*Catholic District School Board Writing Partnership*

# Course Profile

## Physics

Grade 11
University Preparation
SPH3U

- *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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**Acknowledgments**

Catholic District School Board Writing Teams – Physics

Lead Board
Hamilton-Wentworth Catholic District School Board
Remo Presutti, Manager

Course Profile Writing Team
Gerry Fuchs, Hamilton-Wentworth CDSB (Lead Writer)
Jeffrey Martin, Niagara CDSB
Michael Varrasso, Hamilton-Wentworth CDSB

Course Profile Internal Review Team
Dr. Anthony Cuschieri, Hamilton-Wentworth CDSB
Maurice DiGiuseppe, Toronto CDSB
Milan Sanader, Dufferin-Peel CDSB

University Destination Reviewer
Dr. Stefan Zukotynski, University of Toronto

Institute for Catholic Education (ICE)
Angelo Bolotta

Catholic Curriculum Cooperative of Central Ontario (CCCC)

# Course Overview
# Physics, Grade 11, University Preparation, SPH3U

**Prerequisite:** *Science, Grade 10, Academic*

## Course Description

This course develops students' understanding of the basic concepts of physics. Students study the laws of dynamics and explore different kinds of forces, the quantification and forms of energy (mechanical, sound, light, thermal, and electrical), and the way energy is transformed and transmitted. They develop scientific-inquiry skills as they verify accepted laws and solve both assigned problems and those emerging from their investigations. Students analyse the interrelationships between physics and technology, and consider the impact of technological applications of physics on society and the environment.

## How This Course Supports the Ontario Catholic School Graduate Expectations

Through the study of physics, students have the opportunity to "discover the laws which govern the universe, as well as their interrelationship." They (scientists, and therefore students) can "stand in wonderment and humility before the created and feel drawn to the love of the Author of all things." (address of Pope John Paul II to the Jubilee of Scientists May 25, 2000) The study of any science helps students to learn to be reflective, critical, and creative thinkers, as well as discerning believers, who can apply their knowledge to the world around them. They can then make appropriate decisions in light of Gospel values and Church teachings. Through the study of the techniques of science, particularly experimentation, students learn to be collaborative contributors to an interdependent team, respecting the rights, responsibilities, and contributions of others. 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 to use resources wisely in order to fulfill their roles as stewards of God's creation. "By increasing his knowledge of the universe ... man has a veiled perception ... of the presence of God...." (address of Pope John Paul II to the Jubilee of Scientists May 25, 2000)

## Course Notes

Students of physics not only go on to study the theoretical aspects of the discipline but also enroll in engineering and other technical programs at the post secondary level. Throughout the course students are given many opportunities to analyse, describe, and explain various technological applications of the physics principles studied. In particular, students are given opportunities to construct, test, and refine optical and electro-magnetic devices. Although no single culminating activity is suggested, the construction and testing of these devices is recommended as a component of the final assessment of the course.

Teachers should provide ample opportunities 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 System (WHMIS) legislation and must practice established safe laboratory procedures. Experimental work provides students with an opportunity to develop their inquiry skills in each unit of the course. The skills essential for scientific investigation are found on pages 89 and 90 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 should to use computer technology that has been developed for use in physics. Computer interfaces for laboratory equipment, multimedia applications, databases, and computer-based simulations should be used wherever appropriate to do so. Care should be taken, however, to ensure that students are provided with adequate opportunity to learn how to use the computer technology and to understand the physics concepts being studied.

The underlying theme of the course is the concept of energy, its meaning and application to various 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 is Electricity and Magnetism. This is so the students begin investigating the applications of physics in a context of the world around them, and then investigate the theoretical underpinnings of the technological applications. Students have experienced many electrical devices, so an investigation of their structure and operation is a natural starting point. They have also studied the characteristics of electricity in Grade 9, including electrical energy, power, and efficiency. This provides a basis for the discussion of different forms of energy and the transformation of energy. After Electricity and Magnetism the teacher may develop the theoretical and mathematical basis of the rest of the course by dealing with Force and Motion. The teacher builds on the concepts of kinematics introduced in Grade 10 to develop the concepts of dynamics. Additional time is included in this unit to allow the teacher to review the essential kinematics equations from Grade 10. However, teachers should be careful to not spend too much time on the review of the concepts taught in Grade 10. From this foundation, teachers can develop the mathematical relationships among Energy, Work and Power. This unit was developed in detail in order to model the design of a physics unit in the new curriculum and to show how the Catholic Graduate Expectations may be incorporated into the curriculum. The last two units recommended are Waves and Sound, followed by Light and Geometric Optics.

Units 1 and 5 provide the opportunity to construct, test, and refine various devices that are an application of physics principles. Students may submit either one of these devices for their final evaluation after they have made some refinements. Students should be introduced to the building project early in the unit. Additional time has been allocated to these units to provide sufficient time for students to build and test their devices. It is possible to switch the order of the last two units to allow sufficient time to build the optical device before the end of the course.

## Units: Titles and Time

| | | |
|---|---|---|
| Unit 1 | Electricity and Magnetism | 25 hours |
| Unit 2 | Forces and Motion | 24 hours |
| * Unit 3 | Energy, Work, and Power | 22 hours |
| Unit 4 | Waves and Sound | 15 hours |
| Unit 5 | Light and Geometric Optics | 24 hours |

* This unit is fully developed in this Course Profile.

### Unit 1: Electricity and Magnetism

**Time:** 25 hours

**Unit Description**

In this unit students begin by reflecting on the many electrical devices that exist in the world around them. They may express their gratitude for God's creation that allows us to create so many useful devices through a prayer such as that written by St. Francis of Assisi or by reading relevant scriptures. They study the basic principles and laws of electricity and magnetism through experimentation. Using these principles, students construct, test, and refine a working prototype device. They are made aware of the energy changes involved in the operation of electrical devices.

This is a basis for the more detailed study of energy, work and power. Students are asked to consider the value of the many electrical devices used by people in light of the need to share and to conserve the world's resources.

**Note:** The numbering of the Scientific Investigation Skills (SIS) is taken from the order of the expectations given on page 89 and 90 of *The Ontario Curriculum Grades 11 and 12 Science 2000*.

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 is clear to the teacher which category should be weighted more heavily.

**Unit Overview Chart**

| Cluster | Expectations | Assessment | Focus/Task |
|---|---|---|---|
| 1 | EMV.01<br>EM1.01, 1.02<br>SIS.08, .09<br>CGE 2ab | **Knowledge** | Electricity terminology and concepts:<br>• basic definitions<br>• simple problem solving involving the definitions<br>• review of simple electrical circuits |
| 2 | EMV.01, EMV.02<br>EM1.01, .03<br>EM2.01<br>EM3.01<br>SIS.01, .03, .06, .10<br>CGE 2abcd, 5a | Knowledge<br>**Inquiry**<br>Communication<br>**Making Connections** | Magnetic fields:<br>• experiments to examine the properties of magnetic fields<br>• applications of magnetic fields in practical devices |
| 3 | EMV.01, EMV.02, EMV.03<br>EM1.01, 1.04, 1.05, 1.06<br>EM2.02<br>EM3.02<br>SIS.01, .02, .03, .04, .05, .06, .10, .11<br>CGE 2cd, 5a | Knowledge<br>**Inquiry**<br>**Communication**<br>Making Connections | Electro-magnetism concepts:<br>• experiments to relate the current in a straight conductor and a coil with the magnetic field produced<br>• historical development of technologies related to magnetic fields |
| 4 | EMV.01, EMV.02, EMV.03<br>EM1.01, 1.07, 1.08, 1.09<br>EM2.03<br>EM3.02<br>SIS.01, .02, .03, .04, .05, .06, .10, .11<br>CGE 2cd, 5a | Knowledge<br>**Inquiry**<br>**Communication**<br>Making Connections | Electro-magnetic induction concepts:<br>• Faraday's Law<br>• Lenz's Law and AC/DC electricity<br>• quantitative calculations using transformers |
| 5 | EMV.02<br>EM2.04<br>SIS.07, .10, .12<br>CGE 2cd, 3f, 4f, 5ab, 7i | Inquiry<br>**Communication**<br>**Making Connections** | Application of electromagnetism:<br>• building an Electro-magnetic device<br>• possible careers |

## Unit 2: Forces and Motion

**Time:** 24 hours

**Unit Description**

The study of Force and Motion prepares the theoretical groundwork for physics. This is essential before introducing the concepts of energy and energy transformations. In this unit students demonstrate an understanding of the relationship between forces and the acceleration of an object by first examining the factors that affect linear motion in the horizontal direction. Students investigate the effect of gravitational force by analysing linear motion in the vertical direction. In both cases students use graphs and vector diagrams to aid in their quantitative analysis. Newton's laws of motion and their applications are investigated as students apply free-body diagrams to various situations to determine the net force acting on an object. Through experimentation and data analysis students verify Newton's second law of motion. Finally, students apply the concepts of force and motion to explain the design and function of various transportation and sports technologies. Students evaluate these developments based on principles of the Catholic faith tradition.

