Science

Applied Science 701A
Acknowledgments

The P.E.I. Department of Education and Early Childhood Development expresses its indebtedness to members of the provincial curriculum committee for their professional expertise and insights in developing this Applied Science 701A curriculum guide. In addition, the curriculum committee and pilot teachers who contributed comments and suggestions are to be commended for their commitment to developing exemplary science programs.

The Prince Edward Island Applied Science Curriculum Committee

Charlottetown Rural High School  Rob Redmond
Kensington Intermediate Senior High  Lewis Andrews
Kinkora Regional High School  Ian Gillis
Montague Senior High School  Randy Harper
Morell Regional High School  Steven Wynne
Three Oaks Senior High  David Ramsay
Westisle Composite High School  George Charchuk

Holland College  Debbie Hogan

Department of Education and Early Childhood Development  Jonathan Hayes
## Contents

### Course Overview
- Introduction ................................................................. 1
- Focus and Context ...................................................... 1
- Aim ............................................................................. 2

### Program Design and Components
- Learning and Teaching Science ................................. 3
- Communicating in Science ......................................... 4
- The Three Processes of Scientific Literacy .................. 5
- Meeting the Needs of All Learners .............................. 6
- Science for EAL Learners ............................................ 7
- Assessment and Evaluation ....................................... 8
- Assessment Techniques .......................................... 8

### Curriculum Outcomes Framework
- Overview ...................................................................... 11
- Essential Graduation Learnings ............................ 12
- General Curriculum Outcomes ................................. 13
- Key-Stage Curriculum Outcomes ......................... 13
- Specific Curriculum Outcomes .............................. 13
- Attitude Outcomes .................................................. 14
- Curriculum Guide Organization ......................... 17
- The Four-Column Spread ........................................... 18
- Section Overview/Specific Curriculum Outcomes .... 20

### Curriculum Sections
- Career Profile ............................................................ 24
- Energy Sources .......................................................... 26
- Student Reflections, Skills Logbook, Engineering Notebook 28
- Introduction to Robotics ........................................... 30
- Building a Protobot .................................................. 32
- Microcontroller and Transmitter ............................. 34
- Speed, Power, Torque, and DC Motors ..................... 36
- Gears, Chains, and Sprockets .................................. 38
- Advanced Gears ....................................................... 40
- Friction and Traction ................................................ 42
- Drivetrain Design and Tank Tread Drive .................. 44
- Object Manipulation, Rotating Joints, and Linkages .... 46
- Bumper and Limit Switches ...................................... 48
- Final Project ............................................................. 50

### Appendices
- Appendix A ................................................................. 53
- Appendix B ............................................................... 57
- Appendix C ............................................................... 63
- Appendix D ............................................................... 67
Course Overview

Introduction
Applied Science 701A is a physical science course that develops student scientific and technological knowledge and skills. It contains a balance of theory, design and hands-on/minds-on activities that build students’ scientific and technological literacy and help them to understand and appreciate scientific and technological concepts and processes.

Focus and Context
Applied Science 701A has a balanced focus on the three processes of scientific literacy - inquiry, problem solving, and decision making. Robotics design and construction is the primary context within which students will obtain knowledge and skills associated with Applied Science 701A. In this course students will have an opportunity to engage in an engineering design process which will culminate in a final robot competition. Students will also have the opportunity to obtain skills and knowledge related to employability and possible careers. In addition, Education for Sustainable Development (ESD) will be a foundational component of this course.

Employability Skills
The Conference Board of Canada’s Employability Skills 2000+ lists critical skills that are needed in the workplace. These skills are divided into three categories - fundamental skills, teamwork skills, personal management skills - and largely relate to communication, problem solving, positive thinking, adaptability, teamwork, science, technology, and mathematics. Students will be engaged in an ongoing project in which they must identify desired skills from Employability Skills 2000+ and provide evidence of having acquired skills from the list.

Education for Sustainable Development
Education for Sustainable Development involves incorporating the key themes of sustainable development - such as sustainable consumption, environmental protection, and climate change - into the education system. Applied Science 701A will engage students in an energy project that will promote learning from a social, environmental, and economic perspective and allow them to explore how these perspectives are interrelated and interdependent.
Aim

The aim of science education in the Atlantic provinces is to develop scientific literacy. Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them. To develop scientific literacy, students require diverse learning experiences that provide opportunities to explore, analyse, evaluate, synthesise, appreciate, and understand the interrelationships among science, technology, society, and the environment.

Whether the student is acquiring new knowledge, engaging in the processes of scientific literacy, assembling experimental apparatus, or constructing a new device, collaboration plays a very significant role in science education. Consequently, teamwork is strategically incorporated in the Applied Science 701A course design. Students are expected to work in teams during the planning and building phases of robot design and construction. Furthermore, the “Energy Sources” section of this curriculum describes a project which explicitly involves students working in groups. The energy sources project and the final course project (robot competition) both culminate in group presentations, and peers can debate the merits of the presentation in a collaborative arena.

