly used tools and equipment. They will develop scientific-inquiry skills as they verify accepted laws of physics and solve both assigned problems and those emerging from their investigations. Students will consider the impact of technological applications of physics on society and the environment. Students will also recognize the ethical ramifications of scientific knowledge and technological applications.

How This Course Supports The Ontario Catholic School Graduate Expectations

The study of science helps students to learn to be reflective, critical, and creative thinkers, as well as discerning believers who can apply their knowledge in the spirit of social justice to the world around them. They can make appropriate decisions in light of Gospel values and Church teachings. The study of science teaches students to be collaborative contributors to an interdependent team, respecting the rights, responsibilities, and contributions of others. Studying the applications of science with a goal of getting to college leads students to find meaning, dignity, fulfillment, and vocation in the work they do. Overall, students become aware of the spiritual, as well as the physical dimension, of the world and of the need to respect the environment and the sustainability of resources and their wise use in order to fulfil their roles as stewards of God's creation. It is the Christian perspective on life and its meaning as revealed in Jesus Christ that underlies our approach to education and is reflected throughout the curriculum.

Course Notes

The overall intention of the Science curriculum is that all graduates of Ontario secondary schools will strive for excellence and a high degree of scientific literacy while maintaining a sense of wonder about the world around them. Accordingly, the Physics curriculum for the College Preparation course is activity-based as much as it is an organized body of knowledge. It cannot be learned in any meaningful way by reading and discussion alone. The experimental and practical nature of Physics with its potential applications to the world of work is emphasized. The teacher provides ample opportunity for students to engage in safe, effective laboratory activities in all units of the course. The health and safety of teachers and students must be of paramount importance when conducting laboratory activities. All must comply with the provisions of Workplace Hazardous Materials Information Systems (WHMIS) legislation as well as the Ontario Electrical Code and must practise established safe laboratory procedures. Students should recognize the importance of these legislations with regards to their future destinations.

College Preparation courses are designed to equip students with the knowledge and skills necessary to meet the entrance requirements for college programs. Teaching and learning emphasize concrete applications of the theoretical material covered in the course and also emphasizes the development of critical thinking and problem-solving skills.

The skills essential for scientific investigation are found on pages 113 and 114 of *The Ontario Curriculum, Grades 11 and 12, Science, 2000*. These skills apply to all areas of the course and must be developed in all the course units. Assessment of the students' mastery of these skills must be included in the evaluation of their achievement of the expectations for the course. In this profile these skill expectations have been coded as Scientific Investigation Skills (SIS.01 to SIS.12).

Students may use computer applications that have been developed for use in Physics. Computer interfaces for laboratory equipment, multimedia applications, databases, and computer-based simulations may be used wherever appropriate to do so. Care must be taken, however, to ensure that students are provided with adequate opportunity to interact with real materials and equipment in order to understand the physics concepts being studied. In all units, students are expected to design and to construct devices that illustrate the particular technology that is the focus of the unit. They also evaluate the technology according to criteria relating to efficiency and its risks and benefits to society.

Rational for Unit Sequencing

The underlying theme of the course is the application of technology to various energy transformations in the world around us. The strands of the course are recommended as the units of study. It is recommended that the first unit taught be Mechanical Systems, in order that the students may begin by investigating the applications of Physics in a context of the world around them and then by investigating the basics of simple machines before they go on to other technological applications such as hydraulic and pneumatic systems and electricity and electronics that may also apply the concepts of machines using different driving mechanisms. These units may then be followed with Communications Technology, which may integrate all of the previous technologies. The course may end with an examination of more complex systems that include a variety of technologies to transform energy from one form to another.

It is recommended, wherever possible, that teachers use a "reverse approach" to teaching the units. This means to begin with the applications of the concepts of the unit that exist in the world around the students and then to go on to the underlying physics laws and theories that explain why things work as they do. Students are encouraged to recognize the "sacred" within the secular and see the hand of God in the laws and structures of the physical environment.

Frequently students have their own concepts about how the world works and these concepts have implications for their learning of physics concepts. If teachers can anticipate these preconceptions or alternate concepts, they can address them explicitly in their teaching. A useful source to help teachers identify possible preconceptions is a website called "Students' Alternate Conceptions" found at http://phys.udallas.edu/C3P/altconcp.html or "Science Hobbyist Misconceptions" found at http://www.amasci.com/miscon/opphys.html

Units: Titles and Time

Unit 1	Mechanical Systems	24 hours
Unit 2	Hydraulic and Pneumatic Systems	22 hours
Unit 3	Electricity and Electronics	22 hours
* Unit 4	Communications Technology	24 hours
Unit 5	Energy Transformations	18 hours

* This unit is fully developed in this Course Profile.

Unit Overviews

Unit 1: Mechanical Systems

Time: 24 hours

Unit Description

Students are introduced to the concept of force and applications in daily life by examining the factors affecting friction. Students analyse all forces acting on an object and through Newton's laws, explain the resulting motion of the object. Newton's laws are verified experimentally. Force concepts are applied to simple machines such as the lever, the inclined plane, and modifications of these. After determining the mechanical advantage of several devices, students recognize the need for simple machines and are able to explain the function of those found in devices such as robotic equipment and the Canadarm. In the Middle Ages, human life and technology in the West centred round the construction of sacred buildings, particularly cathedrals. Students explore how people applied simple machines to erect outstanding masterpieces of architecture spurred on by their deep faith and reverence to God and His Church. The culminating activity of the unit has students design and build a simple machine in order to solve a practical problem.

Since each cluster includes several learning expectations, various Achievement Chart categories may be assessed; however, one or more areas tend to have a greater emphasis. These categories have been indicated in **bold** in order that it be clear to the teacher which category should be weighted more heavily.

Unit Synopsis Chart

Cluster	Learning Expectations	Assessment Categories	Focus/Tasks
1	MSV.01, MSV.02, MSV.03, MS1.01, MS2.02, MS3.01 SIS.01, .05, .08, .09 CGE 2c, 3c	**Knowledge/ Understanding** Inquiry **Making Connections**	Force Concepts - basic definitions - experiment
2	MSV.01, MSV.02, MS1.01, MS1.02, MS1.03, MS2.01 SIS.01, .03, .06 CGE 2c	Knowledge/ Understanding **Inquiry** **Communication**	Newton's Laws of Motion - free-body diagrams - application to moving bodies - experimental verification
3	MSV.01, MSV.03, MS1.01, MS1.04, MS1.05, MS1.06, MS2.03 SIS.02, .08, .09 CGE 2b, 3c	**Knowledge/ Understanding** **Inquiry** Communication	Simple Machines - describe types - solve simple torque problems - experiments
4	MSV.01, MSV.02, MSV.03, MS1.01, MS1.07, MS1.08, MS2.04, MS2.05, MS3.02, MS3.03 SIS.07, .08, .09 CGE 2ce, 3b, 5a	Knowledge/ Understanding **Inquiry** **Communication** **Making Connections**	Applications of Simple Machines - mechanical advantage - compound machines and technological systems - construction of a simple/compound machine

Unit 2: Hydraulic and Pneumatic Systems

Time: 22 hours

Unit Description

Students are made aware of the applications of hydraulic and pneumatic systems in the world around them and then go on to investigate the physical principles involved, such as Bernoulli's and Pascal's principles. They investigate these principles through experiments and analyse quantitatively the work, power, and time involved in hydraulic and pneumatic circuits. Students then go on to design, construct, and evaluate a model hydraulic or pneumatic system. They identify some of the social and economic consequences of the use of robotic systems in light of Catholic social teaching relating to the value of human work.

Unit Synopsis Chart

Cluster	Learning Expectations	Assessment Categories	Focus/Tasks
1	HPV.03, HP3.02, HP3.03 SIS.12 CGE 2e, 5bd	Communication **Making Connections**	Observing Hydraulic and Pneumatic Systems - visit school auto shop or a local garage - view film on industrial use of robots - reflect on impact of fluid systems on society
2	HPV.01, HP1.01, HP1.02, HP1.03, HP1.05, HP1.07, HP1.08 SIS.06, .07, .08 CGE 2abc, 4f	**Knowledge/ Understanding** Inquiry Making Connections	Scientific Principles of Hydraulic and Pneumatic Systems - teacher-directed lesson on Bernoulli's and Pascal's principles - demonstration of applications of principles - problem solving involving relationships in principles
3	HPV.02, HP1.04, HP1.06, HP2.01, HP2.02, HP2.03, HP2.05 SIS.02, .03, .05, .07, .08, .09, .11 CGE 2abc, 4cef, 5ab	**Knowledge/ Understanding** Communication **Inquiry**	Investigations with Hydraulic and Pneumatic Systems - teacher-directed lesson on components in fluid systems - teacher lesson on static pressure head - student experiments on Bernoulli's and Pascal's principles
4	HPV.02, HP2.04, HP2.06 SIS.03, .10 CGE 5adgh	Knowledge/ Understanding **Inquiry** **Communication** **Making Connections**	Building a Model Hydraulic and Pneumatic System - teacher-directed lesson on drawing fluid circuits using symbols - research a fluid system - build a model system
5	HPV.03, HP3.01, HP3.02, HP3.03 SIS. 03, .04, .10, .12 CGE 3cdf, 4ef, 5bdf	Inquiry **Communication** **Making Connections**	Social Consequences of Hydraulic and Pneumatic Systems - analyse social consequences of fluid system - present fluid system and consequences to class

Unit 3: Electricity and Electronics

Time: 22 hours

Unit Description

Students develop their skills with electric circuits introduced in Grade 9 Science. First, students examine the theoretical aspects of circuits through the analysis of circuit problems involving potential difference, current, and resistance. Second, students assemble circuits and measure voltage, current, and resistance values at various points throughout the circuit to reinforce Ohm's Law for fixed resistances and Kirchhoff's laws. Furthermore, students explore the operations of electronic control devices as well as analog and digital circuits and electrical sub-circuits. Students employ their knowledge of circuit theory as they design, build, and test a circuit that performs a simple function. Lastly, students choose an electric appliance and describe its operation, historical development, and its performance in terms of its impact on society and the environment. Students are encouraged to challenge the view that industrial and public consumption of electricity is a criterion to gauge the "development" and "progress" of a country.

Unit Synopsis Chart

Cluster	Learning Expectations	Assessment Categories	Focus/Tasks
1	EEV.01, EE1.01, EE1.02, EE1.03, EE1.05, EE2.04 SIS.05, .06, .08, .11 CGE 3c	**Knowledge/ Understanding** **Communication**	Theory of Circuits - current, voltage and resistance calculations
2	EEV.02, EE1.01, EE2.01, EE2.02, EE2.03, EE2.04, EE3.03 SIS.01, .02, .10 CGE 3c	Knowledge/ Understanding **Inquiry**	Practical Circuits - assembling and testing circuits - applying Kirchhoff's laws
3	EEV.02, EE1.04, EE1.06, EE1.07 SIS.09, .12 CGE 2e	**Knowledge/ Understanding** Making Connections	Control Devices and Sub-Circuits - analog versus digital circuits - integrated circuits and CPUs
4	EEV.02, EE1.01, EE2.01, EE2.02, EE2.03, EE2.05, SIS.03, .07 CGE 4ef	**Inquiry** **Making Connections**	Design and Construct an Electrical Circuit to Perform a Simple Function
5	EEV.03, EE1.01, EE2.06, EE3.01, EE3.02 SIS.04, .05 CGE 2bc, 5e	**Communication** **Making Connections**	Historical Development, and Analysis of an Electrical Appliance - common applications of simple circuits - trace the historical development of an electrical appliance

Unit 4: Communications Technology

Time: 24 hours

Unit Description

Students are introduced to various communication technologies and their roles in society. Students explore the properties of periodic motion and the behaviour of waves through direct experimentation. Also, students investigate the refraction of light by verifying Snell's Law. Students describe and explain how the phenomena of reflection and interference of sound waves as well as the reflection, refraction, and interference of light and of electromagnetic waves are employed in modern day communication science. Furthermore, students describe and evaluate Canadian contributions to communication science. Students employ their knowledge of communication science and electronics as they design, build, and demonstrate the operation of a simple communication system. Finally, students learn that communication technology is a tool of great power that can be used for good or evil depending on how it is used. Catholic social teaching requires that the media be used ethically and morally. Students apply this knowledge as they assess the risks and benefits to society, and to the environment, of using a particular communication technology. Students learn about and reflect on the widening gap between communication-rich and communication-poor countries and recognize the unethical nature of this imbalance of resources.