**Unit Overview Chart**

| Cluster | Expectations | Assessment | Focus/Task |
|---|---|---|---|
| 1 | FMV.01<br>FM1.01, 1.02, 1.03, 2.01<br>SIS.01, .02, .03, .06, .08, .09<br>CGE 2cd | **Knowledge**<br>**Inquiry** | Motion in the horizontal plane:<br>• type of motion and the forces acting<br>• apply vector diagrams of forces<br>• experiments to study this |
| 2 | FMV.01, FMV.03<br>FM1.01, 1.02, 1.04, 1.05, 2.03, 3.01<br>SIS.06, .07, .08, .09, .11<br>CGE 2c, 3c | **Knowledge**<br>Communications<br>Making Connections | Motion in the vertical plane:<br>• the effect of gravitational force on motion |
| 3 | FMV.02<br>FM1.01, 1.06, 1.07, 2.04<br>SIS.01, .02, .06, .07, .08, .09, .11<br>CGE 2b, 3c | **Knowledge**<br>Inquiry<br>Communications | Applying Newton's Laws:<br>• free body diagrams<br>• vector diagrams to study motion |
| 4 | FMV.02<br>FM1.08, 2.02, 2.03, 2.04<br>SIS.01, .02, .03, .04, .05, .06, .08, .09, .10, .12<br>CGE 2e, 3c, 4f, 5ae | Knowledge<br>**Inquiry**<br>Communications | Verifying Newton's Second Law:<br>• through experiment<br>• solving problems relating to its application |
| 5 | FMV.03<br>FM2.03, 2.04, 3.02, .03<br>SIS.04, .06, .08, .09, .12<br>CGE 2be, 3f, 4f, 5e | **Communications**<br>**Making Connections** | Applications of force:<br>• to technology<br>• to sport<br>• various societal issues related to them |

## Unit 3: Energy, Work, and Power

**Time:** 22 hours

**Unit Description**

Both the qualitative and quantitative concepts of work and energy are studied through reference to the electrical devices studied previously. The concepts of kinetic energy, gravitational potential energy, thermal energy, and heat are reviewed. Students investigate the concept of energy conservation in more detail in order to analyse the costs and benefits of various energy sources and energy transformation technologies. This provides them with an opportunity to reflect on the need for energy conservation in a world that has a disproportionate amount of energy used by a small segment of the world's population. Students reflect on the energy consumption in a Canadian city compared to a similar city in a developing country. The issue of stewardship and the distribution of wealth among the nations of the world is discussed. The transfer of energy through wave motion is then further studied in the next unit.

**Unit Overview Chart**

| Cluster | Expectations | Assessment | Focus/Task |
|---|---|---|---|
| 1 | EWV.01<br>EW1.01, 1.02, 1.03<br>SIS.06, .07, .08, .11<br>CGE 2c, 3c | **Knowledge** | Work and energy concepts:<br>• definitions<br>• mathematical problem solving |
| 2 | EWV.01, EWV.02<br>EW1.01, 1.03, 1.04, 1.05<br>EW2.01, 2.02, 2.03<br>SIS.01, .02, .03, .05, .06, .07, .08, .09, .10, .11<br>CGE 2c, 3c, 4f, 5ae | Knowledge<br>**Inquiry**<br>Communication | Energy transformations and power:<br>• experiments<br>• mathematical problem solving |
| 3 | EWV.01, EWV.02, EWV.03<br>EW1.03, 1.04, 1.05<br>EW2.01, 2.02, 2.03<br>EW3.02<br>SIS.01, .02, .03, .04, 09, .10, .12<br>CGE 2cd, 3c, 4f, 5ae | Knowledge<br>**Inquiry**<br>Communication<br>**Making Connections** | Efficiency of transformations of energy:<br>• experiments<br>• mathematical problem solving |
| 4 | EWV.03<br>EW1.04, 1.05<br>EW2.03<br>EW3.01<br>SIS.04, .05, .09, .11, .12<br>CGE 1d, 2de, 3c, 7dei | Knowledge<br>Inquiry<br>**Communication**<br>**Making Connections** | Societal and environmental issues:<br>• related to energy sources<br>• related to energy transformation |

## Unit 4: Waves and Sound

**Time**: 15 hours

**Unit Description**

Through experimentation and simulation students investigate the production, transmission and interactions of mechanical waves. Students demonstrate an understanding of sound as a wave and analyse resonance both qualitatively and quantitatively. Technological devices employing the principles of waves and sound are described by students and evaluated in terms of their enhancement of the quality of life. These wave properties are revisited again in the context of light and geometric optics.

**Unit Overview Chart**

| Cluster | Expectations | Assessment | Focus/Task |
|---|---|---|---|
| 1 | WSV.01, WSV.02<br>WS1.01, 1.02, 1.04<br>WS2.01<br>SIS.08, .09<br>CGE 2ab | **Knowledge**<br>Inquiry | Wave terminology and concepts:<br>• related to the motion of mechanical waves in different media<br>• experiments<br>• diagrams |
| 2 | WSV.02<br>WS1.03<br>WS2.02<br>WS3.02<br>SIS.01, .02, .03, .07, .10, .11<br>CGE 2ab, 5a | **Knowledge**<br>**Inquiry**<br>Making Connections | Sound as a wave:<br>• demonstrations<br>• experiments |
| 3 | WSV.03<br>WS1.04, 1.05, 1.06, 1.08<br>WS2.03<br>WS3.02<br>SIS.01, .02, .03, .06, .07, .10, .11<br>CGE 2c, 3c, 5a | **Knowledge**<br>**Inquiry**<br>Making Connections | Resonance:<br>• meaning of concept<br>• experiments |
| 4 | WSV.03<br>WS1.07, 1.08<br>WS2.03<br>WS3.01, 3.02,3.03<br>SIS.01, .02, .03, .04, .05, .12<br>CGE 2c, 3c, 4f, 5ab | Knowledge<br>Inquiry<br>Communication<br>**Making Connections** | Applications of waves and sound:<br>• demonstrations<br>• experiments<br>• research |

## Unit 5: Light and Geometric Optics

**Time:** 24 hours

**Unit Description**

The Light and Geometric Optics unit is designed to provide students with an opportunity to evaluate the contribution of optical devices in fields such as entertainment, communications, and health. The construction and testing of an optical device prototype is the final activity in the unit. The theoretical and practical framework needed to accomplish this project are developed in the first three groups of expectations. The properties of light along with natural phenomena are described using the scientific model for light propagation. Students analyse image formation with lenses in quantitative terms and through the use of ray diagrams. Students submit the prototype and prepare a discussion of the societal impact of the device as a component of the final evaluation. Students are encouraged to explore the symbolic use of "light" within their faith tradition and in scripture.

**Unit Overview Chart**

| Cluster | Expectations | Assessment | Focus/Task |
|---|---|---|---|
| 1 | LGV.01, .02<br>LG1.01, 1.03, 1.04<br>SIS.06, .07, .08<br>CGE 2b, 3c, 5a | **Knowledge** | Light Properties:<br>• demonstrations<br>• a scientific model for light |
| 2 | LGV.02<br>LG1.02, 2.01, 2.02, 2.04<br>SIS.01, .02, .03, .07, .09, .10, .11<br>CGE 2c, 3c | Knowledge<br>**Inquiry**<br>Communication | Explaining light:<br>• ray diagrams<br>• experiments |
| 3 | LGV.02<br>LG1.05, 1.06, 1.07, 2.02, 2.04<br>SIS.01, .02, .03, .05, .07, .09, .10, .11<br>CGE 2c, 3c, 5a | Knowledge<br>**Inquiry**<br>Communication | Effects of lenses:<br>• ray diagrams<br>• experiments |
| 4 | LGV.03<br>LG1.06, 2.05, 3.01, 3.02, 3.03<br>SIS.04, .05, .09, .12<br>CGE 2ce, 3ce, 4f, 5a | Knowledge<br>Inquiry<br>**Communication**<br>**Making Connections** | Applications of light:<br>• construction of an optical device<br>• research optical devices<br>• presentation of impact of optical devices on society |

## Teaching/Learning Strategies

Since this is a university preparation course, Teaching and Learning Strategies emphasize the theoretical aspects of the course content but also include concrete applications. 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.

An essential expectation of this course requires students to construct, test and refine models of optical and electromagnetic devices. It is important to teach students that model building involves a problem solving process similar to the scientific method. Students begin by brainstorming possible solutions to a practical problem. This is similar to making a hypothesis in an investigation. They then build a model of the proposed solution and test it to determine if it adequately solves the practical problem. This is similar to the experimentation stage of the scientific method. Once the testing is complete the model may be improved and tested again until a satisfactory result is achieved.

Faith implies that one interprets the realities and phenomena of this world as manifestations of the mystery of God, who created and sustains the universe. Writing reflections is a strategy that can help students raise their thoughts to this transcendental reality. The reflections notebook can also help students achieve some of the Catholic Graduate Expectations. In writing reflections, students should consider a "Learning/Valuing/Acting Model." "Learning" involves the students reflecting on what they have learned from the course, from reading newspapers, from watching television news shows or from their own experience with an issue. "Valuing" requires students to reflect on which Catholic values are important in dealing with the issue. "Acting" requires students to decide on a course of action, taking what they value and putting it into practice, using what they have learned.

This model promotes the importance of the need to act appropriately in light of what we know and what we value. In this way students are constantly challenging themselves about the social teachings of the Church and the importance of every individual's actions in working towards the common good. This model should be considered when dealing with issues of environmental stewardship, community, social justice and the wise use of resources. Whenever this model is suggested as the basis for a reflection, it will be referenced as the "Learning/Valuing/Acting Model".

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 of the Achievement Charts. Some strategies may be used to develop several types of understanding.

Expectations that require the development of knowledge/understanding may be developed through:

- Audio-visual presentations – films or videos viewed to illustrate concepts or examples that may be difficult to observe 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 their definition or other explanations of each symbol and its corresponding unit;
- Independent Study – students explore and research a topic of interest (an important component of the model building activity in unit 1 and 5);
- Notebook – a student collection of daily work, teacher handouts, and homework attempted and completed;
- 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 the development of inquiry skills may be developed through:

- Case Study – investigation of real and simulated problems provided by the teacher;
- Independent Study – students explore and research a topic of interest (an important component of the model building activity in unit 1 and 5);
- Lab Based Inquiry – students perform investigations in the laboratory under the supervision of the teacher;
- Model Building – students construct physical representations of electrical and optical devices.