It is recommended that students have the opportunity to work through a series of team-building exercises at the beginning of this course. The purpose of these exercises is to have students recognise the importance of knowing the strengths of members of a team, communicating in the team dynamic, and viewing successes and failures as equally important in knowledge construction.
Program Design and Components

Learning and Teaching Science

What students learn is fundamentally connected to how they learn it. The aim of scientific literacy for all has created a need for new forms of classroom organization, communication, and instructional strategies. The teacher is a facilitator of learning whose major tasks include:

- creating a classroom environment to support the learning and teaching of science;
- designing effective learning experiences that help students achieve designated outcomes;
- stimulating and managing classroom discourse in support of student learning;
- learning about and then using students’ motivations, interests, abilities, and learning styles to improve learning and teaching;
- assessing student learning, the scientific tasks and activities involved, and the learning environment to make ongoing instructional decisions;
- selecting teaching strategies from a wide repertoire.

Effective science learning and teaching take place in a variety of situations. Instructional settings and strategies should create an environment that reflects a constructive, active view of the learning process. Learning occurs through actively constructing one’s own meaning and assimilating new information to develop a new understanding.

The development of scientific literacy in students is a function of the kinds of tasks they engage in, the discourse in which they participate, and the settings in which these activities occur. Students’ disposition towards science is also shaped by these factors. Consequently, the aim of developing scientific literacy requires careful attention to all of these facets of curriculum.

Learning experiences in science education should vary and should include opportunities for group and individual work, discussion among students as well as between teacher and students, and hands-on/minds-on activities that allow students to construct and evaluate explanations for the phenomena under investigation. Such investigations and the evaluation of the evidence accumulated provide opportunities for students to develop their understanding of the nature of science and the nature and status of scientific knowledge.
Communicating in Science

Learning experiences should provide opportunities for students to use writing and other forms of representation as ways to learning. Students at all grade levels should be encouraged to use writing to speculate, theorize, summarize, discover connections, describe processes, express understandings, raise questions, and make sense of new information by using their own language as a step to the language of science. Science logs are useful for such expressive and reflective writing. Purposeful note making is an intrinsic part of learning in science, helping students better record, organize, and understand information from a variety of sources. The process of creating webs, maps, charts, tables, graphs, drawings, and diagrams to represent data and results helps students learn, and also provides them with useful study tools.

Learning experiences in science should also provide abundant opportunities for students to communicate their findings and understandings to others, both formally and informally, using a variety of forms for a range of purposes and audiences. Such experiences should encourage students to use effective ways of recording and conveying information and ideas and to use the vocabulary of science in expressing their understandings. It is through opportunities to talk and write about the concepts they need to learn that students come to better understand both the concepts and the related vocabulary.

Learners will need explicit instruction in, and demonstration of, the strategies they need to develop and apply in reading, viewing, interpreting, and using a range of science texts for various purposes. It will be equally important for students to have demonstrations of the strategies they need to develop and apply in selecting, constructing, and using various forms for communicating in science.
An individual can be considered scientifically literate when he/she is familiar with, and able to engage in, three processes: inquiry, problem solving, and decision making.

### The Three Processes of Scientific Literacy

#### Inquiry

Scientific inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analysing data, and interpreting data are fundamental to engaging in science. These activities provide students with opportunities to understand and practise the process of theory development in science and the nature of science.

#### Problem Solving

The process of problem solving involves seeking solutions to human problems. It consists of proposing, creating, and testing prototypes, products, and techniques to determine the best solution to a given problem.

#### Decision Making

The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are important in their own right, and they also provide a relevant context for engaging in scientific inquiry and/or problem solving.
Meeting the Needs of All Learners

Foundation for the Atlantic Canada Science Curriculum stresses the need to design and implement a science curriculum that provides equitable opportunities for all students according to their abilities, needs, and interests. Teachers must be aware of, and make adaptations to accommodate, the diverse range of learners in their classes. To adapt instructional strategies, assessment practices, and learning resources to the needs of all learners, teachers must create opportunities that will permit them to address their various learning styles.

As well, teachers must not only remain aware of and avoid gender and cultural biases in their teaching; they must also actively address cultural and gender stereotyping (e.g., about who is interested in and who can succeed in science and mathematics). Research supports the position that when science curriculum is made personally meaningful and socially and culturally relevant, it is more engaging for groups traditionally under-represented in science, and indeed, for all students.

While this curriculum guide presents specific outcomes for each unit, it must be acknowledged that students will progress at different rates.

Teachers should provide materials and strategies that accommodate student diversity, and should validate students when they achieve the outcomes to the best of their abilities.