Unit Synopsis Chart

Cluster	Learning Expectations	Assessment Categories	Focus/Tasks

1	CTV.01, CTV.02,
	CT1.01, CT1.02, CT1.03,
	CT1.04, CT1.05, CT1.06,
	CT2.01, CT2.02, CT2.03
	SIS.02, .03, .06, .10
	CGE 3c, 4f
		Knowledge/ Understanding
		Inquiry
		Communication
		Making Connections
			Vibrations and Waves
			- teacher-directed lesson on:
			  - periodic motion
			  - superposition
			  - interference
			- student lab activities
			- student problem solving

2	CTV.01, CTV.02,
	CT1.01, CT1.07, CT1.08,
	CT2.04, CT2.05
	SIS.02, .03, .05, .09, .10
	CGE 3c, 4f
		Knowledge/ Understanding
		Inquiry
		Communication
		Making Connections
			Light
			- teacher demonstration on:
			  - reflection
			  - refraction
			  - interference
			- student lab activities
			- student problem solving

3	CTV.01, CTV.03, CT1.05, CT1.06, CT1.08, CT1.09 CT2.06, CT3.02 SIS.04, .12 CGE 2be, 3b	**Communication** **Making Connections**	Sound, Light and Communication Technologies - class trip - student research - poster presentation
4	CTV.01, CTV.02, CT1.09, CT2.07, CT3.03 SIS.01, .07 CGE 4ef	**Inquiry** **Communication** Making Connections	Build a Communications System - student research - building a device - presenting the device
5	CTV.03, CT3.01, CT3.03 SIS.04, .07 CGE 1d, 2bc, 3cdf, 7efg	**Communication** **Making Connections**	Communication Technologies and You - class discussion - student research - written report - student reflection

Unit 5: Energy Transformations

Time: 18 hours

Unit Description

Students examine various systems that convert one form of energy to another. Once familiar with the different possible energy transformations, students quantitatively determine the power and efficiencies of these systems and use the results to design a device for a particular function that utilizes at least four functional energy transfers. As many systems rely on non-renewable resources, the students have an opportunity to evaluate the advantages and disadvantages of energy transforming devices that are based on renewable resources. The concept of energy transformation lends itself to reflection on the whole issue of "conversion" in a religious sense where a person re-directs his or her energy to a more wholesome and righteous lifestyle. Students may research examples of saints who experience this transformation of energy such as St. Ignatius of Loyola who transformed his energy from a military one to a religious one.

Unit Synopsis Chart

Cluster	Learning Expectations	Assessment Categories	Focus/Tasks
1	ETV.01, ETV.03, ET1.01, ET1.02, ET1.03, ET3.01 SIS.04, .08, .09 CGE 2b, 3c	**Knowledge/ Understanding** **Communication**	Energy Terminology and Concepts - basic definitions - types of transformations - comparison of types - operation of transformation devices
2	ETV.01, ETV.02, ET1.05, ET2.01, ET2.02 SIS.01, .02, 03, .09, .10 CGE 3c, 5a	Knowledge/ Understanding **Inquiry** **Communication** Making Connections	Energy Transformation Devices - determining efficiency of a device - construction of a device
3	ETV.01, ETV.03, ET1.04, ET3.02 SIS.05, .07 CGE 1d, 2e, 3bc, 7ij	Knowledge/ Understanding **Communication** **Making Connections**	Energy Resources - comparison of different sources - advantages/disadvantages of devices utilizing renewable resources

Teaching/Learning Strategies

Since this is a College Preparation course, teaching and learning strategies emphasize the practical applications of the course content but they also include some theoretical aspects of the content. Physics is an activity as much as it is an organized body of knowledge. It cannot be learned in any meaningful way by reading and discussion alone. The experimental nature of Physics is emphasized. Furthermore, each unit includes a "design and construct" component to help students understand the nature of the technological application. Students should be explicitly taught the design process and shown how it compares to the scientific method. Students' initial attempts to design a model are like a hypothesis that is then tested through the building and testing of the model like an experiment. Once the testing is complete, the model may be improved and tested again until a satisfactory result is achieved.

One option for teachers to consider in one or more of the units is to teach the unit in a reverse order. That is, begin with the applications of the technology and then develop the theory that explains how the technology works. This may be accomplished by either bringing to the class examples of devices that use a particular technology or taking the students on a trip to a site that makes use of the technology such as that found in a factory, garage, or repair shop.

Students are required to become aware of the social and economic consequences of the various technologies that they are studying. They also assess the risks and benefits to society as well as to the environment of introducing particular technologies. They should do this within the context of the social teaching of the Church, that technology is never morally neutral. This should be accomplished by class discussion and then the incorporation of this discussion into any written reports that accompany the "design and construct" project of each unit.

Throughout the course, students are given numerous and varied opportunities to acquire knowledge and to develop skills. Some instructional strategies are more suited to the development of particular types of understanding. Therefore instructional strategies may be placed into categories similar to the categories of learning found in the Achievement Chart. Some strategies may be used to develop several types of understanding. Some examples are listed below:

Expectations that involve **Knowledge/Understanding** may be developed through:

- Audio-visual Presentations: films or videos viewed to illustrate concepts or examples that may be difficult to observe and perform directly;
- Collaborative/Cooperative Learning: various small group learning techniques as constructed by the teacher, e.g., think/pair/share, jigsaw;
- Computer-based Learning: students use simulations and relevant computer programs to explore science problems;
- Equation List: a list of equations used in a particular unit, along with the definition or other explanations of each symbol, its corresponding unit and possible restrictions or conditions for its use;
- Independent Study: students explore and research a topic of interest (an important component of the "design and construct" activity in all units);
- Notebook: a student collection of daily work, teacher handouts, and homework attempted and completed;
- Reading: students read about and explore primitive but effective and sustainable technologies used in developing countries that seek to develop their economic activities relying on their own resources rather than becoming dependent on expensive technology;
- Teacher-directed Lessons and Demonstrations: introductions to key concepts of the course used in all units;
- Vocabulary List: a list of specific physics terminology used in a particular unit, along with their definition or other explanation of their meaning.

Expectations that involve **Inquiry** skills may be developed through:

- Computer Simulations – students use computer programs to perform activities that are difficult to do in the laboratory;
- Independent Study- students explore and research a topic of interest (an important component of the design and construct activity in all units);
- Lab-based Inquiry: students perform investigations in the laboratory under the supervision of the teacher;
- Model Building: students construct physical representations of various devices.

Expectations that involve Communication may be developed through:

- Conferencing: teacher-student discussion;
- Interviewing: students engage in a conversation or dialogue with a person in order to gain information or insights from the person being interviewed or to give information to a person conducting the interview;
- Lab Book: a notebook or a binder that students use to record their observations of all in-class experiments;

- Log Book: a written record of the progress of each student's design and construct activity with reference to problems encountered, successes, refinements, and improvements;
- Reading: students may read books dealing with ethical issues relating to topics in this course and discussing/presenting some of their concepts;
- Report/Presentation: an oral and/or written presentation to the class of a model constructed, perhaps as a poster or a videotaped format.

Expectations that provide opportunities to expand their knowledge and to **Make Connections** may be developed through:

- Guest Speaker: an expert is invited from outside the school to present ideas, alternative perspectives, opinions, descriptions of real-life experiences and applications and answer questions generated by students;
- Field trip: students may visit a place of work or an industry, such as an auto shop, a recording studio, a lighting booth, or a sound stage;
- Outreach: students are invited to contact local charitable and development organizations (St. Vincent de Paul Society, Salvation Army, Scarborough Missions, Canadian Catholic Organization for Development and Peace, etc.) to see if there is a need for used audio or electronic equipment or other technological devices such as computers that may be collected and then donated to those who are less fortunate.

Assessment & Evaluation of Student Achievement

Assessment is the process of gathering information from a variety of sources that accurately reflects how well a student is achieving the curriculum expectations. In Science, these expectations include the understanding of basic concepts, which may be assessed for Knowledge/Understanding; the development of skills of inquiry and communication, which may be assessed for Inquiry and Communication; and relating Science to Technology, Society, and the Environment, which may be assessed for Making Connections.

Because some students will not have studied Science since Grade 10, teachers may need to use some of the strategies listed below as diagnostic so that they will have information to appropriately adjust instructional strategies to the students' preparedness. In order to provide maximum opportunity for the development of student learning, opportunities within collaborative activities and the use of student reflection should be encouraged as formative assessment. These peer and self-assessment opportunities should be introduced, where possible.

Assessment strategies include:

Paper-and-Pencil Tasks

- quizzes
- tests
- lab reports

Performance Tasks

- student demonstration of science skills
- student interviews
- experiments performed by student
- model building
- model demonstrations

Personal Communication
- short written reports
- lab reports
- log books
- student teacher conferences

Assessment tools include:
- checklists
- marking schemes
- rubrics
- anecdotal comments with suggestions for improvement

In this College Preparation course the weighting of the four categories is based on the rationale that teaching and learning emphasizes concrete applications of the theoretical material covered in the course, and also emphasizes the development of critical thinking and problem-solving skills.

Evaluation refers to the process of judging the quality of student work on the basis of established criteria, and then assigning a value to represent that quality. The value assigned will be in the form of a percentage grade. According to the *Program Planning and Assessment 2000* Policy:

Seventy per cent of the grade will be based on assessments and evaluations conducted throughout the course. Thirty per cent of the grade will be based upon a final evaluation in the form of an examination, performance, essay, and/or other method of evaluation suitable to the course content and administered towards the end of the course. The analysis of a student-designed and built project that uses at least four functional energy transformations, conducted as part of the unit on Energy Transformations, is a good example of a performance task that could count for part of this thirty per cent. A Final Examination, evaluated for all four categories identified in the Achievement Chart and addressing all units of the course may count for the rest of the thirty per cent.

Accommodations

The teacher must consider the needs of exceptional students in planning the delivery of the science curriculum. Accommodations to the program activities and/or to the learning environment may be necessary. Where the student has an Individual Education Plan (IEP) the course will be modified to meet the student's needs as outlined in the plan. For students with physical or learning impairments, classroom and laboratory activities should be altered to permit as much participation as possible. Where possible, peers should be encouraged to assist students in order to permit participation in some group or individual activities. For assessment it may be necessary to use oral testing, a scribe to record answers given orally, or other demonstrations of learning in order to determine the level of achievement of certain students.

Enrichment possibilities should be considered. Students could be encouraged to read articles relating to the development of new technological applications or possible future technological devices. They may also be encouraged to view shows on television that deal with new technologies and to write a brief report on them for sharing in class, or to participate in special events sponsored by colleges such as bridge building that allows them to extend their work beyond ordinary day to day tasks.

For English as a Second Language (ESL) students or English Literacy Development (ELD) students, teachers should provide opportunities for the students to demonstrate their learning by alternative means (such as spoken English, direct demonstration and pictorial representation) while written English is developing.

Resources

Units in this Course Profile make reference to the use of specific texts, magazines, films, videos, and websites. The teacher needs to consult their board policies regarding use of any copyrighted materials. Before reproducing materials for student use from printed publications, the teacher needs to ensure that their board has a Cancopy licence and that this licence covers the resources they wish to use. Before screening videos/films with their students, the teacher needs to ensure that their board/school has obtained the appropriate public performance videocassette licence from an authorized distributor, e.g., Audio Cine Films Inc. The teacher is reminded that much of the material on the Internet is protected by copyright. The copyright is usually owned by the person or organization that created the work. Reproduction of any work or substantial part of any work on the Internet is not allowed without permission of the owner.

Print

Science classrooms should have a Bible available for reference. The teacher should consult the Religion department in the school or the school Chaplain for the version used by the school. Many schools use the *New American Catholic Bible*, published by Fireside Bible Publishers, Wichita, Kansas 67201.