Expectations that encourage the development of communication may be developed through:

- Conferencing – teacher to 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;
- Writing – student writing concerning issues raised in the course (particularly useful in considering issues such as stewardship, justice regarding the fair distribution of natural resources, and the need to invest fairly in Third World countries from a Catholic perspective; the "Learning/Valuing/Acting Model" should be used);
- 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 student's model building with reference to problems encountered, successes and refinements;
- Report/Presentation – an oral and/or written presentation of a researched topic to the class, 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 answer questions generated by students;
- Writing – student writing concerning issues raised in the course (particularly useful in considering issues such as stewardship, justice regarding the fair distribution of natural resources, and the need to invest fairly in Third World countries from a Catholic perspective; the "Learning/Valuing/Acting Model" should be used);
- Outreach – students are invited to contact local charitable organizations (St. Vincent de Paul Society, Salvation Army, Scarborough Missions etc.) to see if there is a need for used eye glasses or other technological devices such as computers that may be collected and donated to those who have limited access to such devices.

## 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 and Understanding; the Developing 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.

Assessment strategies should include the following:

Paper-and-Pencil Tasks (most suitable for assessing Knowledge/Understanding)

- quizzes
- tests
- lab reports

Performance Tasks (most suitable for assessing Inquiry and Making Connections)

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

Personal Communication (most suitable for assessing Communication)

- short written reports
- notebooks
- lab reports
- log books
- self assessment
- student-teacher conferences

Observation (most suitable for assessing Inquiry and Communication)

- formal/informal by teacher

Assessment tools include:

- checklists
- marking schemes
- rubrics
- anecdotal comments with suggestions for improvement

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 *Program Planning and Assessment 2000*, 70% of the student's course grade will be based on the assessments and evaluations conducted throughout the course and 30% will be based upon an examination, performance, essay and/or other method of evaluation suitable to the course content and administered towards the end of the course. The assessment and evaluation in this university preparation science course reflects the course emphasis on theoretical aspects of the content as well as the concrete applications. It is recommended that a final examination should be used as a component of the final evaluation along with the building and testing of a practical device. One of the two devices produced, along with their construction log and their report on the device and its societal implications, should be submitted for assessment. The final project submitted must be a refinement of the earlier work. The Final Examination should be evaluated for all four categories identified in the Achievement Chart. The construction log may be evaluated for inquiry and communication, the report on the device may be evaluated for knowledge/understanding, communication, and making connections and the actual device may be evaluated for knowledge/understanding and inquiry.

## Accommodations

Teachers must consider the needs of exceptional students in planning the delivery of the science curriculum. All students should be challenged according to their abilities. Accommodations to the program activities and/or to the environment may be necessary. Where the student has an Individual Education Plan (IEP) the course will be adapted to meet the student's needs as outlined in the plan. 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. 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. For additional specific suggestions for students with learning disabilities, visual impairment, or hearing impairment teachers should consult Appendix A4 of the Catholic Profile for the Grade 10 Locally Developed Course.

Enrichment possibilities should be considered. Students may be encouraged to read historical articles relating to the development of scientific theories or devices. They may also be encouraged to participate in a Science Fair, Science Olympics or other special events sponsored by colleges or universities that allow them to extend their work beyond the day to day and the ordinary.

## Resources

### Print

Various approved textbooks that exist for the previous Grade 12 and OAC physics courses can be consulted in order to determine proper procedures for science skill development as well as background knowledge for students. There will be new textbooks written by various publishers for this course. Teachers should consult them when they are available, however they should be aware that they may contain information beyond the range of the actual course expectations. Teachers should consult *The Ontario Curriculum, Grades 11 and 12: Science 2000* to be sure appropriate activities are pursued.

Science classrooms should also have a Bible available for reference. Teachers 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 Catholic Bible Publishers, Wichita, Kansas 1992.

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 *The Crucible* published by the Science Teachers Association of Ontario are useful sources of current information about physics and the teaching of physics.

Some useful textbook resources include the following:

Finley, M. *Let's Begin With Prayer*. Indiana: Ave Maria Press Inc., 1997. ISBN 0-87793-615-3

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

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 ed. 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

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

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

Various other print resources that teachers may wish to have available are identified in the unit developed in detail. Refer to the introduction to the developed unit for specific examples.

### Videotapes

*Beyond the Mechanical Universe* (1987) series of 26 videos available through Magic Lantern Communications Ltd.

*Energy and Society* (1995) available through Hawkhill Video

*Mechanical Universe: Introduction to Physics* (1985) series of 26 videos available through Magic Lantern Communications Ltd.

*Physics Demonstrations in Electricity and Magnetism* available through Physics Curriculum and Instruction

*Physics Demonstrations in Light* available through Physics Curriculum and Instruction

*Physics Demonstrations in Mechanics* available through Physics Curriculum and Instruction

*Physics Demonstrations in Sound and Waves* available through Physics Curriculum and Instruction

*Physics Essentials* (1996) series of 6 videos available through Magic Lantern Communications Ltd.

*Physics-The Basic Science* (1995) available through Hawkhill Video

*Physics: What Matters, What Moves* (1992) series of 6 videos available through Magic Lantern Communications Ltd.

### Computer Software

*Crocodile Physics* – simulations of various physics phenomena available through Spectrum Educational Supplies

*Data Studio* and related probes available through Merlan Scientific

*Interactive Physics* – a modeling and simulation program available from Tangent Scientific

### Internet Sites

American Association of Physics Teachers – www.aapt.org

American Physical Society – http://physicscentral.com

Catholic Information Network – www.cin.org/

How Stuff Works – www.howstuffworks.com/sports-physiology.htm

Multimedia Physics Studios – http://www.glenbrook.k12.il.us/gbssci/phys/mmediaindex.html#work

Physical Sciences Resource Center – www.psrc-online.org

Science Joy Wagon – www.sciencejoywagon.com/physicszone/

Science Teachers' Association of Ontario – www.stao.org

The Institute of Physics – http://physicsweb.org/resources

The Physics Teacher's Index – http://www.messiah.edu/hpages/facstaff/barrett/phy_ind.htm

### Models and Manipulatives

Electrical and magnetic devices, power supplies, voltmeters, ammeters, oscilloscopes, soldering irons, wire strippers, computers and relevant interfaces along with assorted laboratory equipment should be available in the classroom.

## 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 are required to complete 40 hours of community involvement activities prior to graduation. They should consult the Board's list of eligible Christian Service activities 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 and society.

In all classes teachers 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 11, University Preparation, SPH3U

## Scientific Investigation Skills

**SIS.01** · demonstrate an understanding of safety practices by selecting, operating, and storing equipment appropriately, and by acting in accordance with the Workplace Hazardous Materials Information System (WHMIS) legislation in selecting and applying techniques for handling, storing, and disposing of laboratory materials (e.g., check all electrical equipment for damage prior to conducting an experiment);

**SIS.02** · select appropriate instruments and use them effectively and accurately in collecting observations and data (e.g., collect data accurately using stopwatches, photogates, or data loggers);

**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., investigate the relationships among force, mass, and acceleration);

**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., interpret data, using graphs and graphical analysis techniques; explain, using a ray diagram, the operation of an optical instrument);

**SIS.06** · use appropriate scientific models (theories, laws, explanatory devices) to explain and predict the behaviour of natural phenomena (e.g., use the kinetic molecular theory of matter to explain thermal energy and its transfer [heat]); use ray diagrams to predict the location and nature of images created by lenses);

**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 (units of measurement of the *Système international d'unités*, or International System of 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, 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 with reference to experimental uncertainty;

**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., electrical engineer, computer technologist).

## Forces and Motion

### Overall Expectations

**FMV.01** · demonstrate an understanding of the relationship between forces and the acceleration of an object in linear motion;

**FMV.02** · investigate, through experimentation, the effect of a net force on the linear motion of an object, and analyse the effect in quantitative terms, using graphs, free-body diagrams, and vector diagrams;

**FMV.03** · describe the contributions of Galileo and Newton to the understanding of dynamics; evaluate and describe technological advances related to motion; and identify the effects of societal influences on transportation and safety issues.

## Specific Expectations

**Understanding Basic Concepts**

**FM1.01** – define and describe concepts and units related to force and motion (e.g., vectors, scalars, displacement, uniform motion, instantaneous and average velocity, uniform acceleration, instantaneous and average acceleration, applied force, net force, static friction, kinetic friction, coefficients of friction);

**FM1.02** – describe and explain different kinds of motion, and apply quantitatively the relationships among displacement, velocity, and acceleration in specific contexts;

**FM1.03** – analyse uniform motion in the horizontal plane in a variety of situations, using vector diagrams;

**FM1.04** – identify and describe the fundamental forces of nature;

**FM1.05** – analyse and describe the gravitational force acting on an object near, and at a distance from, the surface of the Earth;

**FM1.06** – analyse and describe the forces acting on an object, using free-body diagrams, and determine the acceleration of the object;

**FM1.07** – state Newton's laws, and apply them to explain the motion of objects in a variety of contexts;

**FM1.08** – analyse in quantitative terms, using Newton's laws, the relationships among the net force acting on an object, its mass, and its acceleration.

**Developing Skills of Inquiry and Communication**

**FM2.01** – design and carry out an experiment to identify specific variables that affect motion (e.g., conduct an experiment to determine the factors that affect the motion of an object sliding along a surface);

**FM2.02** – carry out experiments to verify Newton's second law of motion;

**FM2.03** – interpret patterns and trends in data by means of graphs drawn by hand or by computer, and infer or calculate linear and non-linear relationships among variables (e.g., analyse and explain the motion of objects, using displacement-time graphs, velocity-time graphs, and acceleration-time graphs);

**FM2.04** – analyse the motion of objects, using vector diagrams, free-body diagrams, uniform acceleration equations, and Newton's laws of motion.