Magazines such as *Physics Today* published monthly by the American Institute of Physics, *The Physics Teacher* published by the American Association of Physics Teachers, and *Crucible* published by the Science Teachers Association of Ontario are useful sources of current information about physics and the teaching of physics. Also magazines such as *Popular Science* and *Discover* may provide some additional information about new technological developments or applications.

Some useful textbook resources include:

Dick, Greg, A. Geddis, E. James, T. McCaul, B. McGuire, R. Poole, and B. Holzer. *McGraw-Hill Physics 11.* Toronto: McGraw-Hill Ryerson, 2001. ISBN 0-07-088691-1

Dyer, Frank S. and William R. Tallman. *Physics in Action.* Toronto: Harcourt Brace Jovanovich Canada Inc., 1991. ISBN 0-7747-1349-6

Giancoli, D.C. *Physics: Principles with Applications,* 2nd edition. Toronto: Prentice-Hall, 1985. ISBN 0-13-672627-5

Hewitt, Paul G. *Conceptual Physics.* Don Mills: Addison-Wesley Publishing Co., Inc., 1987. ISBN 0-201-20728-1

Hirsch, Alan, D. Martindale, S. Bibla, and C. Stewart. *Nelson Physics 11.* Toronto: Nelson Thomson Learning, 2002. ISBN 0-17-612102-1

Hirsch, Alan J. *Physics for a Modern World.* Toronto: John Wiley and Sons, 1986. ISBN 0-471-79747-2

Kane, J.W. and M.M. Sternheim. *Physics,* 3rd edition. Toronto: John Wiley and Sons, 1988. ISBN 0-471-85221-X

Martin, B. and C. Sprank. *Physic-AL: An Activity Approach to Physics.* Edmonton: J.M.Lebel Enterprises Ltd., 1989. ISBN 0-920008-30-5

Martindale, D.G., et al. *Fundamentals of Physics: An Introductory Course.* Toronto: D.C.Heath, 1987. ISBN 0-669-95113-7

Martindale, D.G., R.W. Heath, and P.C. Eastman. *Fundamentals of Physics: A Senior Course.* Toronto: D.C. Heath, 1986. ISBN 0-669-95047-5

Nowikow, Igor and Brian Heimbecker. *Physics: Concepts and Connections.* Toronto: Irwin Publishing, 2001. ISBN 0-7725-2872-1

Spencer, P.T., K.G. McNeill, and J.H. MacLachlan. *Matter and Energy: The Foundation of Modern Physics,* 3rd edition. Toronto: Irwin Publishing, 1987. ISBN 0-7725-1558-1

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Wolfe, T.J.E., E. Brown, D. Parker, and F. Mustoe. *Physics Today 1.* Scarborough: Prentice-Hall Canada Inc., 1989. ISBN 0-13-669391-1

Zebrowski, Ernest Jr. *Practical Physics.* Toronto: McGraw-Hill, Inc., 1980. ISBN 0-07-072788-0

Videotapes

Beyond the Mechanical Universe series of 26 videos available through Magic Lantern Communications Ltd. (www.magiclantern.ca)

Electricity and Magnetism available through Magic Lantern Communications Ltd. (www.magiclantern.ca)

Electromagnetism available through Classroom Video (www.classroomvideo.com)

Energy and Society available through Hawkhill Video (www.hawkhill.com)

Interference of Light available through Classroom Video (www.classroomvideo.com)

*Mechanical Universe: Introduction to Phy*sics series of 26 videos available through Magic Lantern Communications Ltd. (www.magiclantern.ca)

Physics Demonstrations in Electricity and Magnetism available through Physics Curriculum and Instruction (www.physicscurriculum.com)

Physics Demonstrations in Light available through Physics Curriculum and Instruction (www.physicscurriculum.com)

Physics Demonstrations in Mechanics available through Physics Curriculum and Instruction (www.physicscurriculum.com)

Physics Demonstrations in Sound and Waves available through Physics Curriculum and Instruction (www.physicscurriculum.com)

Physics Essentials series of 6 videos available through Magic Lantern Communications Ltd. (www.magiclantern.ca)

Physics-The Basic Science available through Hawkhill Video (www.hawkhill.com)

Physics: What Matters, What Moves series of 6 videos available through Magic Lantern Communications Ltd. (www.magiclantern.ca)

Refraction and Images available through Classroom Video (www.classroomvideo.com)

Resonance available through Magic Lantern Communications Ltd. (www.magiclantern.ca)

Computer Software

Crocodile Physics - simulations of various physics phenomena available through Spectrum Educational Supplies (www.spectrumed.com)

Data Studio and related probes available through Merlan Scientific (www.merlan.ca)

Interactive Physics - a modelling and simulation program available from Tangent Scientific (www.tangentscientific.com)

Internet Sites

The URL's for the websites were verified by the writers prior to publication. Given the frequency with which these designations change, teachers should always verify the websites prior to assigning them for student use.

American Association of Physics Teachers – www.aapt.org

American Physical Society – http://physicscentral.com

Canadian Conference of Catholic Bishops – www.cccb.ca

Catholic Information Network – www.cin.org/
Fluid Power Journal – www.FluidPowerJournal.com
How Stuff Works – www.howstuffworks.com/sports-physiology.htm
Hydraulics Training and references – fluidpowerzone.com
Ontario Association of Physics Teachers – www.uoguelph.ca/OAPT/index.html
Multimedia Physics Studios – http://www.glenbrook.k12.il.us/gbssci/phys/mmedia/index.html#work
Physical Sciences Resource Center – www.psrc-online.org
Pneumatics Industry Reference – www.pneumaticsonline.com
Science Joy Wagon – www.sciencejoywagon.com/physicszone/
Science Teachers' Association of Ontario – www.stao.org
Students' Alternate Conceptions – http://phys.udallas.edu/C3P/altconcp.html
The Institute of Physics – http://physicsweb.org/resources
The Physics Teacher's Index – http://www.messiah.edu/hpages/facstaff/barrett/phy_ind.htm
The Vatican – www.vatican.va/

Models and Manipulatives

Electrical, magnetic and electromagnetic devices, power supplies, voltmeters, ammeters, oscilloscopes, soldering irons, wire strippers, plastic tubing, syringes, computers, and relevant interfaces along with various laboratory equipment

OSS Considerations

Students can benefit from experience in science related activities in the workplace through cooperative education or work experience placements within the community. They may consider a Cooperative Education or a work experience placement related to this science course. Students should explore various science related careers throughout the course and consider them when they are developing their Annual Education Plan (AEP).

Students should be reminded that they are required to complete 40 hours of community involvement activities prior to graduation. They should consult their board's list of eligible Christian Service activities for suggestions to complete this requirement.

Students graduating from Ontario schools are expected to be technologically literate. Through the study of this science course students should be able to understand and apply technological concepts, to use computers in various applications, and to analyse the implications of technology on individuals, on society, and on the environment.

In all classes, the teacher should make sure to adopt measures to provide a safe environment for learning, free from all types of harassment, violence, and expressions of prejudice.

Coded Expectations, Physics, Grade 12, College Preparation, SPH4C

Scientific Investigation Skills

SIS.01 - demonstrate an understanding of appropriate safety practices by selecting, operating, and storing electrical equipment, components, and materials in accordance with the Ontario Electrical Code, and by acting in accordance with Workplace Hazardous Materials Information System (WHMIS) legislation in selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., wear appropriate protective goggles and clothing when soldering electrical connections or carrying out experiments involving fluids under pressure);

SIS.02 - select appropriate instruments and testing equipment and use them effectively and accurately in collecting observations and data (e.g., troubleshoot electrical circuits using electrical tools and such measuring instruments as ammeters, voltmeters, and oscilloscopes);

SIS.03 - demonstrate the skills required to design and carry out experiments related to the topics under study, controlling major variables and adapting or extending procedures where required (e.g., design and carry out an experiment to determine the relationships among force, area, pressure, volume, and time in a hydraulic system);

SIS.04 - locate, select, analyse, and integrate information on topics under study, working independently and as part of a team, and using appropriate library and electronic research tools, including Internet sites;

SIS.05 - compile, organize, and interpret data, using appropriate formats and treatments, including tables, flow charts, graphs, and diagrams (e.g., explain the reflection and refraction of light in various situations, using ray diagrams);

SIS.06 - use appropriate scientific models (theories, laws, explanatory devices) to explain and predict the behaviour of natural phenomena;

SIS.07 - analyse and synthesize information for the purpose of identifying problems for inquiry, and solve the problems using a variety of problem-solving skills;

SIS.08 - select and use appropriate SI units, and apply unit analysis techniques when solving problems;

SIS.09 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation (e.g., algebraic equations, vector diagrams, free-body diagrams, ray diagrams, graphs, graphing programs, spreadsheets) to communicate scientific ideas, plans, and experimental results;

SIS.10 - communicate the procedures and results of investigations and research for specific purposes using data tables, laboratory reports, and research papers, and account for discrepancies between theoretical and experimental values (e.g., compile a table listing the efficiencies of the energy transformations that occur in the operation of some transducers used in communications systems);

SIS.11 - express the result of any calculation involving experimental data to the appropriate number of decimal places or significant figures;

SIS.12 - identify and describe science- and technology-based careers related to the subject area under study (e.g., filmmaker, kinesiologist, navigator, tool-and-die maker, machinist, fluid power technologist, communications technician).

Mechanical Systems

Overall Expectations

MSV.01 · describe and apply concepts related to forces, Newton's laws of motion, static and kinetic friction, simple machines, torques, and mechanical advantage;

MSV.02 · design and carry out experiments to investigate forces, coefficients of friction, and the operation of simple machines;

MSV.03 · identify and analyse applications of applied forces, friction, and simple machines in real-world machines and in the human body.

Specific Expectations

Understanding Basic Concepts

MS1.01 – define and describe the concepts and units related to force, coefficients of friction, torque, mechanical advantage, and work;

MS1.02 – state Newton's laws of motion, and apply them to mechanical systems (e.g., identify and explain the conditions associated with the movement of objects at constant velocity);

MS1.03 – analyse, in qualitative and quantitative terms, the forces (e.g., gravitational forces, applied forces, friction forces) acting on an object in a variety of situations, and describe the resulting motion of the object;

MS1.04 – identify, describe, and illustrate applications of types of simple machines, that is, the inclined plane and the lever, and modifications of these (the wedge, the screw, the pulley, and the wheel and axle);

MS1.05 – apply quantitatively the relationships among torque, force, and displacement in simple machines;

MS1.06 – state the law of the lever, and apply it quantitatively in a variety of situations for all three classes of levers;

MS1.07 – explain the operation and mechanical advantage of simple machines;

MS1.08 – determine the mechanical advantage of a variety of compound machines and bio-mechanical systems.

Developing Skills of Inquiry and Communication

MS2.01 – verify Newton's second law of motion through experimentation;

MS2.02 – determine, through experimentation, the factors affecting static and dynamic friction and the corresponding coefficients of friction;

MS2.03 – select appropriate instruments and use them effectively and accurately in investigating the relationships among force, displacement, and torque for the load arm and effort arm of levers;

MS2.04 – analyse, in quantitative terms, a mechanical system with respect to its component simple machines, input and output forces, and mechanical advantage (e.g., determine the mechanical advantage of the simple machines in a bicycle);

MS2.05 – construct a simple or compound machine to solve a practical problem, and determine its mechanical advantage (e.g., design and construct a prototype of a machine for lifting a patient from a hospital bed, calculate the mechanical advantage of each of the simple machines used in the device, and explain the operation of each simple machine).

Relating Science to Technology, Society, and the Environment

MS3.01 – describe advantages and disadvantages of friction in real-world situations, as well as methods used to increase or reduce friction in these situations (e.g., advantages of, and methods for increasing, friction on the surface of car tires and the soles of mountain-climbing boots; disadvantages of, and methods for reducing, friction between moving parts on industrial machines, and on wheels spinning on axles);

MS3.02 – describe the role of machines in everyday domestic life and in industry (e.g., identify simple machines that are part of a device used in the home, and explain the function of each machine; explain the function of the simple machines used in one of the following: robotics equipment, pulley systems, lever systems on backhoes, bulldozers, winches, the "Canadarm");

MS3.03 – analyse natural and technological systems that employ the principles of simple machines, and explain their function and structure (e.g., analyse the operation of the human arm in terms of the operation of a lever).