**Relating Science to Technology, Society, and the Environment**

**FM3.01** – explain how the contributions of Galileo and Newton revolutionized the scientific thinking of their time and provided the foundation for understanding the relationship between motion and force;

**FM3.02** – evaluate the design of technological solutions to transportation needs and, using scientific principles, explain the way they function (e.g., evaluate the design, and explain the operation of, airbags in cars, tread patterns on car tires, or braking systems);

**FM3.03** – analyse and explain the relationship between an understanding of forces and motion and an understanding of political, economic, environmental, and safety issues in the development and use of transportation technologies (including terrestrial and space vehicles) and recreation and sports equipment.

## Energy, Work, and Power

### Overall Expectations

**EWV.01** · demonstrate an understanding, in qualitative and quantitative terms, of the concepts of work, energy (kinetic energy, gravitational potential energy, and thermal energy and its transfer [heat]), energy transformations, efficiency, and power;

**EWV.02** · design and carry out experiments and solve problems involving energy transformations and the law of conservation of energy;

**EWV.03** · analyse the costs and benefits of various energy sources and energy-transformation technologies that are used around the world, and explain how the application of scientific principles related to mechanical energy has led to the enhancement of sports and recreational activities.

### Specific Expectations

**Understanding Basic Concepts**

**EW1.01** – define and describe the concepts and units related to energy, work, and power (e.g., energy, work, power, gravitational potential energy, kinetic energy, thermal energy and its transfer [heat], efficiency);

**EW1.02** – identify conditions required for work to be done, and apply quantitatively the relationships among work, force, and displacement along the line of the force;

**EW1.03** – analyse, in qualitative and quantitative terms, simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat), using the law of conservation of energy;

**EW1.04** – apply quantitatively the relationships among power, energy, and time in a variety of contexts;

**EW1.05** – analyse, in quantitative terms, the relationships among per-cent efficiency, input energy, and useful output energy for several energy transformations.

**Developing Skills of Inquiry and Communication**

**EW2.01** – design and carry out experiments related to energy transformations, identifying and controlling major variables (e.g., design and carry out an experiment to identify the energy transformations of a swinging pendulum, and to verify the law of conservation of energy; design and carry out an experiment to determine the power produced by a student);

**EW2.02** – analyse and interpret experimental data or computer simulations involving work, gravitational potential energy, kinetic energy, thermal energy and its transfer (heat), and the efficiency of the energy transformation (e.g., experimental data on the motion of a swinging pendulum or a falling or sliding mass in terms of the energy transformations that occur);

**EW2.03** – communicate the procedures, data, and conclusions of investigations involving work, mechanical energy, power, thermal energy and its transfer (heat), and the law of conservation of energy, using appropriate means (e.g., oral and written descriptions, numerical and/or graphical analyses, tables, diagrams).

**Relating Science to Technology, Society, and the Environment**

**EW3.01** – analyse, using their own or given criteria, the economic, social, and environmental impact of various energy sources (e.g., wind, tidal flow, falling water, the sun, thermal energy and its transfer [heat]) and energy-transformation technologies (e.g., hydroelectric power plants and energy transformations produced by other renewable sources, fossil fuel, and nuclear power plants) used around the world;

**EW3.02** – analyse and explain improvements in sports performance, using principles and concepts related to work, kinetic and potential energy, and the law of conservation of energy (e.g., explain the importance of the initial kinetic energy of a pole vaulter or high jumper).

## Waves and Sound

### Overall Expectations

**WSV.01** · demonstrate an understanding of the properties of mechanical waves and sound and the principles underlying the production, transmission, interaction, and reception of mechanical waves and sound;

**WSV.02** · investigate the properties of mechanical waves and sound through experiments or simulations, and compare predicted results with actual results;

**WSV.03** · describe and explain ways in which mechanical waves and sound are produced in nature, and evaluate the contributions to entertainment, health, and safety of technologies that make use of mechanical waves and sound.

### Specific Expectations

**Understanding Basic Concepts**

**WS1.01** – define and describe the concepts and units related to mechanical waves (e.g., longitudinal wave, transverse wave, cycle, period, frequency, amplitude, phase, wavelength, velocity, superposition, constructive and destructive interference, standing waves, resonance);

**WS1.02** – describe and illustrate the properties of transverse and longitudinal waves in different media, and analyse the velocity of waves travelling in those media in quantitative terms;

**WS1.03** – compare the speed of sound in different media, and describe the effect of temperature on the speed of sound;

**WS1.04** – explain and graphically illustrate the principle of superposition, and identify examples of constructive and destructive interference;

**WS1.05** – analyse the components of resonance and identify the conditions required for resonance to occur in vibrating objects and in various media;

**WS1.06** – identify the properties of standing waves and, for both mechanical and sound waves, explain the conditions required for standing waves to occur;

**WS1.07** – explain the Doppler effect, and predict in qualitative terms the frequency change that will occur in a variety of conditions;

**WS1.08** – analyse, in quantitative terms, the conditions needed for resonance in air columns, and explain how resonance is used in a variety of situations (e.g., analyse resonance conditions in air columns in quantitative terms, identify musical instruments using such air columns, and explain how different notes are produced).

**Developing Skills of Inquiry and Communication**

**WS2.01** – draw, measure, analyse, and interpret the properties of waves (e.g., reflection, diffraction, and interference, including interference that results in standing waves) during their transmission in a medium and from one medium to another, and during their interaction with matter;

**WS2.02** – design and conduct an experiment to determine the speed of waves in a medium, compare theoretical and empirical values, and account for discrepancies;

**WS2.03** – analyse, through experimentation, the conditions required to produce resonance in vibrating objects and/or in air columns (e.g., in string instruments, tuning forks, wind instruments), predict the conditions required to produce resonance in specific cases, and determine whether the predictions are correct through experimentation.

**Relating Science to Technology, Society, and the Environment**

**WS3.01** – describe how knowledge of the properties of waves is applied in the design of buildings (e.g., with respect to acoustics) and of various technological devices (e.g., musical instruments, audio-visual and home entertainment equipment), as well as in explanations of how sounds are produced and transmitted in nature, and how they interact with matter in nature (e.g., how organisms produce or receive infrasonic, audible, and ultrasonic sounds);

**WS3.02** – evaluate the effectiveness of a technological device related to human perception of sound (e.g., hearing aid, earphones, cell phone), using given criteria;

**WS3.03** – identify sources of noise in different environments (e.g., traffic noise in neighbourhoods adjacent to highways), and explain how such noise can be reduced to acceptable levels (e.g., noise can be reduced by the erection of highway noise barriers or the use of protective headphones).

## Light and Geometric Optics

### Overall Expectations

**LGV.01** · demonstrate an understanding of the properties of light and the principles underlying the transmission of light through a medium and from one medium to another;

**LGV.02** · investigate the properties of light through experimentation, and illustrate and predict the behaviour of light through the use of ray diagrams and algebraic equations;

**LGV.03** · evaluate the contributions to such areas as entertainment, communications, and health made by the development of optical devices and other technologies designed to make use of light.

### Specific Expectations

**Understanding Basic Concepts**

**LG1.01** – define and describe concepts and units related to light (e.g., reflection, refraction, partial reflection and refraction, index of refraction, total internal reflection, critical angle, focal point, image);

**LG1.02** – describe the scientific model for light and use it to explain optical effects that occur as natural phenomena (e.g., apparent depth, shimmering, mirage, rainbow);

**LG1.03** – predict, in qualitative and quantitative terms, the refraction of light as it passes from one medium to another, using Snell's law;

**LG1.04** – explain the conditions required for total internal reflection, using light-ray diagrams, and analyse and describe situations in which these conditions occur;

**LG1.05** – describe and explain, with the aid of light-ray diagrams, the characteristics and positions of the images formed by lenses;

**LG1.06** – describe the effects of converging and diverging lenses on light, and explain why each type of lens is used in specific optical devices;

**LG1.07** – analyse, in quantitative terms, the characteristics and positions of images formed by lenses.

**Developing Skills of Inquiry and Communication**

**LG2.01** – demonstrate and illustrate, using light-ray diagrams, the refraction, partial refraction and reflection, critical angle, and total internal reflection of light at the interface of a variety of media;

**LG2.02** – carry out an experiment to verify Snell's law;

**LG2.03** – predict, using ray diagrams and algebraic equations, the image position and characteristics of a converging lens, and verify the predictions through experimentation;

**LG2.04** – carry out experiments involving the transmission of light, compare theoretical predictions and empirical evidence, and account for discrepancies (e.g., given the index of refraction, predict and verify the critical angle of incidence of a substance; given the focal length of a lens, predict and verify the position and characteristics of an image);

**LG2.05** – construct, test, and refine a prototype of an optical device (e.g., construct at least one of the following: telescope, microscope, binoculars, periscope, device producing a mirage or a shimmering effect).

**Relating Science to Technology, Society, and the Environment**

**LG3.01** – describe how images are produced and reproduced for the purposes of entertainment and culture (e.g., in movie theatres, in audio-visual and home entertainment equipment, in optical illusions);

**LG3.02** – evaluate, using given criteria, the effectiveness of a technological device or procedure related to human perception of light (e.g., eyeglasses, contact lenses, virtual reality "glasses", infra-red or low light vision sensors, laser surgery);

**LG3.03** – analyse, describe, and explain optical effects that are produced by technological devices (e.g., periscopes, binoculars, optical fibres, retro-reflectors, cameras, telescopes, microscopes, overhead projectors).

## Electricity and Magnetism

### Overall Expectations

**EMV.01** · demonstrate an understanding of the properties, physical quantities, principles, and laws related to electricity, magnetic fields, and electromagnetic induction;

**EMV.02** · carry out experiments or simulations, and construct a prototype device, to demonstrate characteristic properties of magnetic fields and electromagnetic induction;

**EMV.03** · identify and describe examples of domestic and industrial technologies that were developed on the basis of the scientific understanding of magnetic fields.