Electricity and Electronics

Overall Expectations

EEV.01 · demonstrate an understanding of common applications of electrical and electronic circuits, and the function and configuration of the components used;

EEV.02 · construct, analyse, and troubleshoot simple electrical circuits by using schematic diagrams and appropriate electrical tools and measuring equipment, and by examining familiar electrical devices;

EEV.03 · investigate the development and application of electrical technologies and their impact on local and global economies and the environment.

Specific Expectations

Understanding Basic Concepts

EE1.01 – define and describe the concepts and units related to electrical and electronic systems (e.g., direct current, alternating current, electric potential, resistance, power, energy);

EE1.02 – compare direct current and alternating current in qualitative terms, and describe situations in which each is used;

EE1.03 – describe the function of basic circuit components (e.g., power supplies, resistors, diodes, fuses, circuit breakers, light-emitting diodes [LEDs], capacitors, and switching devices);

EE1.04 – analyse and describe the operation of electrical and electronic devices that control other systems (e.g., programmable thermostats, control switches for fans or pumps, logic circuits, security systems, smoke detectors);

EE1.05 – analyse, in quantitative terms, circuit problems involving potential difference, current, and resistance;

EE1.06 – distinguish between, and explain the functions of, analog and digital circuits (e.g., identify one device that requires an analog circuit to function – audio amplifier, audio-tape recorder – and another that requires a digital circuit – computer data storage device, alarm circuit, compact disc [CD] recording, digital video disc [DVD] – and explain why each kind of circuit is used);

EE1.07 – describe examples of electrical sub-circuits that are micro-miniaturized and used as "black boxes" that serve a particular purpose in electronic equipment (e.g., identify and describe the function of a computer central processing unit [CPU] and a "smart" telephone card).

Developing Skills of Inquiry and Communication

EE2.01 – use appropriate meters (analog or digital), computer probes, and oscilloscopes to measure electric potential difference, current, and resistance in electrical circuits;

EE2.02 – construct simple electrical circuits using common tools appropriately and safely (e.g., soldering irons, wire strippers, crimping tools, screwdrivers, common connectors);

EE2.03 – draw, by hand or using a computer, schematic diagrams to represent real circuits;

EE2.04 – analyse, in quantitative terms, real or computer-simulated circuits, using Ohm's law and Kirchhoff's rules;

EE2.05 – design and construct an electrical circuit to perform a simple function (e.g., perimeter security system, water-level detector), and evaluate it on the basis of specified criteria;

EE2.06 – analyse real or simulated circuits to identify faults and suggest corrective changes (e.g., analyse the operation of a small home appliance and identify the problem in one that is broken or defective).

Relating Science to Technology, Society, and the Environment

EE3.01 – describe common applications of simple circuits, and identify the energy transformations that occur (e.g., energy transformations in one of the following appliances or devices: refrigerator, kettle, food mixer, amplifier, television set, light bulb, oscillator, electromagnet, electric motor, garage door opener);

EE3.02 – investigate the use and historical development of an electrical or electronic appliance or device (e.g., dry-cell, rechargeable battery, toaster, refrigerator, computer), and describe its performance since its development with respect to safety, cost, availability, and environmental impact;

EE3.03 – identify and describe proper safety procedures to be used when working with electrical circuits, and identify electrical hazards that may occur in the science classroom or at home.

Hydraulic and Pneumatic Systems

Overall Expectations

HPV.01 · demonstrate an understanding of the scientific principles related to fluid statics and dynamics, and to hydraulic and pneumatic systems;

HPV.02 · design and carry out investigations of fluid statics and dynamics, and of simple hydraulic and pneumatic systems;

HPV.03 · analyse and describe the social and economic consequences of the development of technological applications related to the motion and control of fluids.

Specific Expectations

Understanding Basic Concepts

HP1.01 – define and describe the concepts and units related to fluids and to hydraulic and pneumatic systems (e.g., density, atmospheric pressure, absolute pressure, laminar and turbulent flow, static pressure head, pressure, volume, flow rate);

HP1.02 – identify factors affecting laminar flow, and describe examples of laminar flow (e.g., identify the factors affecting the streamlining of cars, boats, planes, turbine blades, propellers, golf balls, or shark skin, and describe how each of these factors has been considered in the design of at least one of these applications);

HP1.03 – state Bernoulli's principle and explain some of its applications in the fields of technology and health (e.g., explain spray atomizers, propellers, spoilers on racing cars, turbine blades in jet engines);

HP1.04 – identify factors affecting static pressure head, analyse static pressure head in quantitative terms, and explain its effects in liquids and gases (e.g., identify factors affecting static pressure head in the Earth's atmosphere and calculate the absolute pressure at 5000 m);

HP1.05 – state Pascal's principle and explain its applications in the transmission of forces in fluid systems;

HP1.06 – describe common components used in hydraulic and pneumatic systems (e.g., cylinders, valves, motors, fluids, hoses, connectors, pumps, reservoirs);

HP1.07 – apply quantitatively the relationships among force, area, pressure, volume, and time in hydraulic and pneumatic systems (e.g., calculate the force exerted by the hydraulically operated brake pad on the wheel of a motorcycle or car; calculate the time required for a robotic system to complete one cycle of operation);

HP1.08 – analyse, in quantitative terms, the relationships among work, power, and time in hydraulic and pneumatic circuits.

Developing Skills of Inquiry and Communication

HP2.01 – demonstrate Bernoulli's principle through experiments (e.g., experiments involving wind tunnel demonstrations, suspension of table tennis balls, blowing between pieces of paper, or use of a Venturi tube);

HP2.02 – identify factors that affect the static pressure head in fluids by carrying out procedures, compare theoretical and empirical values, and account for discrepancies;

HP2.03 – verify Pascal's principle through experimentation;

HP2.04 – draw simple hydraulic or pneumatic circuits, using correct circuit symbols;

HP2.05 – determine, through experimentation, the relationships among force, area, pressure, volume, and time in a hydraulic or pneumatic system (e.g., build a two-cylinder circuit using small plastic cylinders filled with air or water, and measure and quantitatively analyse the extension of the cylinders and the forces exerted by them);

HP2.06 – design, construct, and evaluate a hydraulic or pneumatic system (e.g., the braking system on a car; a clamping device; a model of a crane) and solve problems as they arise.

Relating Science to Technology, Society, and the Environment

HP3.01 – describe the historical development of fluid systems, analyse their design, and determine why these technologies were developed and improved (e.g., identify examples of the use of hydraulic systems in aircraft and other transportation vehicles, in heavy equipment, and in precision machining, and explain why they have become the preferred system for each of the identified uses);

HP3.02 – identify and analyse some of the social and economic consequences of the use of robotic systems for many different kinds of operations (e.g., identify examples of the use of robotic systems in the computer-manufacturing industry, for lifting and manoeuvring heavy objects on assembly lines in factories, for handling hazardous materials, and for activities under water and in space, and explain how the use of robotics has affected the training required of people employed in these industries);

HP3.03 – identify various applications of hydraulic and pneumatic systems in everyday life, and evaluate the impact of the use of these systems on the quality of life.

Communications Technology

Overall Expectations

CTV.01 · demonstrate an understanding of the scientific principles and technological applications involved in the design, development, and operation of communications systems;

CTV.02 · design and carry out experiments to investigate and illustrate the fundamental operating principles and basic components of communications systems;

CTV.03 · identify and describe Canadian contributions to communications technology, and demonstrate awareness of the wide-ranging and ever-growing influence of communications technology on the global community.

Specific Expectations

Understanding Basic Concepts

CT1.01 – define and explain the concepts and units related to communications technology (e.g., frequency, period, cycle, wavelength, amplitude, longitudinal and transverse waves, electromagnetic waves, reflection, refraction, total internal reflection, interference, transmission, absorption);

CT1.02 – describe the periodic motion of a vibrating object in qualitative terms, and analyse it in quantitative terms (e.g., the motion of a pendulum, a vibrating spring, a tuning fork);

CT1.03 – describe the characteristics of waves, and analyse, in quantitative terms, the relationships among velocity, frequency, and wavelength to explain the behaviour of waves in different media;

CT1.04 – explain and illustrate the principle of superposition of waves (e.g., explain the sound produced by a musical instrument in terms of its fundamental frequency and the associated overtones, and draw diagrams to show the relationships between them);

CT1.05 – describe how the interference of waves is used in communications technology;

CT1.06 – explain, in qualitative terms, and illustrate how the reflection of waves is used in communications technology (e.g., in loudspeaker enclosures, police radar, communications satellites, parabolic reflectors);

CT1.07 – explain and predict, in quantitative terms and with the use of Snell's law, the refraction of electromagnetic waves;

CT1.08 – describe and illustrate total internal reflection, and explain its significance in communications systems;

CT1.09 – analyse and describe the sequences of energy transformations and transmissions that occur in commonly used communications systems (e.g., analyse and describe the function of each of the energy transformations that occur in a sound system, a video camera, a video cassette recorder [VCR], and a television set).

Developing Skills of Inquiry and Communication

CT2.01 – determine, through experimentation, the properties of and the relationships among the major variables for a vibrating object (e.g., conduct an experiment to determine the factors that affect the frequency of a pendulum);

CT2.02 – investigate, through experimentation or the use of computer simulations, the characteristics of transverse and longitudinal mechanical waves (e.g., conduct experiments, using slinkies, springs, wave machines, ripple tanks);

CT2.03 – demonstrate and explain the principle of superposition (e.g., explain the production of standing waves, overtones in musical instruments, beats in sound waves, amplitude and frequency modulation in radio waves);

CT2.04 – verify Snell's law through experimentation, and identify the conditions required for total internal reflection;

CT2.05 – investigate the reflection and refraction of light through experimentation, and interpret results using algebraic and geometric models (e.g., investigate reflection of light from differently shaped surfaces, refraction of light in different media, and total internal reflection);

CT2.06 – analyse, in qualitative terms, the operation of simple transducers used in communications systems or in information-processing equipment (e.g., in microphones, loudspeakers, tape recorder heads, remote controllers, product code readers), and describe the energy transformations that occur;

CT2.07 – design and construct a simple communications system, and demonstrate the operation of each of the major components in the system (e.g., design and construct a simple house intercom system).

Relating Science to Technology, Society, and the Environment

CT3.01 – evaluate, using their own criteria, available models of a particular communications system or device (e.g., cell phone, computer system, satellite data transmission system, home entertainment system), and determine which model is the best on the basis of their evaluation;

CT3.02 – describe and evaluate Canadian contributions to communications science and technology (e.g., evaluate the contributions of Alexander Graham Bell, Reginald A. Fessenden, the Canadian communications industry, or the Canadian satellite and space exploration industry);

CT3.03 – assess, using their own criteria, the risks and benefits to society and the environment of introducing a particular technology from the communications industry (e.g., consider such factors as effects on personal privacy, control of the mass media, criminal activities, health concerns related to electric and magnetic fields, and the transfer of information).

Energy Transformations

Overall Expectations

ETV.01 · demonstrate an understanding of forms of energy, energy sources, energy transformations, energy losses, and efficiency, and the operation of common energy-transforming devices;

ETV.02 · construct or investigate devices that involve energy sources, energy transformations, and energy losses, and assess their efficiency;

ETV.03 · analyse and describe the operation of various technologies based on energy transfers and transformations, and evaluate the potential of energy-transformation technologies that use sources of renewable energy.

Specific Expectations

Understanding Basic Concepts

ET1.01 – define and describe the concepts and units related to energy transformations (e.g., energy, forms of energy, power, efficiency);

ET1.02 – describe and compare various energy transformations (e.g., describe energy transformations among mechanical, sound, thermal, electromagnetic, gravitational, and nuclear forms of energy);

ET1.03 – describe, with the aid of diagrams, the operation of energy-transforming devices (e.g., electric motors and generators, heat engines, photoelectric cells, electrochemical cells);

ET1.04 – analyse and describe, using energy flow diagrams, the relationships among and efficiencies of various energy sources (e.g., the sun, natural gas, oil, coal, moving water), transformations (e.g., between thermal energy and its transfer [heat] and electrical energy), transmissions (e.g., of electrical energy), and energy losses (e.g., of electrical energy as a result of resistance);

ET1.05 – determine, in quantitative terms, the power and efficiency of energy transformations in some common devices (e.g., electric motor, internal combustion engine, incandescent light bulb, fluorescent light bulb).