### Specific Expectations

**Understanding Basic Concepts**

**EM1.01** – define and describe the concepts and units related to electricity and magnetism (e.g., electric charge, electric current, electric potential, electron flow, magnetic field, electromagnetic induction, energy, power, kilowatt-hour);

**EM1.02** – describe the two conventions used to denote the direction of movement of electric charge in an electric circuit (i.e., electric current [movement of positive charge] and electron flow [movement of negative charge]), recognizing that electric current is the preferred convention;

**EM1.03** – describe the properties, including the three-dimensional nature, of magnetic fields;

**EM1.04** – describe and illustrate the magnetic field produced by an electric current in a long straight conductor and in a solenoid;

**EM1.05** – analyse and predict, by applying the right-hand rule, the direction of the magnetic field produced when electric current flows through a long straight conductor and through a solenoid;

**EM1.06** – state the motor principle, explain the factors that affect the force on a current-carrying conductor in a magnetic field, and, using the right-hand rule, illustrate the resulting motion of the conductor;

**EM1.07** – analyse and describe electromagnetic induction in qualitative terms, and apply Lenz's law to explain, predict, and illustrate the direction of the electric current induced by a changing magnetic field, using the right-hand rule;

**EM1.08** – compare direct current (DC) and alternating current (AC) in qualitative terms, and explain the importance of alternating current in the transmission of electrical energy;

**EM1.09** – explain, in terms of the interaction of electricity and magnetism, and analyse in quantitative terms, the operation of transformers (e.g., describe the basic parts and the operation of step-up and step-down transformers; solve problems involving energy, power, potential difference, current, and the number of turns in the primary and secondary coils of a transformer).

**Developing Skills of Inquiry and Communication**

**EM2.01** – conduct an experiment to identify the properties of magnetic fields (e.g., use magnetic compasses and iron filings to identify the properties of magnetic fields), and describe the properties that they find;

**EM2.02** – interpret and illustrate, on the basis of experimental data, the magnetic field produced by a current flowing in a long straight conductor and in a coil;

**EM2.03** – conduct an experiment to identify the factors that affect the magnitude and direction of the electric current induced by a changing magnetic field;

**EM2.04** – construct, test, and refine a prototype of a device that operates using the principles of electromagnetism (e.g., construct an operating prototype of one of the following devices: electric bell, loudspeaker, ammeter, electric motor, electric generator).

**Relating Science to Technology, Society, and the Environment**

**EM3.01** – analyse and describe the operation of industrial and domestic technological systems based on principles related to magnetic fields (e.g., electric motors, electric generators, components in home entertainment systems, computers, doorbells, telephones, credit cards);

**EM3.02** – describe the historical development of technologies related to magnetic fields (e.g., electric motors and generators, cathode ray [TV] tubes, medical equipment, loudspeakers, magnetic information storage).

## 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 3: Energy, Work, and Power

**Time:** 22 hours

## Unit Description

The qualitative and quantitative aspects of work and energy are examined with particular reference to the electrical devices studied in Unit 1. Students investigate the concept of energy conservation in more detail in order to compare the costs and benefits of various energy sources and energy transformation technologies. This provides them with an opportunity to reflect on the need for energy conservation in a world that has a disproportionate amount of energy used by a small segment of the world's population. Students compare the energy consumption of a Canadian city compared to that of a similar city in a developing country. The issue of stewardship and the distribution of wealth among the nations of the world is discussed. The transfer of energy through wave motion is then further studied in the next unit.

## Unit Synopsis Chart

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

| Activity | Time | Expectations | Assessment | Task (Strategy) |
|---|---|---|---|---|
| 1. **Energy and Work** | 195 min. | EWV.01<br>EW1.01, 1.02, 1.03<br>SIS.06, .07, .08, .11<br>CGE 2c, 3c | **Knowledge** | • Teacher-directed lessons<br>• Student work stations<br>• Vocabulary list<br>• Mathematical problem solving |
| 2. **Investigating Energy Transformations**<br>2.1 Energy Transformations and Conservation<br>2.2 Power and Efficiency<br>2.3 An Investigation of Energy Conservation and Efficiency | 375 min. | EWV.01, EWV.02<br>EW1.01, 1.03, 1.04, 1.05<br>EW2.01, 2.02, 2.03<br>SIS.01, .02, .03, .05, .06, .07, .08, .09, .10, .11<br>CGE 2c, 3c, 4f, 5ae | Knowledge<br>**Inquiry**<br>Communication | • Teacher demonstrations<br>• Student investigations<br>• Mathematical problem solving |

| | | | | |
|---|---|---|---|---|
| 3. **Energy Transformations in Sports**<br>3.1 Investigating the Human "Machine"<br>3.2 Energy Transformations in Sport<br>3.3 Technology and Performance in Sport | 375 min. | EWV.01, EWV.02, EWV.03<br>EW1.03, 1.04, 1.05<br>EW2.01, 2.02, 2.03<br>EW3.02<br>SIS.01, .02, .03, .04, .09, .10, .12<br>CGE 2cd, 3c, 4f, 5ae | Knowledge<br>**Inquiry**<br>Communication<br>**Making Connections** | • Student investigations<br>• Student research<br>• Audio-visual presentations<br>• Case study<br>• Mathematical problem solving |
| 4. **Catholic Symposium on Energy Resources and Technologies** | 375 min. | EWV.03<br>EW1.04, 1.05<br>EW2.03<br>EW3.01<br>SIS.04, .05, .09, .11, .12<br>CGE 1d, 2de, 3c, 7dei | Knowledge<br>Inquiry<br>**Communication**<br>**Making Connections** | • Student research<br>• Audio-visual presentations<br>• Independent study<br>• Reflections<br>• Student conference |

## Activity 1: Energy and Work

**Time:** 195 minutes

### Description

Students investigate different forms of energy and determine the conditions for physical work to be done. Students apply the formulae for work, gravitational potential energy and kinetic energy to various problems in order to understand the connection between work and energy.

### Strand(s) & Learning Expectations

**Strand(s):** Energy, Work, and Power

**Overall Expectations**

EWV.01 - demonstrate an understanding, in qualitative and quantitative terms, of the concepts of work, energy (kinetic energy, gravitational potential energy, and thermal energy and its transfer [heat]), energy transformations, efficiency, and power.

**Specific Expectations**

EW1.01 - define and describe the concepts and units related to energy, work, and power;
EW1.02 - identify conditions required for work to be done, and apply quantitatively the relationship among work, force, and displacement along the line of the force;
EW1.03 - analyse, in qualitative and quantitative terms, simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat), using the law of conservation of energy.

**Scientific Investigation Skills**

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 (units of measurement of the *Système international d'unités*, or International System of Units), and apply unit analysis techniques when solving problems;
SIS.11 - express the results of any calculation involving experimental data to the appropriate number of decimal places or significant figures.

**Ontario Catholic School Graduate Expectations**
CGE2c - presents information and ideas clearly and honestly and with sensitivity to others.
CGE3c - thinks reflectively and creatively to evaluate situations and solve problems.

## Prior Knowledge & Skills

- Grade 5: Energy and Control – Conservation of Energy
- Grade 7: Energy and Control – Heat

## Planning Notes

- A number of stations are set up to highlight various forms of energy and to demonstrate that work is required to change the energy of an object. These stations should include (but are not limited to) the following:
  - a block of wood and a piece of sandpaper (to demonstrate thermal energy and sound energy)
  - a heavy mass (raised to different heights by the students to demonstrate gravitational potential energy)
  - a toy car (pushed by a force to demonstrate kinetic energy)
  - elastic bands and springs (to demonstrate elastic energy stored in certain objects)
  - a drum (to demonstrate sound energy)
  - a hand operated electric generator connected to a light bulb (to demonstrate electrical energy being converted to radiant energy)
  - a battery (to demonstrate chemical energy being converted to electrical energy)
  - a match (teacher demonstration only to demonstrate chemical potential energy being transferred into radiant energy, thermal energy and sound energy)
- A handout should be prepared that defines the various forms of energy that the students will encounter as they rotate through the stations.
- The inclusion of the hand operated generator and the transfer of electrical energy into another form is a continuation from Unit 1 (Electricity and Magnetism). The generation of electrical energy is the basis for the student's research of different forms of energy production (Activity 4 in this unit).
- When discussing thermal energy and its transfer (heat) the principles of the kinetic molecular theory of matter should be incorporated, i.e., hot particles move faster and travel farther than cold particles; temperature as a measure of the average thermal energy should also be discussed.
- In Activity 4 of this unit, students host an in-class symposium on the social, economic, and environmental aspects of various types of energy production technologies. The students should be assigned to specific groups during Activity 1 in preparation for this symposium.

## Teaching/Learning Strategies

The teacher:

- prepares a number of stations around the room where students will investigate the various forms of energy and how work is required to change the energy of an object;
- prepares a handout that defines the various forms of energy;
- places the students into groups of three that will rotate through all of the stations;
- assists students with the understanding of the various forms of energy evident at the stations;
- leads a whole class discussion to summarize the findings of the groups;

- introduces the principles of the kinetic molecular theory of matter in the discussion of thermal energy and its transfer (heat);
- demonstrates, by tossing a basketball, that an object may have two types of energy at the same time;
- introduces the concept of work, in appropriate units, and establishes the conditions for work to be done on an object;
- demonstrates proper problem solving techniques (stressing the use of free-body diagrams and the conditions for work) to solve problems involving work;
- further develops the concepts of gravitational potential energy and kinetic energy by introducing the formulae (and appropriate units) associated with these forms of energy;
- demonstrates proper problem solving techniques to solve problems involving gravitational potential energy and kinetic energy;
- prepares a quiz involving work and energy;
- administers and assesses the quiz.

Students:

- rotate through the various stations and record their findings on the handout;
- participate in the whole class discussion by sharing their results and observations;
- further develop their problem solving techniques by solving problems involving work, gravitational potential energy and kinetic energy.

### Assessment & Evaluation of Student Achievement

- A paper-and-pencil task (e.g. quiz) may be assessed for knowledge and understanding using a marking scheme (EW1.01, EW1.02, EW1.03, SIS.07, SIS.08, SIS.11).

### Accommodations

- See the Course Overview for general accommodations.
- Possible enrichment activities:
  - Research the form of energy stored in the nucleus of an atom (Nuclear Energy);
  - Research the role of Rest Mass Energy in nuclear power plants.

### Resources

**Print**

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

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

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

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

## Activity 2: Investigating Energy Transformations

**Time:** 375 minutes

### Description

Students investigate energy transformations, power and efficiency. Demonstrations, group work and classroom discussions are used to develop the concepts and problem solving skills. Students design and perform an experiment to test the theory developed in the first part of the activity.

### Strand(s) & Learning Expectations

**Strand(s):** Energy, Work, and Power

**Overall Expectations**

EWV.01 - demonstrate an understanding, in qualitative and quantitative terms, of the concepts of work, energy (kinetic energy, gravitational potential energy, and thermal energy and its transfer [heat]), energy transformations, efficiency, and power;
EWV.02 - design and carry out experiments and solve problems involving energy transformations and the law of conservation of energy.

**Specific Expectations**

EW1.01 - define and describe the concepts and units related to energy, work, and power;
EW1.03 - analyse, in qualitative and quantitative terms, simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat), using the law of conservation of energy;
EW1.04 - apply quantitatively the relationships among power, energy, and time in a variety of contexts;
EW1.05 - analyse, in quantitative terms, the relationships among per-cent efficiency, input energy, and useful output energy for several energy transformations;
EW2.01 - design and carry out experiments related to energy transformations, identifying and controlling major variables;
EW2.02 - analyse and interpret experimental data or computer simulations involving work, gravitational potential energy, kinetic energy, thermal energy and its transfer (heat), and the efficiency of the energy transformation;
EW2.03 - communicate the procedures, data, and conclusions of investigations involving work, mechanical energy, power, thermal energy and its transfer (heat), and the law of conservation of energy, using appropriate means.

**Scientific Investigation Skills**

SIS.01 - demonstrate an understanding of safety practices by selecting, operating, and storing equipment appropriately, and by acting in accordance with the Workplace Hazardous Materials Information System (WHMIS) legislation in selecting and applying techniques for handling, storing, and disposing of laboratory;
SIS.02 - select appropriate instruments 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.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 (units of measurement of the *Système international d'unités*, or International System of Units), and apply unit analysis techniques when solving problems;

SIS.09 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation;
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 with reference to experimental uncertainty;
SIS.11 - express the result of any calculation involving experimental data to the appropriate number of decimal places or significant figures.

**Ontario Catholic School Graduate Expectations**
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 4f - applies effective communication, decision-making, problem-solving, time and resource management skills;
CGE 5a - works effectively as an interdependent team member;
CGE 5e - respects the rights and responsibilities and contributions of self and others.

## Prior Knowledge & Skills

- Grade 5: Energy and Control – Conservation of Energy
- Grade 7: Energy and Control – Heat
- Grade 8: Structures and Mechanisms – Mechanical Efficiency

## Planning Notes

- Prepare a demonstration of real life examples of energy transformations.
- Prepare a demonstration using various devices that use energy at different rates. Calculate the energy used, the energy given off (or produced) and estimate the efficiency of the transformation. Write an information sheet for each device.
- Have a variety of materials present that could be applied to the investigation of energy transformations e.g., ramps, air tracks, gliders, objects to roll or slide down the ramps, pendulum bobs, masses and pulleys.
- Ensure that measuring devices and recording timers or stop watches are available.
- If possible, use graphing calculators and Calculator Based Rangers (CBRs) motion detectors.

## Teaching/Learning Strategies

### Activity 2.1: Energy Transformations and Conservation

The teacher:

- introduces the concept of energy transformation through a demonstration (e.g., a tennis ball dropped from a height);
- reviews the type of energy discussed in Activity 1;
- divides the students into small groups and provides each group with a real life example of an energy transformation to be analysed on the basis of energy types before, during and after the transformation, e.g., a car rolling down a hill, a pendulum swinging, a falling object, a person lifting a mass, a car being pushed on a flat surface;
- ensures that a representative from each group presents his/her group's analysis to the class;
- introduces the concept of total energy through one of the examples given to the students;
- introduces the concept that a relationship or law governs energy transformations; asks students to analyse their example on the basis of the amount of total energy before, during and after the energy transformation in order to illustrate the possible relationship;
- leads a discussion on the results of the previous analysis and presents the students with the law of energy conservation;

- provides a variety of worked examples of the law of energy conservation applied to simple situations (e.g., a roller coaster problem);
- outlines a common approach to problem solving using conservation of energy.

Students:

- discuss with their groups the example presented to them on the basis of energy transformations;
- choose a student to present their analysis to the class;
- analyse, with their groups, the example on the basis of total energy;
- apply the law of energy conservation to worked examples and problems presented.

### Activity 2.2: Power and Efficiency

The teacher:

- introduces power as a rate of energy consumed by a device through a demonstration (e.g., light bulbs of different power ratings);
- introduces the mathematical relationship and units for power;
- leads a discussion about energy input and energy output using a device as an example;
- introduces the concept of efficiency and outlines how students would make an estimate of efficiency for a device;
- divides the students into groups; has each group analyse a different device that uses energy (each device should have an information sheet with the needed facts for the analysis; the analysis should be based on the following criteria: a calculation of the energy used by the device and a method to estimate the efficiency of the device based upon the energy input and the energy output, e.g., calculate the energy input for a hair dyer for a 5 minute time interval, estimate of the energy output and then calculate the efficiency);
- conferences with the groups to insure that the analysis is being carried out based on the given criteria;
- provides a set of worked example problems consisting of calculations for power and efficiency;
- assesses the students on the analysis of their device through their group analysis and individual quiz;
- emphasises the need for responsible stewardship to avoid the waste of natural resources.

Students:

- analyse in groups a device on the basis of power and efficiency;
- submit a summary sheet of their analysis for assessment, one per group;
- apply the mathematical relationships for power and efficiency through worked examples and other problems;
- write an individual quiz to demonstrate their knowledge/understanding of efficiency calculations.

### Activity 2.3: An Investigation of Energy Conservation and Efficiency

The teacher:

- reviews the concepts of work, energy, conservation of energy and efficiency;
- outlines a method for the design of an experiment that will investigate the conservation of energy, the loss of energy to heat and the efficiency of an energy transformation;
- reviews appropriate use of the equipment available and experimental techniques used for the measurement of the quantities needed for the analysis;
- reviews the analysis of uncertainty in measurement and calculations;
- provides a list of equipment that will be made available to the students;
- divides the students into small groups to design an experiment that will allow them to measure energy conservation, loss of energy to heat and efficiency of an energy transformation;
- conferences with the groups to assess their plans and ensures the design will accomplish the expectations and be safe to perform;

- assesses each group's plan in their logbook;
- supplies each group with the equipment requested;
- meets with each group while they are conducting their experiment to answer questions regarding the operation of equipment and the recording of data;
- reviews the format of the lab report with students and outlines the specific criteria that will be used to assess the report.

Students:

- contribute to the design of an experiment to measure conservation of energy, loss of energy to heat and efficiency of an energy transformation;
- modify plans and refine the design if needed after conference with the teacher;
- submit a design for the experiment to be assessed in their logbooks;
- perform the experiment, measure the quantities needed for the analysis;
- analyse the results of the experiment;
- complete a lab report and submit for evaluation; answering the following discussion questions in the report: What factors contributed to the loss of energy in your design? How could this loss of energy be limited?
- write a lab quiz to demonstrate their knowledge/understanding of the lab procedure, lab analysis and the results.

### Assessment & Evaluation of Student Achievement

- Individual student lab performance may be assessed for knowledge/understanding and inquiry using a laboratory skills checklist. (EW2.01, SIS.01, SIS.02, SIS.03)
- Group lab design can be assessed for inquiry using a laboratory design checklist. (EW2.01)
- Lab reports may be assessed and evaluated for knowledge/understanding, inquiry and communication using a lab report rubric. (EW2.02, EW2.03, SIS.03, SIS.09, SIS.10)
- Lab quiz may be assessed and evaluated for knowledge/understanding, inquiry and communication using a marking scheme. (EW2.02, EW2.03, SIS.03, SIS.09, SIS.10)
- Individual problem solving skills may be evaluated using a paper and pencil quiz based upon data provided for another device. (EW1.04, EW1.05, SIS.07, SIS.08, SIS.11)

### Accommodations

- See the Course Overview for general accommodations.
- Possible enrichment activities:
  - Research the history of the law of energy conservation;
  - Research some examples of attempts at perpetual motion machines.

### Resources

**Print**

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

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

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

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

**Video**
*Energy - The Pulse of Life Series*. Cambridge Educational 1994 (available through McIntyre Media)
*Renewable Power: Earth's Clean Energy Destiny*. Video Project 1996 (available through McNabb & Connolly)

## Activity 3: Energy Transformations in Sports

**Time:** 375 minutes

### Description

This activity includes an investigation of the power developed by a student in a chosen situation. The students will analyse some simple energy transformations in sport then select a sport for a more detailed study. The final product of this study will be a poster presentation. The presentation will show how technology has made an impact on performance in a sport.

### Strand(s) & Learning Expectations

**Strand(s):** Energy, Work, and Power

**Overall Expectations**

EWV.01 - demonstrate an understanding, in qualitative and quantitative terms, of the concepts of work, energy (kinetic energy, gravitational potential energy, and thermal energy and its transfer [heat]), energy transformations, efficiency, and power;
EWV.02 - design and carry out experiments and solve problems involving energy transformations and the law of conservation of energy;
EWV.03 - analyse the costs and benefits of various energy sources and energy-transformation technologies that are used around the world, and explain how the application of scientific principles related to mechanical energy has led to the enhancement of sports and recreation activities.