Developing Skills of Inquiry and Communication

ET2.01 – determine, through experimentation, the efficiency of a simple process of energy transformation (e.g., a rubber band stretched to propel a cart through photogates; an electric motor used to lift a mass);

ET2.02 – collaboratively design and build a device that uses at least four functional energy transformations to complete a task (e.g., an alarm system for a house), and explain its operation.

Relating Science to Technology, Society, and the Environment

ET3.01 – analyse and describe examples of technologies based on various combinations of energy transfer and transformation (e.g., a shock absorber, a vehicular airbag, a Mars landing system);

ET3.02 – evaluate the benefits and drawbacks, with respect to such factors as economic viability, use of energy resources, efficiency, safety, and general utility, of energy-transforming devices based on sources of renewable energy (e.g., photoelectric cells, solar cookers, hydrogen fuel cells, wind-up radios, Archimedes' pumps).

Ontario Catholic School Graduate Expectations

The graduate is expected to be:

A Discerning Believer Formed in the Catholic Faith Community who

CGE1a -illustrates a basic understanding of the **saving story** of our Christian faith;
CGE1b -participates in the **sacramental life** of the church and demonstrates an understanding of the centrality of the Eucharist to our Catholic story;
CGE1c -actively reflects on **God's Word** as communicated through the Hebrew and Christian scriptures;
CGE1d -develops attitudes and values founded on Catholic **social teaching** and acts to promote social responsibility, human solidarity and the common good;
CGE1e -speaks the **language of life**... "recognizing that life is an unearned gift and that a person entrusted with life does not own it but that one is called to protect and cherish it." (Witnesses to Faith)
CGE1f -seeks intimacy with God and celebrates **communion** with God, others and creation through prayer and worship;
CGE1g -understands that one's purpose or **call in life** comes from God and strives to discern and live out this call throughout life's journey;
CGE1h -respects the **faith traditions**, world religions and the life-journeys **of all people of good will**;
CGE1i -integrates faith with life;
CGE1j -recognizes that "sin, human weakness, conflict and forgiveness are part of the human journey" and that the cross, the ultimate sign of forgiveness is at the heart of **redemption**. (Witnesses to Faith)

An Effective Communicator who
CGE2a -listens actively and critically to understand and learn in light of gospel values;
CGE2b -reads, understands and uses written materials effectively;
CGE2c -presents information and ideas clearly and honestly and with sensitivity to others;
CGE2d -writes and speaks fluently one or both of Canada's official languages;
CGE2e -uses and integrates the Catholic faith tradition, in the critical analysis of the arts, media, technology and information systems to enhance the quality of life.

A Reflective and Creative Thinker who
CGE3a -recognizes there is more grace in our world than sin and that hope is essential in facing all challenges;
CGE3b -creates, adapts, evaluates new ideas in light of the common good;
CGE3c -thinks reflectively and creatively to evaluate situations and solve problems;
CGE3d -makes decisions in light of gospel values with an informed moral conscience;
CGE3e -adopts a holistic approach to life by integrating learning from various subject areas and experience;
CGE3f -examines, evaluates and applies knowledge of interdependent systems (physical, political, ethical, socio-economic and ecological) for the development of a just and compassionate society.

A Self-Directed, Responsible, Life Long Learner who

CGE4a -demonstrates a confident and positive sense of self and respect for the dignity and welfare of others;
CGE4b -demonstrates flexibility and adaptability;
CGE4c -takes initiative and demonstrates Christian leadership;
CGE4d -responds to, manages and constructively influences change in a discerning manner;
CGE4e -sets appropriate goals and priorities in school, work and personal life;
CGE4f -applies effective communication, decision-making, problem-solving, time and resource management skills;
CGE4g -examines and reflects on one's personal values, abilities and aspirations influencing life's choices and opportunities;
CGE4h -participates in leisure and fitness activities for a balanced and healthy lifestyle.

A Collaborative Contributor who

CGE5a -works effectively as an interdependent team member;
CGE5b -thinks critically about the meaning and purpose of work;
CGE5c -develops one's God-given potential and makes a meaningful contribution to society;
CGE5d -finds meaning, dignity, fulfillment and vocation in work which contributes to the common good;
CGE5e -respects the rights, responsibilities and contributions of self and others;
CGE5f -exercises Christian leadership in the achievement of individual and group goals;
CGE5g -achieves excellence, originality, and integrity in one's own work and supports these qualities in the work of others;
CGE5h -applies skills for employability, self-employment and entrepreneurship relative to Christian vocation.

A Caring Family Member who

CGE6a -relates to family members in a loving, compassionate and respectful manner;
CGE6b -recognizes human intimacy and sexuality as God given gifts, to be used as the creator intended;
CGE6c -values and honours the important role of the family in society;
CGE6d -values and nurtures opportunities for family prayer;
CGE6e -ministers to the family, school, parish, and wider community through service.

A Responsible Citizen who

CGE7a -acts morally and legally as a person formed in Catholic traditions;
CGE7b -accepts accountability for one's own actions;
CGE7c -seeks and grants forgiveness;
CGE7d -promotes the sacredness of life;
CGE7e -witnesses Catholic social teaching by promoting equality, democracy, and solidarity for a just, peaceful and compassionate society;
CGE7f -respects and affirms the diversity and interdependence of the world's peoples and cultures;
CGE7g -respects and understands the history, cultural heritage and pluralism of today's contemporary society;
CGE7h -exercises the rights and responsibilities of Canadian citizenship;
CGE7i -respects the environment and uses resources wisely;
CGE7j -contributes to the common good.

Unit 4: Communications Technology

Time: 24 hours

Unit Description

Students are introduced to various communication technologies and their roles in society. They explore the properties of periodic motion, and the behaviour of waves through direct experimentation. Also, students investigate the refraction of light by verifying Snell's Law. They describe and explain how the phenomena of reflection and interference of sound waves as well as the reflection, refraction, and interference of light and of electromagnetic waves are employed in modern day communication science. Furthermore, students describe and evaluate Canadian contributions to communication science. They employ their knowledge of communication science and electronics as they design, build, and demonstrate the operation of a simple communication system. Finally, students learn that communication technology is a tool of great power that can be used for good or evil depending on how it is used. Catholic social teaching requires that the media be used ethically and morally. Students apply this knowledge as they assess the risks and benefits to society, and to the environment, of using a particular communication technology. Students learn about and reflect on the widening gap between communication-rich and communication-poor countries and recognize the unethical nature of this imbalance of resources.

Unit Synopsis Chart

Note: Since each cluster includes several learning expectations, various Achievement Chart categories may be assessed; however, one or more areas tend to have a greater emphasis. These categories have been indicated in **bold** in order that it be clear to the teacher which category the teaching emphasizes.

Activity	Time	Learning Expectations	Assessment Categories	Tasks
1. Vibrations and waves 1.1 Periodic motion and vibrations 1.2 Characteristics of waves 1.3 Superposition of waves	6.5 hours	CTV.01, CTV.02, CT1.01, CT1.02, CT1.03, CT1.04, CT1.05, CT1.06, CT2.01, CT2.02, CT2.03 SIS.02, .03, .06, .10 CGE 3c, 4f	**Knowledge/ Understanding** **Inquiry** **Communication** Making Connections	- teacher-directed lessons - lab activity - vocabulary list - mathematical problem solving
2. Light 2.1 Refraction and Snell's Law 2.2 Total Internal Reflection	6 hours	CTV.01, CTV.02, CT1.01, CT1.07, CT1.08, CT2.04, CT2.05 SIS.02, .03, .05, .09, .10 CGE 3c, 4f	**Knowledge/ Understanding** **Inquiry** Communication Making Connections	- teacher demonstration - student investigation - mathematical problem solving
3. Sound, Light, and Communication Technologies 3.1 Devices 3.2 Canadian Contributions to Communication	5 hours	CTV.01, CTV.03, CT1.05, CT1.06, CT1.08, CT1.09 CT2.06, CT3.02 SIS.04, .12 CGE 2be, 3b	**Communication** **Making Connections**	- class trip - student research - report presentation - poster presentation

Activity	Time	Learning Expectations	Assessment Categories	Tasks
4. Build a Communications System	4 hours	CTV.01, CTV.02, CT1.09, CT2.07, CT3.03 SIS.01, .07 CGE 4ef	**Inquiry** **Communication** Making Connections	- student research - planning to build a device - building a device - explaining a device - sharing devices
5. Communications Technologies and You 5.1 Evaluation of a Communications System or Device 5.2 Assessing the Impact of Communications Technologies	2.5 hours	CTV.03, CT3.01, CT3.03 SIS.04, .07 CGE 1d, 2bc, 3cdf, 7efg	**Communication** **Making Connections**	- class discussion - creation of evaluation criteria - student research - written report - written reflection on the justice issue connected with the lack of communication technology in developing countries

Activity 1: Vibrations and Waves

Time: 6.5 hours

Description

Students explore periodic motion by determining the frequency of a pendulum and experimenting with the factors that affect its frequency. They then investigate the various properties and characteristics of transverse and longitudinal waves as propagated by different media. Lastly, students investigate, demonstrate, and explain the superposition and hence the interference of waves through a series of interactive lab stations.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE 3c - thinks reflectively and creatively to evaluate situations and solve problems;
CGE 4f - applies effective communication, decision-making, problem-solving, time and resource management skills.

Strand(s): Communications Technology

Overall Expectations

CTV.01 - demonstrate an understanding of the scientific principles and technological applications involved in the design, development, and operation of communication systems;
CTV.02 - design and carry out experiments to investigate and illustrate the fundamental operating principles and basic components of communications systems.

Specific Expectations

CT1.01 - define and explain the concepts and units related to communications technology;
CT1.02 - describe the periodic motion of a vibrating object in qualitative terms and analyse it in quantitative terms;
CT1.03 - describe the characteristics of waves, and analyse, in quantitative terms, the relationships among velocity, frequency, and wavelength to explain the behaviour of waves in different media;

CT1.04 - explain and illustrate the principle of superposition of waves;
CT1.05 - describe how the interference of waves is used in communications technology;
CT1.06 - explain in qualitative terms and illustrate how the reflection of waves is used in communications technology;
CT2.01 - determine, through experimentation, the properties, of and the relationships, among the major variables for a vibrating object;
CT2.02 - investigate, through experimentation or the use of computer simulations, the characteristics of transverse and longitudinal mechanical waves;
CT2.03 - demonstrate and explain the principle of superposition.

Scientific Investigation Skills
SIS.02 - select appropriate instruments and testing equipment and use them effectively and accurately in collecting observations and data;
SIS.03 - demonstrate the skills required to design and carry out experiments related to the topics under study, controlling major variables and adapting or extending procedures where required;
SIS.06 - use appropriate scientific models (theories, laws, explanatory devices) to explain and predict the behaviour of natural phenomena;
SIS.10 - communicate the procedures and results of investigations and research for specific purposes using data tables, laboratory reports, and research papers, and account for discrepancies between theoretical and experimental values.

Prior Knowledge & Skills

- Grade 9 and 10 Science (Academic or Applied) - Lab Skills

Planning Notes

- Set up various stations demonstrating vibrating objects, e.g., pendulum, weighted vertical spring, ripple tank, tuning forks, etc.
- For Activity 1.1, the experiment on wave properties should include the speed of a wave on a coiled spring and the reflection of waves from both fixed and free ends.
- Design quizzes to include communication type questions that allow students to describe and explain wave properties and characteristics.
- For Activity 1.2, ripple tanks, wave machines, and computer software should be set up as lab stations through which students can rotate. This allows students to further demonstrate the transmission and reflection of transverse and of longitudinal waves in different media.
- For Activity 1.3, ripple tanks, vibrating strings, and computer software should be set up as lab stations through which students can rotate in order to explain and demonstrate the superposition of waves, the creation of constructive interference, destructive interference, and standing waves, as well as amplitude and frequency modulation in radio waves.
- For Activity 1.3 students can demonstrate the production of standing waves and beats using a resonance apparatus.

Teaching/Learning Strategies

Activity 1.1: Periodic Motion and Vibrations

The teacher:

- introduces the concepts and definitions of periodic motion, cycle, period, and frequency;
- introduces the relationship between period and frequency;
- leads a whole class discussion on how to determine the period and frequency of a pendulum and on the factors that may affect its frequency, e.g., mass of bob, amplitude, length of string, type of string, etc.;

- determines the pairing of students for the pendulum lab activity and assigns the factor to be investigated by each lab group;
- records all team results on the board to facilitate a comparison;
- leads a whole-class discussion on the results and inferences of the lab activity;
- assesses individual lab reports;
- demonstrates various problem-solving techniques required in the analysis of word problems involving vibrating objects and assigns word problems to students;
- instructs students to rotate through the stations demonstrating various vibrating objects;
- conferences with students as they visit the stations;
- reviews the fact that sound is caused by vibrating objects;
- assesses and takes up the quiz.

Students:

- write the definitions of periodic motion, cycle, period, and frequency on their vocabulary sheets;
- write the formulae for period and frequency on their formula sheet;
- participate in the whole-class discussion on the factors that may affect the frequency of a pendulum;
- hypothesize what effect the altering of their specific variable may have on the frequency of the pendulum;
- in pairs, perform the pendulum lab activity;
- participate in the discussion of the results;
- write an individual lab report of their findings, being sure to discuss any discrepancies and the agreement/disagreement of their hypothesis with their results;
- employ various problem-solving techniques to solve word problems related to the motion of vibrating objects;
- rotate through various stations and describe in their notes the motion of the vibrating objects;
- write a quiz on periodic motion and vibrating objects.

Activity 1.2: Characteristics of Waves

The teacher:

- introduces the concepts and definitions of the main types of waves (longitudinal and transverse), their frequency, wavelength, and amplitude;
- demonstrates the production of transverse and longitudinal waves using a coiled spring;
- determines the groupings for the experiment on wave properties;
- conferences with students during the experiment;
- instructs students to rotate through the stations demonstrating the reflection and transmission of transverse and longitudinal waves;
- reviews the fact that sound is caused by vibrations and is transmitted as a longitudinal wave;
- conferences with students while they are visiting the stations;
- assesses individual student summaries on wave properties for completeness;
- introduces the relationship between velocity, frequency, and wavelength;
- demonstrates the relationship between amplitude and loudness using a tuning fork or a vibrating string, and between wavelength and frequency using a vibrating spring or an oscilloscope attached to an audio frequency generator;
- prepares a quiz on wave characteristics for waves in different media;
- assesses and takes up the quiz.

Students:

- write the definitions of wavelength, amplitude, longitudinal and transverse waves on their vocabulary sheet;
- in their groups, perform the experiment on wave properties;
- summarize their observations on wave properties in their notes;
- rotate through various stations demonstrating the reflection and transmission of transverse and longitudinal waves;
- write the relationship between speed, frequency, and wavelength on their formula sheet;
- further develop their problem-solving techniques to solve problems involving speed, frequency, and wavelength for waves in different media;
- write a quiz on wave characteristics.

Activity 1.3: Superposition of Waves

The teacher:

- introduces and demonstrates the concept of the superposition of waves and standing waves;
- introduces and demonstrates the concept of mechanical resonance in waves;
- introduces and demonstrates the concept of acoustical resonance as the natural amplification of a sound wave through the superposition of waves and the response of an object capable of vibrating to the periodic force exerted by vibrating air molecules;
- points out the dependence of the speed of sound on the temperature of the medium;
- calculates with students the value for the speed of sound in air in their classroom, using a formula;
- instructs students to rotate through the stations designed to demonstrate various superposition effects;
- conferences with students while they rotate through the superposition lab stations.

Students:

- rotate through a series of lab stations designed to demonstrate various superposition effects;
- conference with the teacher in order to explain and demonstrate their knowledge and skill involving the superposition of waves.

Assessment & Evaluation of Student Achievement

- Individual lab report on the pendulum may be assessed for Knowledge/Understanding, Communication and Inquiry using a rubric (CT1.01, CT2.01, SIS.02, SIS.03, SIS.10).
- Quiz on periodic motion and vibrating objects may be assessed for Knowledge/Understanding and Communication using a marking scheme (CT1.01, CT1.02).
- Individual student summaries on wave properties may be assessed for completeness and Communication using a checklist (CT2.02, SIS.03).
- Quiz on wave characteristics may be assessed for Knowledge/Understanding and Communication using a marking scheme (CT1.01, CT1.03, SIS.06).
- Student explanations and demonstrations of superposition may be assessed for Inquiry through teacher conferences (CT1.01, CT1.03, CT1.04, CT1.05, CT1.06, CT2.03, SIS.03).

Accommodations

- See the Course Overview for general accommodations.
- Possible enrichment activities:
  - Research the history and development of a specific musical instrument.
  - Research the design of a specific musical instrument and build a working model of the instrument.

Resources

Print

Gardner, R. *Science Projects About Sound.* United States of America: Enslow Publishers, Inc., 2000. ISBN 0-7660-1166-6

Giles, B. *Inventions and Inventors, Volume 3: Communications.* Connecticut: Grolier Educational, 2000. ISBN 0-7172-9387-4

Gunderson, P. Erik. *The Handy Physics Answer Book.* United States of America: Visible Ink Press, 1999. ISBN 1-57859-058-2

Lafferty, P. *Marshall Cavendish More Science Projects Communications.* New York: Marshall Cavendish Corporation, 1989. ISBN 1-85435-181-8

Computer Software

Oscillations and Waves - Fable Multimedia available from Tangent Scientific (www.tangentscientific.com)

Ripple Tank - Logal Physics Explorer Series available from Tangent Scientific (www.tangentscientific.com)

Waves - Logal Physics Explorer Series available from Tangent Scientific (www.tangentscientific.com)

Data Studio software, involving sensors and interfaces available from Merlan Scientific (www.merlan.ca)

Websites

Telecommunications systems – www.howstuffworks.com/category.htm?cat=tele

AM and FM radio waves – http://hyperphysics.phy-astr.gsu.edu/hbase/audio/bcast.html#c4

AM wave demo – http://www.purchon.com/physics/waves.htm

Superposition of waves demo – http://webphysics.ph.msstate.edu/jc/library/

Activity 2: Light

Time: 6 hours

Description

In this activity, students investigate refraction by experimentally verifying Snell's Law and the conditions necessary for total internal reflection.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE 3c - thinks reflectively and creatively to evaluate situations and solve problems;
CGE 4f - applies effective communication, decision-making, problem-solving, time and resource management skills.

Strand(s): Communications Technology

Overall Expectations

CTV.01 - demonstrate an understanding of the scientific principles and technological applications involved in the design, development, and operation of communication systems;
CTV.02 - design and carry out experiments to investigate and illustrate the fundamental operating principles and basic components of communications systems.

Specific Expectations
CT1.01 - define and explain the concepts and units related to communications technology;
CT1.07 - explain and predict, in quantitative terms and with the use of Snell's law, the refraction of electromagnetic waves;
CT1.08 - describe and illustrate total internal reflection and explain its significance in communications systems;
CT2.04 - verify Snell's law through experimentation and identify the conditions required for total internal reflection;
CT2.05 - investigate the reflection and refraction of light through experimentation and interpret results using algebraic and geometric models.

Scientific Investigation Skills
SIS.02 - select appropriate instruments and testing equipment and use them effectively and accurately in collecting observations and data;
SIS.03 - demonstrate the skills required to design and carry out experiments related to the topics under study, controlling major variables, and adapting or extending procedures where required;
SIS.05 - compile, organize, and interpret data using appropriate formats and treatments, including tables, flow charts, graphs, and diagrams;
SIS.09 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate scientific ideas, plans, and experimental results;
SIS.10 - communicate the procedures and results of investigations and research for specific purposes using data tables, laboratory reports, and research papers, and account for discrepancies between theoretical and experimental values.

Prior Knowledge & Skills

- Grade 8: Energy and Control - Optics
- Grade 9 Science (Applied or Academic) - Lab Skills
- Grade 10 Science (Applied or Academic) - Lab Skills

Planning Notes

- Various exhibits can be set up to illustrate refraction, e.g., a beaker filled with water with a pencil in it, glass or plastic circular disks or semicircular disks with a laser pen available to shine though them, etc. **Note:** Use of a laser pen should de done as a teacher demonstration because of safety concerns for possible eye damage. The teacher should first confirm that laser pens are allowed in the school. Teachers should consult safety notes in *Be Safe* a publication of Science Teachers Association of Ontario.
- Various transparent media should be available for Activity 2.1 and 2.2 such as glass or plastic semicircular disks, semicircular petri dishes that can hold water, and polar coordinate graph paper to facilitate the measuring of angles.
- A handout should be supplied outlining the proper technique for aligning a ray box for a given angle of incidence so students are able to avoid multiple refractions.

Teaching/Learning Strategies

Activity 2.1: Refraction and Snell's Law

The teacher:

- introduces the phenomenon of refraction through a demonstration, e.g., a pencil placed at an angle in a jar of water;
- defines index of refraction and how it relates to the concept of refraction;
- introduces the concept of Snell's Law;

- provides a variety of worked examples of Snell's Law;
- outlines a common approach to problem solving;
- reviews the appropriate use of the relevant equipment available and the experimental techniques used for the measurement of the quantities needed for the analysis;
- provides a list of equipment that will be made available to students, e.g., ray boxes, polar coordinate graph paper, glass or plastic semicircular disks;
- divides the students into small groups to design an experiment that allows them to verify Snell's Law;
- conferences with groups to assess their plans and to ensure that the design accomplishes the expectations successfully and safely;
- prepares a quiz;
- assesses and takes up the quiz.

Students:

- discuss with the class their personal observations of refraction;
- apply Snell's Law to solve simple problems presented;
- contribute to the design of an experiment to verify Snell's Law;
- modify plans and refine the design if needed after conference with the teacher;
- perform the experiment and measure the quantities needed for the analysis;
- analyse the results of the experiment;
- write a lab report and submit it for evaluation;
- write a quiz to determine their knowledge/understanding of Snell's Law.

Activity 2.2: Total Internal Reflection

The teacher:

- demonstrates total internal reflection by providing several situations that operate on this principle, e.g., directing laser light through a bent lucite rod or an optic fibre;
- introduces the concept of critical angle as it relates to total internal reflection;
- outlines a procedure whereby students use the same media as in Activity 2.1 to determine the critical angle, as well as the conditions for total internal reflection;
- divides students into small groups and provides each group with the same equipment as was used in Activity 2.1;
- prepares, gives, marks, and takes up a lab quiz.

Students:

- observe the teacher directing laser light through a bent Lucite rod or optic fibre.
- perform the experiment and submit one summary sheet per group for assessment;
- write a lab quiz to demonstrate their knowledge/understanding of total internal reflection.

Assessment & Evaluation of Student Achievement

- Individual lab report on refraction may be assessed for Knowledge/Understanding, Communication, and Inquiry using a rubric (CT1.01, CT2.04, SIS.02, SIS.03, SIS.05, SIS.09, SIS.10).
- Quiz on Snell's Law may be assessed for Knowledge/Understanding and Communication using a marking scheme (CT1.01, CT1.07).
- Group summary sheet on total internal reflection may be assessed for Knowledge/Understanding, Communication, and Inquiry (CT2.04, SIS.05, SIS.09).
- Individual lab quiz on total internal reflection may be assessed for Knowledge/Understanding and Inquiry (CT1.01, CT2.04).

Accommodations

- See the Course Overview for general accommodations
- Possible enrichment activities:
  - Research the speed of light and its connection with the index of refraction.
  - Research total internal reflection for the case where neither medium is air.