**Specific Expectations**

EW1.03 - analyse, in qualitative and quantitative terms, simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat), using the law of conservation of energy;
EW1.04 - apply quantitatively the relationships among power, energy, and time in a variety of contexts;
EW1.05 - analyse, in quantitative terms, the relationships among per-cent efficiency, input energy, and useful output energy for several energy transformations;
EW2.01 - design and carry out experiments related to energy transformations, identifying and controlling major variables;
EW2.02 - analyse and interpret experimental data or computer simulations involving work, gravitational potential energy, kinetic energy, thermal energy and its transfer (heat), and the efficiency of the energy transformation;
EW2.03 - communicate the procedures, data, and conclusions of investigations involving work, mechanical energy, power, thermal energy and its transfer (heat), and the law of conservation of energy, using appropriate means;
EW3.02 - analyse and explain improvements in sports performance, using principles and concepts related to work, kinetic and potential energy, and the law of conservation of energy.

**Scientific Investigation Skills**

SIS.01 - demonstrate an understanding of safety practices by selecting, operating, and storing equipment appropriately, and by acting in accordance with the Workplace Hazardous Materials Information System (WHMIS) legislation in selecting and applying techniques for handling, storing, and disposing of laboratory materials;

SIS.02 - select appropriate instruments 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.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.09 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation;
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 with reference to experimental uncertainty; 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.

**Ontario Catholic School Graduate Expectations**
CGE 2c - presents information and ideas clearly and honestly and with sensitivity to others;
CGE 2d - writes and speaks fluently in one or both of Canada's official languages.
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.
CGE 5a - works effectively as an interdependent team member;
CGE 5e - respects the rights and responsibilities and contributions of self and others.

## Prior Knowledge & Skills

- Ability to collect information (written and numerical) from a variety of sources for use in a report/presentation;
- skills in the use of the Internet and CD ROM;
- the ability to reference sources using an acceptable format;
- communication of ideas in a poster format;
- creating data tables.

## Planning Notes

- Prepare the demonstration for power developed by a human and a quiz involving energy use in the human body.
- Ensure that measuring devices and stop watches are available.
- Prepare a demonstration and real life examples of energy transformations in sports.
- Book library/computer time for one period to allow time for research.
- Collect and make available print resources such as articles from periodicals and coaching manuals.
- Assign the students to heterogeneous groups to allow all students to contribute to the task.
- Prepare a sample information sheet to be used as a model for students.
- Remind the students of the ethical use of information sources including the Internet.
- Provide opportunities for feedback.

## Teaching/Learning Strategies

### Activity 3.1: Investigating the Human "Machine"

The teacher:

- leads the class as they answer a true/false quiz involving facts about the human body relating to energy and motion e.g., the average efficiency of a muscle converting chemical potential energy to mechanical energy is 24%, a nerve impulse can travel as fast as 120 m/s, there are 100 000 km of blood vessels in an adult body;
- introduces the concept of power developed by a human through a demonstration and calculation, e.g., the power developed while climbing stairs or lifting weights;
- determines the specific lab groups;
- outlines possible options for experimental design to compare the power developed by a human in two different actions;
- outlines the criteria for assessment of the final lab report and group work;
- meets with each group of students as they conduct the experiment to ensure safe and proper use of equipment and recording of information;
- assesses each student's work habits during the investigation.

Students:

- determine two possible options to measure and compare the power developed by a human;
- perform the investigation;
- calculate the power developed in each situation;
- complete individual lab reports, outlining their results and considering the following questions: Which muscle groups were used in each situation? Which situation would result in exhaustion first? Which muscles are capable of producing the greatest power?

### Activity 3.2: Energy Transformations in Sport

The teacher:

- presents the class with a numerical example of a transformation of energy from sport (e.g., a high jumper converting kinetic energy into potential energy);
- outlines the solution to the example, given a set of initial conditions (e.g., mass of jumper, initial velocity, initial height);
- divides the students into groups and provides each group an energy transformation in sport to analyse on the basis of types and amounts of energy before and after the transformation, e.g., What initial velocity is needed for a pole vaulter to clear a given height?;
- leads the class in a discussion of the results of each groups analysis;
- introduces the concept that technology plays a role in sport performance.

Students:

- work in groups to analyse a given example of an energy transformation in sport;
- present their results in a teacher led discussion.

### Activity 3.3: Technology and Performance in Sport

The teacher:

- introduces an example of a technological advancement that has changed performance in a sport (e.g., the dimples on a golf ball, fibreglass poles used for the pole vault);
- outlines the expectations for the poster project through an assignment criteria worksheet;
- divides the students into groups;
- provides a choice of sports that students may select for their presentations;
- insures that each member of the group will make a specific contribution that may be evaluated;
- conferences with students regarding appropriate level of detail for the study.

Students:

- meet with their group and select a topic;
- fill out a group work form regarding the roles of group members and the timetable for those goals;
- conduct research for the poster presentation and information sheet (this will be distributed to the class during the group's presentation);
- prepare a poster and information sheet to be used for a presentation including: a diagram outlining the types of energy and transformations involved in the sport; a time line for advancements in performance in their chosen sport; a description of the technological advancement and how it is used to make an energy transformation more efficient than previous technology (this can include a change in technique as well as equipment);
- present their project to the class.

### Assessment & Evaluation of Student Achievement

- Individual student lab performance may be evaluated for Knowledge/Understanding and Inquiry using a laboratory skills checklist. (EW2.01, EW 2.02, EW2.03, SIS.02, SIS.03)
- Student Knowledge/Understanding of energy transformations in sports may be assessed by means of conferencing with the teacher. (EW2.03, EW3.02)
- Student contribution to the group may be assessed by means of a collaboration checklist. (SIS.09)
- Student poster and presentation may be evaluated for Knowledge/Understanding, Communication and Making Connections by means of a presentation rubric. (EW1.03, EW2.03, EW3.02, SIS.10)

### Accommodations

- See the Course Overview for general accommodations.
- Possible enrichment activities:
  - students may produce a videotape or a multi-media presentation instead of a poster.

### Resources

Blaser, Mark and Jamie Larsen. "Footwear Physics." *Science Teacher*, V. 63 (May 1996): 36-39.

Brody, Howard. "That's How the Ball Bounces." *The Physics Teacher*, V. 22 (Nov 1982): 494-497.

Edge, Ron. "Golf is a Mysterious Sport." *The Physics Teacher*, V. 36 (Oct 1998): 444.

Frohlich, Cliff. *The Physics of Sports*. Washington; American Association of Physics Teachers, 1986.

Swinson, Derek. "Physics and Snowboarding." *The Physics Teacher*, V. 32 (Dec 1994): 530-534.

Wagner, Glenn. "The 100-metre Dash: Theory and Experiment." *The Physics Teacher*, V. 36 (Mar 1998): 144-146.

Wagner, Glenn and Robert Wood. "Skydiver Survives Death Plunge." *The Physics Teacher*, V. 34 (Dec 1996): 543-545.

Waltham, Chris. "Power Requirements for Rollerblading and Bicycling." *The Physics Teacher*, V. 37 (Sept 1999): 379-388.

**Websites**

Biomechanics World Wide – http://www.per.ualberta.ca/biomechanics/

Glenbrook High School – www.glenbrook.k12.il.us/gbssci/phys/projects/yep/sports/spinet.html

How Stuff Works – www.howstuffworks.com/sports-physiology.htm

Human Kinetics – http://www.humankinetics.com/

Human Performance Technologies – http://www.hpt-biolink.com/

Jump Physics – http://www.personal.engin.umich.edu/~gcoch/jumpphysics/jumpphys.html

Physics of Racing Series – http://members.home.net/rck/phor/

Physics of Sports – http://www.phys.washington.edu/~young/208A/

Science Joy Wagon – www.sciencejoywagon.com/physicszone/lesson/05work/default.htm
Sport and Exercise Sciences Homepage – http://www.birmingham.ac.uk/sportex/
Sport! Science at the Exploratorium – http://www.exploratorium.com/sports/index.html
Sports Science News – http://www.sportsci.org/

### Appendices
Appendix 1 – Sample Information Sheet for Activity 3

## Activity 4: Catholic Symposium on Energy Resources and Technologies
**Time:** 375 minutes

### Description
Students host an in-class symposium to evaluate the social, economic, and environmental impact of various energy sources and energy-transformation technologies used around the world. The students also examine the energy consumption of our society in comparison to that of a developing country. In this way students reflect on their role as responsible citizens and stewards of the Earth's resources.

### Strand(s) and Learning Expectations
**Strand(s):** Energy, Work and Power

**Overall Expectations**
EWV.03 - analyse the costs and benefits of various energy sources and energy-transformation technologies that are used around the world, and explain how the application of scientific principles related to mechanical energy has led to the enhancement of sports and recreational activities.

**Specific Expectations**
EW1.04 - apply quantitatively the relationships among power, energy, and time in a variety of contexts;
EW1.05 - analyse, in quantitative terms, the relationships among per-cent efficiency, input energy, and useful output energy for several energy transformations;
EW2.03 - communicate the procedures, data, and conclusions of investigations involving work, mechanical energy, power, thermal energy and its transfer (heat), and the law of conservation of energy, using appropriate means;
EW3.01 - analyse, using their own or given criteria, the economic, social, and environmental impact of various energy sources and energy-transformation technologies used around the world.

**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.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;
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.

**Ontario Catholic School Graduate Expectations**
CGE1d - develops attitudes and values founded on Catholic social teaching and acts to promote social responsibility, human solidarity, and the common good;
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;
CGE3c - thinks reflectively and creatively to evaluate situations and solve problems;
CGE7d - promotes the sacredness of life;
CGE7e - witnesses Catholic social teaching by promoting equality, democracy, and solidarity for a just, peaceful and compassionate society;
CGE7i - respects the environment and uses resources wisely.