Resources

Be Safe. STACO, 2000. ISBN 1-844592-01-8

Software

Physics Explorer: Geometric Optics. Available from Tangent Scientific (www.tangentscientific.com)

Websites

Science Joy Wagon - www.sciencejoywagon.com/physicszone/lesson/09waves/default.htm
– www.sciencejoywagon.com/physicszone/lesson/09waves/totint/internal.htm

Mississippi State University – http://webphysics.ph.msstate.edu/library/22-2a/index.html
– http://webphysics.ph.msstate.edu/library/22-2b/index.html
– http://webphysics.ph.msstate.edu/library/22-2c/index.html
– http://webphysics.ph.msstate.edu/jc/library

Activity 3: Sound, Light, and Communication Technologies

Time: 5 hours

Description

Students examine specific applications of reflection and interference in communications technology and describe the energy transformations in a device used for such a purpose. Also, students write a report on Canada's contribution to communications technology.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE 2b - reads, understands, and uses written materials effectively;
CGE 2e - uses and integrates the Catholic faith tradition in the critical analysis of the arts, media, technology, and information systems to enhance the quality of life;
CGE 3b - creates, adapts, and evaluates new ideas in light of the common good.

Strand(s): Communications Technology

Overall Expectations

CTV.01 - demonstrate an understanding of the scientific principles and technological applications involved in the design, development, and operation of communication systems;
CTV.03 - identify and describe Canadian contributions to communications technology and demonstrate awareness of the wide-ranging and ever-growing influence of communications technology on the global community.

Specific Expectations

CT1.05 - describe how the interference of waves is used in communications and technology;
CT1.06 - explain in qualitative terms and illustrate how the reflect on of waves is used in communications technology;
CT1.08 - describe and illustrate total internal reflection and explain its significance in communications systems;

CT1.09 - analyse and describe the sequences of energy transformations that occur in commonly used communication systems;
CT2.06 - analyse, in qualitative terms, the operation of simple transducers used in communications systems or in information-processing equipment, and describe the energy transfers that occur;
CT3.02 - describe and evaluate Canadian contributions to communications science and technology.

Scientific Investigation Skills
SIS.04 - locate, select, analyse, and integrate information on topics under study, working independently and as part of a team, and using appropriate library and electronic research tools, including Internet sites;
SIS.12 - identify and describe science-and technology-based careers related to the subject area under study.

Prior Knowledge & Skills

- Students may need to review light and sound concepts studied in Grades 4 to 8.

Planning Notes

- Obtain several devices and/or the operation manuals and specification sheets for devices that:
  - use the principle of reflection;
  - contain a transducer and are used in a communications technology.
- Arranges for the students to visit a local radio or television station.
- Adhere to board policies regarding class trips.
- Arrange for computer lab time to conduct Internet searches and/or library for other sources of information.
- Review the ethical use of the Internet.

Teaching/Learning Strategies

Activity 3.1: Devices

The teacher:

- introduces several examples of devices that work on the principle of the reflection of electromagnetic radiation, e.g., radar gun, parabolic reflectors such as satellite dishes;
- outlines the criteria for assessment of a report on a device utilizing reflection/interference of waves;
- defines energy transformation (which will be dealt with in greater detail in a later unit);
- provides students with various devices used in communication technology;
- introduces the concept of a transducer and where it is commonly used;
- outlines criteria for assessment of a report identifying and describing the type and the sequence of energy transformations in a communication device;
- conferences with students regarding the appropriateness of their selected device;
- discusses the teaching of the Catholic church regarding the media, that it is a powerful tool that must be used ethically and morally;
- encourages students to consider the impact of the media on the values, lifestyles, and culture of the age and to view it from a moral and ethical perspective.

Students:

- write a brief report on how the reflection/interference of waves is used in a communication technology device;
- present findings to the class;
- visit a local radio or television station and identify the various systems/equipment currently used;
- choose one piece of equipment identified on the visit as a research topic;

- conduct research on the communication device in order to explain its operation and identify the energy transfers that take place; a description of the limits of the device could be useful in order to predict where that branch of technology may be headed;
- submit a report for evaluation.

Activity 3.2: Canadian Contributions to Communication

The teacher:

- outlines some of Canada's contributions to communication science and technology, such as Alexander Graham Bell, Reginald A. Fessenden, ANIK communication satellites;
- provides students with the assessment criteria for a poster presentation and information sheet on one of Canada's contributions to communication science and technology;
- conferences with students regarding the appropriateness of their selected topic.

Students:

- conduct an Internet (or other) search for Canadian advances in communication technology;
- present their information in a teacher-led discussion;
- choose an appropriate aspect of Canada's contribution to communication technology;
- conduct research for the poster presentation and information sheet;
- present their poster to the class after distributing their summary sheet;
- research the teaching of the Catholic Church with regards to the use of communication technology in the evangelization of people.

Assessment & Evaluation of Student Achievement

- Written report and presentation on a device utilizing the reflection of light waves may be assessed for Communication and Making Connections using a rubric (CT1.05, CT1.06, SIS.04).
- Written report on a device used in a communications technology may be assessed for Communication and Making Connections using a rubric (CT1.08, CT1.09, CT2.06, SIS.04).
- Student compilations of Canadian contributions to Communications, Science, and Technology may be assessed using a checklist (CT3.02, SIS.04) (Appendix A – Task Rating Scale).
- Poster presentation and summary sheet on a specific aspect of Canada's contribution to communication may be assessed using a rubric (CT3.02, SIS.04, SIS.12) (Appendix B – Task Rubric).

Accommodations

- See the Course Overview for general accommodations.
- Possible enrichment activities:
  - Students may choose to design a multimedia presentation of Canada's contribution to communication rather than a poster.

Resources

Print

Anthony, A. *Radio Wizard Edward Samuel Rogers and the Revolution of Communications.* Canada: Gage Educational Publishing Company, 2000. ISBN 7715-8050-9

Babaian, Sharon Anne. *Radio Communication in Canada: a Historic and Technological Survey.* Ottawa: National Museum of Science and Technology, 1992. ISBN 0660120178

Giles, B. *Inventions and Inventors, Volume3: Communications.* Connecticut: Grolier Educational, 2000. ISBN 0-7172-9387-4

Websites

Canada Science and Technology Museum – http://www.science-tech.nmstc.ca/english/index.cfm

Canada's Digital Collections – http://collections.ic.gc.ca

Canadian Conference of Catholic Bishops – www.cccb.ca

Catholic Information Network – http://www.cin.org

Inter Mirifica: Decree on the Media of Social Communications. Documents of Vatican II, 1963 (available from the Catholic Information Network (CIN) or The Vatican)

Lafferty, P. *Marshall Cavendish More Science Projects Communications.* New York: Marshall Cavendish Corporation, 1989. ISBN 1-85435-181-8

Pornography and Violence in the Media. Pontifical Council For Social Communications, 1989 (available from the Catholic Information Network (CIN) or The Vatican)

Pauline Center for Media Studies
– http://www.daughtersofstpaul.com/mediastudies/mediastudiescenter.html

Aetatis Novae – "Dawn of a New Era." Pontifical Council For Social Communications, 1992 (available online through Pauline Center for Media Studies)

Ethics in Communications. Pontifical Council for Social Communications, 2000, 1992 (available online through Pauline Center for Media Studies)

Ethics in Advertising. Pontifical Council For Social Communications, 1997, 1992 (available online through Pauline Center for Media Studies)

The Vatican – www.vatican.va/

Appendices

Appendix A – Task Rating Scale for Activity 3.2
Appendix B – Task Rubric for Activity 3.2

Activity 4: Build a Communications System

Time: 4 hours

Description

Students research how to build a simple communication device such as a telegraph. They then build the device and present it to the class. They are asked to consider the societal impact, both positive and negative, of the introduction of the device they built.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE 4e - sets appropriate goals and priorities in school, work, and personal life;
CGE 4f - applies effective communication, decision-making, problem-solving, time and resource management skills.

Strand(s): Communications Technology

Overall Expectations

CTV.01 - demonstrate an understanding of the scientific principles and technological applications involved in the design, development, and operation of communication systems;
CTV.02 - design and carry out experiments to investigate and illustrate the fundamental operating principles and basic components of communications systems.

Specific Expectations
CT1.09 - analyse and describe the sequences of energy transformations and transmissions that occur in commonly used communications systems;
CT2.07 - design and construct a simple communications system and demonstrate the operation of each of the major components in the system;
CT3.03 - assess, using their own criteria, the risks, and benefits to society and the environment of introducing a particular technology from the communications industry.

Scientific Investigation Skills
SIS.01 - demonstrate an understanding of appropriate safety practices by selecting, operating, and storing electrical equipment, components, and materials in accordance with the Ontario Electrical Code, and by acting in accordance with Workplace Hazardous Materials Information System (WHMIS) legislation in selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials;
SIS.07 - analyse and synthesize information for the purpose of identifying problems for inquiry, and solve the problems using a variety of problem-solving skills.

Prior Knowledge & Skills

- Grade 9 Science (Academic or Applied) - Electricity Unit
- Grade 12 College Physics Electricity and Electronics unit

Planning Notes

- Collect information on how to build the devices in case students are not able to find plans that they can use.
- Collect materials to make the devices in case students are unable to bring their own resources to class.
- Book Internet time.
- Review ethical use of the Internet.
- Prepares a rubric to assess the telegraph and the presentation of it to the class.
- Allow for time to share the completed devices.

Teaching/Learning Strategies

The teacher:

- presents a short history of the telegraph as an important communication device;
- presents the idea that students are able to build a telegraph key and sounder;
- gives students an opportunity to identify and to collect the necessary materials to build the telegraph;
- gives students one period to work on the device in class and then to complete it on their own time if needed;
- identifies for students the concept of energy transformations and asks them to identify the transformations that take place in a working telegraph;
- identifies for students the concept of benefits and the possibility of risks that might be considered with the telegraph;
- encourages students to think of others;
- allows students class time to present their devices to each other and assesses the products and the presentations.

Students:

- research the construction of a telegraph;
- collect the necessary materials to construct a telegraph;
- construct a telegraph key and a sounder;

- demonstrate their device to the class;
- provide a summary of the energy transformations that take place in a telegraph;
- comment on additional risks and benefits of the telegraph.

Assessment & Evaluation of Student Achievement

- The students' research, construction, and presentation of the telegraph may be assessed for Inquiry, Communications, and Making Connections by means of a suitable rubric (CT1.09, CT2.07, CT3.03, SIS.01, SIS.07).

Accommodations

- See the Course Overview for general accommodations.
- For students having difficulty, make available a commercial model of a device to be assembled.
- Possible enrichment activities:
  - Students may wish to learn Morse code in order to use their device better.
  - Students may research and build a telephone.
  - Students may research and build a model radio receiver.
  - Students may build a low power walkie-talkie operating on the Family Radio Service (FRS) band.
  - Students may use parabolic microphones to simulate a microwave or a satellite communications system.

Resources

Print

Lafferty, P. *Marshall Cavendish More Science Projects Communications.* New York: Marshall Cavendish Corporation, 1989. ISBN 1-85435-181-8

Websites

Alexander Graham Bell's Path to the Telephone
– http://jefferson.vollage.virginia.edu/albell/introduction.html

Electronics projects and electronics tutorials – http://my.integritynet.com.au/purdic/

How to Build Simple Telegraph Sets – http://www.chss.montclair.edu/~pererat/perbuild.html

Activity 5: Communication Technologies and You

Time: 2.5 hours

Description

Students consider the purchase of a particular communications system or device. Individual evaluation criteria, developed by each student, are applied while researching their purchase. Students then assess the impact that the introduction of this particular communications technology would have on society and the environment. During the creation of their assessment criteria, students reflect on the themes of community and the common good as well as on stewardship.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE 1d - develops attitudes and values founded on Catholic social teaching and acts to promote social responsibility, human solidarity, and the common good;
CGE 2b - reads, understands, and uses written materials effectively;
CGE 2c - presents information and ideas clearly and honestly and with sensitivity to others;

CGE 3c - thinks reflectively and creatively to evaluate situations and solve problems;
CGE 3d - makes decisions in light of gospel values with an informed moral conscience;
CGE 3f - examines, evaluates, and applies knowledge of interdependent systems (physical, political, ethical, socio-economic and ecological) for the development of a just and compassionate society;
CGE 7e - witnesses Catholic social teaching by promoting equality, democracy, and solidarity for a just and compassionate society;
CGE 7f - respects and affirms the diversity and interdependence of the world's peoples and cultures;
CGE 7g - respects and understands the history, cultural heritage, and pluralism of today's contemporary society.

Strand(s): Communications Technology

Overall Expectations
CTV.03 - identify and describe Canadian contributions to communications technology, and demonstrate awareness of the wide-ranging and ever-growing influence of communications technology on the global community.

Specific Expectations
CT3.01 - evaluate, using their own criteria, available models of a particular communications system or device, and determine which model is the best on the basis of their evaluation;
CT3.03 - assess, using their own criteria, the risks and benefits to society and the environment of introducing a particular technology from the communications industry.

Scientific Investigation Skills
SIS.04 - locate, select, analyse, and integrate information on topics under study, working independently and as part of a team, and using appropriate library and electronic research tools, including Internet sites;
SIS.07 - analyse and synthesize information for the purpose of identifying problems for inquiry, and solve the problem using a variety of problem-solving skills.

Prior Knowledge & Skills

- Research Skills: Grade 9 Science (Academic or Applied)
- Research Skills: Grade 10 Science (Academic or Applied)

Planning Notes

- For the activity involving the evaluation of a communications system or device, obtain brochures of various models of different communications systems or devices, e.g., cell phones, computer systems, satellite data transmission systems, cable television providers, Internet providers, or home entertainment systems, and start a vertical file for use in the classroom.
- In order to keep their evaluation criteria realistic and personal, students should be instructed to consider their evaluation of the communications system or device as if it were a valid purchase and not a wish list item.
- Factors that should be considered include cost, need, compatibility, country of manufacture, service policy, hidden costs, and the ethical practices of the company.
- Book Internet time.
- Review ethical use of the Internet.
- For the class discussion on how advances in communications technologies have led to the notion of a global community, the teacher needs to emphasize the serious problem of building a genuine global community when the majority of the world's population does not have equal access to the means of communication.

- For the activity on assessing the potential impact that a particular communications technology will have on society, students need to reflect on the statements, "The human person needs to live in society. Society is not for him an extraneous addition but a requirement of his nature. Through the exchange with others, mutual service and dialogue with his brethren, man develops his potential." (Catechism of the Catholic Church, No. 1879), and "We are all members of one body... if one member suffers, all members suffer with it; if one member is honoured, all the members share its joy." (Corinthians 12:21, 26)
- The concepts that form the basis for the students' criteria should involve the following:
  Theme of Community and the Common Good
  - Respect for the Person
    - The potential for the sharing of knowledge and ideas
    - The potential for individual growth
    - The potential for the invasion of privacy
    - The potential for the unauthorised transfer of personal information
    - The potential for the denial of basic human rights and dignities
    - The potential for health concerns due to electromagnetic radiation
  - Allowance for Social Well-Being and the Development of Community
    - The potential for the sharing of culture
    - The potential for promoting community
    - The potential for the destruction of community
    - The potential for the manipulation of a community
    - The potential for the destruction of culture
    - The potential for the evangelization of people

  Theme of Stewardship
  - Respect for the Environment
    - The potential for integration into existing ecosystems
    - The potential for the destruction of an existing ecosystem
    - The potential for the displacement of individuals
    - The potential for the depletion of existing resources
    - The potential of mobilizing people in the defence, protection, and enhancement of natural environment
    - The potential of alerting people on possible contamination, pollution, and other harmful practices perpetrated by individuals, municipalities, governments, or corporations
- Students rate the criteria in order of importance to them and then apply their criteria in an assessment of a particular communications technology, e.g., television, radio, Internet, cell phones, etc.
- Students' individual criteria should consider both benefits and risks in order to make a valid assessment of the impact the introduction of a particular communications technology would have on society and the environment.
- The worksheet (Appendix C) could be used as a template to form the students' individual criteria. Additional concepts could be developed through classroom discussion and individual conferencing based on the communications technologies selected.

Teaching/Learning Strategies

Activity 5.1: Evaluation of a Communications System or Device

The teacher:

- leads a whole-class discussion on the factors that should be considered when planning on purchasing a particular communications system or device;
- instructs students to create their own evaluation criteria by considering the factors that are applicable to their purchase and rating them in order of importance to them;
- instructs students to research their chosen device using their evaluation criteria and write a summary outlining their top three choices;
- conferences with students while they are researching;
- assesses the individual student summaries.

Students:

- participate in the whole-class discussion on the factors that should be considered in the purchase of a particular communications system or device;
- consider the factors that are applicable to the purchase and rate them in order of importance;
- examine brochures and Internet sites in order to rate the communications device according to their chosen criteria;
- write a summary describing how their top three choices meet their criteria and why their criteria was chosen.

Activity 5.2: Assessing the Impact of Communications Technologies

The teacher:

- leads a whole-class discussion on how advances in communications technologies have led to the notion of a global community;
- introduces the statements for student reflection (see Planning Notes);
- leads a whole-class discussion to introduce the concepts that form the criteria that assess the impact of a particular communications technology on society and the environment (see Planning Notes and Appendix C);
- conferences with students while they rate their criteria and choose their particular communications technology;
- conferences with students while they research and use their criteria to assess the impact of their particular communications technology on society and the environment;
- assesses the individual reports.

Students:

- participate in the whole-class discussions;
- choose a particular communications technology to research;
- use the worksheet (Appendix C) to rate the criteria in order of importance to themselves;
- research and apply their criteria in the assessment of the impact of the introduction of a particular communications technology on society and the environment;
- write a report outlining their criteria and their assessment of the communications technology;
- write a reflection on the justice issue connected with the lack of communication technology in developing countries.

Assessment & Evaluation of Student Achievement

- The individual evaluation of a particular communications system or device may be assessed for Communication using a checklist (CT3.01, SIS.04, SIS.07).
- The individual report about the assessment of the impact of the introduction of a particular communications technology may be assessed for Communication and Making Connections using a rubric (Appendix D) (CT3.03, SIS.04, SIS.07).

Accommodations

- See the Course Overview for general accommodations.
- Possible enrichment activities:
  - Research the history and culture of a different nation in an effort to promote the global community.
  - Research the history and development of a particular communications technology.

Resources

Print

Catechism of the Catholic Church. Canadian Conference of Catholic Bishops, 1994.

New American Catholic Bible. Catholic Bible Publishers, Wichita, Kansas, 1992

Parker, S. *Eyewitness Science, Volume 1: Electricity.* Canada: Stoddart Publishing Co. Limited, 1992. ISBN 0-7737-2613-6

Church's documents on the social means of communication

Websites

Better Business Bureau Consumer Services – http://www.bbbmbc.com

Canadian Centre for Ethics and Corporate Policy – http://www.ethicscentre.com

Catholic Information Network – http://www.cin.org

Ethical Consumer – http://www.ethicalconsumer.org

Appendices

Appendix C – Worksheet for Activity 5.2
Appendix D – Activity 5.2 Rubric

Appendix A

Task Rating Scale for Activity 3.2

Canadian advances in communication technology are assessed according to the following three criteria:

1. Appropriate sources cited:
   - Internet (if available);
   - reference books, e.g., encyclopedias;
   - journals/magazines;
   - newspapers;
   - other.

2. Relevancy to topic.

3. Appropriate bibliography.
   The bibliographic format should follow the APA style.

The following may be used as a rating scale for the above checklist:

Criteria	Rating Scale
1. Cited sources are appropriate.	0 1 2 3 4
2. Information relates to the topic	0 1 2 3 4
3. Correct bibliographic style is used.	0 1 2

Appendix B

A Canadian Contribution to Communication

Task Rubric for Activity 3.2

(Poster Presentation and Information Sheet)

Criteria	Level 1 (50-59%)	Level 2 (60-69%)	Level 3 (70-79%)	Level 4 (80-100%)
Knowledge/ Understanding Description of Canadian contribution to communication technology CT3.02	- demonstrates limited understanding of the technology	- demonstrates some understanding of the technology	- demonstrates considerable understanding of the technology	- demonstrates thorough understanding of the technology
Communication Communication of information and evaluation SIS.10	- communicates information and evaluation with limited clarity and precision	- communicates information and evaluation with moderate clarity and precision	- communicates information and evaluation with considerable clarity and precision	- communicates information and evaluation with a high degree of clarity and precision
Poster construction and materials used SIS.05	- meets design criteria in a limited way - makes limited use of materials	- partially meets design criteria - makes adequate use of materials	- meets design criteria - makes effective use of materials	- meets design criteria in an innovative way - materials used in an innovative way
Making Connections Evaluates the technology with respect to its impact on society SIS.12	- evaluates the technology with limited effectiveness	- evaluates the technology with moderate effectiveness	- evaluates the technology with considerable effectiveness	- evaluates the technology with a high degree of effectiveness

Note: A student whose achievement is below Level 1 (50%) has not met the expectations for this assignment or activity

Appendix C

Worksheet for Activity 5.2

The introduction of communications technologies has had an impact on society and the environment. The risks and benefits of this impact affect the culture, community, individuals, and environment of the area. The following themes and concepts are used to create a personal set of criteria that aid you in the assessment of the risks and benefits of the introduction of a specific communication technology.

1. Choose a specific communications technology for assessment, e.g., television, radio, Internet, cell phones, etc.
2. Rank the three main headings: Respect for the Person, Allowance for Social Well-Being and the Development of Community, and Respect for the Environment in order of their importance to you. Place your ranking (1, 2 or 3) in the space provided.

Theme of Community and the Common Good

____ Respect for the Person

- ____ The potential for the sharing of knowledge and ideas
- ____ The potential for individual growth
- ____ The potential for the invasion of privacy
- ____ The potential for the unauthorized transfer of personal information
- ____ The potential for the denial of basic human rights and dignities
- ____ The potential for health concerns due to electromagnetic radiation

____ Allowance for Social Well-Being and the Development of Community

- ____ The potential for the sharing of culture
- ____ The potential for promoting community
- ____ The potential for the destruction of community
- ____ The potential for the manipulation of a community
- ____ The potential for the destruction of culture
- ____ The potential for the evangelization of people

Theme of Stewardship

____ Respect for the Environment

- ____ The potential for integration into existing ecosystems
- ____ The potential for the destruction of an existing ecosystem
- ____ The potential for the displacement of individuals
- ____ The potential for the depletion of existing resources
- ____ The potential of mobilizing people in the defence, protection, and enhancement of natural environment
- ____ The potential of alerting people on possible contamination, pollution, and other harmful practices perpetrated by individuals, municipalities, governments, or corporations

3. Explain your reasons for your ranking of the headings.
4. Within each heading there are various concepts that represent risks and benefits. Choose one risk and one benefit for each heading by placing a check mark in the space provided. This forms the basis for your criteria. Explain your reasons for your selected risks and benefits.
5. Use your selected criteria to assess the risks and benefits to society and the environment of the introduction of your particular communications technology. Include all research and sources.

Appendix D

Activity 5.2 Rubric for Written Report or the Societal Environmental Impact of Introduction a Communication Technology

Category/Criteria	Level 1 (50-59%)	Level 2 (60-69%)	Level 3 (70-79%)	Level 4 (80-100%)
Communication Communication of information and ideas related to communications technology SIS.10	- communicates information and ideas with limited clarity and precision	- communicates information and ideas with moderate clarity and precision	- communicates information and ideas with considerable clarity and precision	- communicates information and ideas with a high degree of clarity and precision
Making Connections Analysis of the criteria selected SIS.07	- analyses the criteria with limited effectiveness	- analyses the criteria with moderate effectiveness	- analyses the criteria with considerable effectiveness	- analyses the criteria with a high degree of effectiveness
Assessment of the risks and benefits of the introduction of a communication technology on society CT3.03	- assesses risks and benefits to society with limited effectiveness	- assesses risks and benefits to society with moderate effectiveness	- assesses risks and benefits to society with considerable effectiveness	- assesses risks and benefits to society with a high degree of effectiveness
Assessment of the risks and benefits of the introduction of a communication technology on the environment CT3.01	- assesses risks and benefits to the environment with limited effectiveness	- assesses risks and benefits to the environment with moderate effectiveness	- assesses risks and benefits to the environment with considerable effectiveness	- assesses risks and benefits to the environment with a high degree of effectiveness

Note: A student whose achievement is below Level 1 (50%) has not met the expectations for this assignment or activity.