### Prior Knowledge & Skills

- Grade 9: Physics – Electricity

### Planning Notes

- This activity is a continuation of the concepts presented in Unit 1 of this course (Electricity and Magnetism).
- The students should be assigned to groups of 3 or 4 and given their energy source and energy transformation technology during Activity 1 of this unit.
- Current information on the energy transformation technologies and world wide energy consumption data are available on the Internet sites listed at the end of this activity.
- Make arrangements to have the students visit the Library/Resource Centre and arrange Internet access through your computer department. If the school library and/or Internet access is not readily available for student use, collect appropriate print materials to form vertical files for each research topic
- Review the ethical use of the Internet with the students.
- Each student is responsible for researching one of the following topics related to their energy source and energy transformation technology:
    - Efficiency: Describe the energy transformations involved with this technology. Calculate the efficiency of the energy transformation technology. Critically analyse the technology and its ability to enhance the quality of life.
    - Economic value: Evaluate the cost of the energy transformation technology. Describe the benefits to the economy of the energy source or energy transformation technology. Discuss possible careers that arise due to the technology.
    - Environmental concerns: As a responsible citizen and steward of the Earth's resources, evaluate the costs and benefits of introducing the energy transformation technology into the environment. Discuss possible locations throughout the world where the technology would be beneficial. Discuss the viability of the energy source with regard to the wise use of resources.
    - Social issues: As a responsible citizen acting to promote social responsibility evaluate the costs and benefits of the use of this energy source and energy transformation technology on our society. Discuss the availability and use of the energy source and technology for the common good of the global community. Discuss the consumption of electricity in our society as compared to that of third world countries.
- It should be stressed that each of the above topics contains questions that cannot be answered through direct research. These require the students to deduce, synthesize and extrapolate using the information gathered during their research and their own values.
- Each group will prepare a fact sheet evaluating their respective energy source and energy transformation technology with respect to the four areas of concern. This fact sheet should be photocopied for distribution during the symposium.
- During the presentation part of the symposium each student will be responsible to present their part of the research.
- The symposium should be scheduled for the last two days of this activity.

- The students reflect on the results of the symposium and write a personal reflection using the Learning/Valuing/Acting Model (see Course Overview). Their reflection should focus on their role as responsible citizens within the global community, and as stewards of the Earth's resources wherein the earth is the first sacrament.

### Teaching/Learning Strategies

The teacher:

- determines the groupings of the students and assigns the energy source and respective energy transformation technology to be researched;
- explains that the symposium approach allows each group to present the aspects of their technology to the rest of the class within a specified amount of time;
- leads a whole class discussion on the need to deduce, synthesize and extrapolate the answers to some of the questions posed using the information researched, e.g., What are the costs and benefits to a community if a dam were to be built in order to harness hydroelectric power?;
- reviews the concepts of electrical energy, power and kilowatt-hours;
- conferences with each group to monitor individual progress;
- opens the symposium with a prayer (Appendix 2 – Sample Prayer);
- moderates the symposium by preparing the order of the presentations and acting as timer (limiting each group to 10 to 15 minutes of presentation time);
- leads a whole class discussion to summarize the results of the symposium;
- assesses and evaluates the fact sheets and presentations;
- instructs the students to write a one page conclusion outlining their best solution for the global community as a whole;
- instructs the students to write a reflection (using the Learning/Valuing/Acting Model) on their role as responsible citizens and stewards of the Earth's resources in view of the world energy consumption data.

Students:

- research the energy source and energy transformation technology with respect to their individual criteria;
- work within their groups to prepare the fact sheet for the symposium;
- present their individual results during the symposium;
- participate in the class discussion summarizing the results of the symposium;
- write a one page conclusion outlining their best solution for the global community;
- write a reflection on their role as responsible citizens and stewards of the Earth's resources in view of the world energy consumption data presented during the symposium.

### Assessment & Evaluation of Student Achievement

- The fact sheet may be assessed and evaluated for knowledge and understanding and making connections using a rubric (EW1.04, EW1.05, EW3.01, SIS.04, SIS.05, SIS.09, SIS.12). (Appendix 3 – Task Rubric)
- The symposium presentation may be assessed and evaluated for communication using a rating scale or a rubric (EW2.03). (Appendix 3 – Task Rubric)

## Accommodations

- See the Course Overview for general accommodations.
- Possible enrichment activities:
  - Write an article for the school or local newspaper outlining the findings of the symposium.
  - Write a letter to your federal representative outlining the findings of the symposium.
  - Write a brief reflective commentary on the words of the Jesuit poet, Gerard Manley Hopkins: "The world is charged with the grandeur of God" or another similar poem.

## Resources

**Print**

Finley, M. *Let's Begin With Prayer*. Indiana: Ave Maria Press Inc., 1997. ISBN 0-87793-615-3

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

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

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

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

**Video**

*Energy - The Pulse of Life Series*. Cambridge Educational 1994 (available through McIntyre Media)
*Renewable Power: Earth's Clean Energy Destiny*. Video Project 1996 (available through McNabb & Connolly)

**Websites**

Alternative Energy Sources – http://zebu.uoregon.edu/energy.html

Catholic Information Network – www.cin.org

EcoNet – www.igc.org/igc/gt/EcoNet/

Energy Information Administration – www.eia.doe.gov/fuelrenewable.html
– www.eia.doe.gov/neic/quickstats.html

Energy Information, Products, and Programs – www.eia.doe.gov/energy/

International Energy Agency – www.iea.org/stats/files/db/f_elcap.htm

Office of Power Technologies – www.eren.doe.gov/power/
– www.eren.doe.gov/RE/

Renewable Energy in Canada – www.newenergy.org/

Renewable Energy Resources – www.itc.nl/ha2/energy/links/

Sustainable technologies – www.lior-int.com/

Sweatshop Watch – www.sweatshopwatch.org/

The Earth Charter – www.earthcharter.org

Worldwide Energy Consumption Data – www.eia.doe.gov/oiaf/ieo98/elec.html

## Appendices

Appendix 2 – Sample Prayer
Appendix 3 – Task Rubric for Activity 4

## Appendix 1

### Sample Information Sheet for Activity 3

**Sport: Speed Skating** **Technology: Slap Skate (also called a Clap Skate)**

I) Diagram of Energy types and Transfers

Work done by the skater is converted to kinetic energy and frictional losses (heat).

Explanation

The work is done primarily by the muscles of the skater's legs. These muscles are supplied energy by a combination of aerobic and anaerobic respiration in the cells. There are two main sources of frictional losses: one is aerodynamic drag and the other is friction between the skate blade and the ice.

II) Time Line of Accomplishments in the Sport

The following table includes the world records for each decade since 1950 along with the number of times the record was broken in the decade. Progress in the men's 2000m long track event is shown in this table:

| Time Interval ( years ) | World Record (2000m men's) | Number of new records |
|---|---|---|
| 1950 – 1960 | 2:06.3 | 6 |
| 1960 – 1970 | 2:01.9 | 6 |
| 1970 – 1980 | 1:54.79 | 4 |
| 1980 – 1990 | 1:52.06 | 5 |
| 1990 – 2000 | 1:45.56 | 10 |

The table shows the most significant progress in time as well as the number of records in the 1990s. Of the ten new records set, seven were set after the introduction of the slap skate.

III) Description of Technology (How is the transfer of energy more efficient?)

Before the introduction of the slap skate, speed skaters used a skate blade that was fixed to the boot of the skate. This skate did not allow the athlete to extend the muscles in the thigh to the full range of motion. If the skater did fully extend, there would be more friction produced with the ice and it would result in a slower speed. The conventional technique was developed to minimize the amount of frictional losses to the ice while maximizing the work done by the athlete.

The slap skate was developed and first used in 1995 by scientists and skaters from the Netherlands. The skate blade is attached to the boot with a hinge. This allows the athlete to extend their leg muscles while keeping the skate blade flat on the ice to reduce friction. The skaters that used the new skate had to make adjustments to their technique to use the full extension in their legs. When this was accomplished, the records started to fall.

## Appendix 2

### Sample Prayer

**For the Environment**

God our loving Creator, you bring us into being as a part of nature, and you give us our natural environment in which to make a home. From you come the gifts of oceans, rivers and lakes, trees, and air to breathe. Help us to do all that we can to preserve our natural environment as we do our work, live in our homes, and create means of transportation. Bless the earth and sky, loving God, and help us to use all our natural resources with future generations in mind. We pray in the name of Jesus, the Lord. Amen.

Finley, M. *Let's Begin With Prayer*. Indiana: Ave Maria Press Inc., 1997. ISBN 0-87793-615-3

## Appendix 3

### Task Rubric for Activity 4

| Categories/Criteria | Level 1 (50-59%) | Level 2 (60-69%) | Level 3 (70-79%) | Level 4 (80-100%) |
|---|---|---|---|---|
| **Knowledge/ Understanding** | | | | |
| **EW1.04** *transfer of concepts to new contexts* | - infrequently transfers simple concepts to new contexts | - sometimes transfers simple concepts to new contexts | - usually transfers simple and some complex concepts to new contexts | - routinely transfers complex concepts to new contexts |
| **EW1.05** *understanding of relationships between concepts* | - demonstrates limited understanding of relationships between concepts | - demonstrates some understanding of relationships between concepts | - demonstrates considerable understanding of relationships between concepts | - demonstrates thorough and insightful understanding of relationships between concepts |
| **Communication** | | | | |
| **EW2.03** *communication of information and ideas* | - 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** | | | | |
| **EW3.01** *analysis of social and economic issues involving science and technology* | - analyses social and economic issues with limited effectiveness | - analyses social and economic issues with moderate effectiveness | - analyses social and economic issues with considerable effectiveness | - analyses complex social and economic issues with a high degree of effectiveness |
| *assessment of impacts of science and technology on the environment* | - assesses environmental impacts with limited effectiveness | - assesses environmental impacts with moderate effectiveness | - assesses environmental impacts with considerable effectiveness | - assesses environmental impacts 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.