It is important that teachers articulate high expectations for all students and ensure that all students have equitable opportunities to experience success as they work toward achieving designated outcomes. Teachers should adapt classroom organization, teaching strategies, assessment practices, time, and learning resources to address students’ needs and build on their strengths. The variety of learning experiences described in this guide provide access for a wide range of learners. Similarly, the suggestions for a variety of assessment practices provide multiple ways for learners to demonstrate their achievements.
Science for EAL Learners

The Prince Edward Island science curriculum is committed to the principle that learners of English as an additional language (EAL) should be full participants in all aspects of science education. English deficiencies and cultural differences must not be barriers to full participation. All students should study a comprehensive science curriculum with high-quality instruction and co-ordinated assessment.

To this end,

- schools should provide EAL learners with support in their dominant language and English language while learning science;
- teachers, counsellors, and other professionals should consider the English-language proficiency level of EAL learners as well as their prior course work in science;
- the science proficiency level of EAL learners should be solely based on their prior academic record and not on other factors;
- science teaching, curriculum, and assessment strategies should be based on best practices and build on the prior knowledge and experiences of students and on their cultural heritage;
- the importance of science and the nature of the science program should be communicated with appropriate language support to both students and parents;
- to verify that barriers have been removed, educators should monitor enrolment and achievement data to determine whether EAL learners have gained access to, and are succeeding in, science courses.
Assessment and Evaluation

The terms assessment and evaluation are often used interchangeably, but they refer to quite different processes. Science curriculum documents developed in Prince Edward Island use these terms for the processes described below.

Assessment is the systematic process of gathering information on student learning.

Evaluation is the process of analysing, reflecting upon, and summarizing assessment information, and making judgments or decisions based upon the information gathered.

The assessment process provides the data, and the evaluation process brings meaning to the data. Together, these processes improve teaching and learning. If we are to encourage enjoyment in learning for students now and throughout their lives, we must develop strategies to involve students in assessment and evaluation at all levels. When students are aware of the outcomes for which they are responsible and of the criteria by which their work will be assessed or evaluated, they can make informed decisions about the most effective ways to demonstrate their learning.

The Prince Edward Island science curriculum reflects the three major processes of science learning: inquiry, problem solving, and decision making. When assessing student progress, it is helpful to know some activities/skills/actions that are associated with each process of science learning. Student learning may be described in terms of ability to perform these tasks.

Assessment Techniques

Assessment techniques should match the style of learning and instruction employed. Several options are suggested in this curriculum guide from which teachers may choose, depending on the curriculum outcomes, class, and school/district policies. It is important that students know the purpose of an assessment, the method used, and the marking scheme being applied. In order that formative assessment support learning, the results, when reported to students, should indicate the improvements expected.
Observation (formal or informal)  This technique provides a way of gathering information fairly quickly while a lesson is in progress. When used formally, the student(s) would be made aware of the observation and the criteria being assessed. Informally, it could be a frequent, but brief, check on a given criterion. Observation may offer information about the participation level of a student in a given task, use of a piece of equipment, or application of a given process. The results may be recorded in the form of checklists, rating scales, or brief written notes. It is important to plan in order that specific criteria are identified, suitable recording forms are ready, and that all students are observed within a reasonable period of time.

Performance  The Applied Science 701A curriculum encourages learning through active participation. Many of the curriculum outcomes found in this guide promote skills and their application. There is a balance between scientific process and content. In order that students appreciate the importance of skill development, it is critical that assessment provide feedback as they develop various skills. These may include the correct use of a piece of equipment; the application of an experimental technique; or the ability to interpret and follow instructions, or to research, organize, and present information. Assessing performance is most often achieved through observing the process.

Journal  Although not assessed in a formal manner, journals provide an opportunity for students to express thoughts and ideas in a reflective way. By recording feelings, perceptions of success, and responses to new concepts, a student may be helped to identify his or her most effective learning style.

Knowing how to learn in an effective way is powerful information. Journal entries also give indicators of developing attitudes to science concepts, processes, and skills, and how these may be applied in the context of society. Self-assessment, through a journal, permits a student to consider strengths and weaknesses, attitudes, interests, and new ideas. Developing patterns may help in career decisions and choices of further study.

Interview  This curriculum promotes understanding and applying scientific concepts. Interviewing a student allows the teacher to confirm that learning has taken place beyond factual recall. Discussion allows a student to display an ability to use information and clarify understanding. Interviews may be brief discussions between teacher and student or they may be more extensive and include student, parent, and teacher. Such conferences allow a student to be pro-active in displaying understanding. It is helpful for students to know which criteria will be used to assess formal interviews. This assessment technique provides an opportunity to students whose verbal presentation skills are stronger than their writing skills.
Assessment Techniques  Continued...

Paper and Pencil (assignment or test)
These techniques can be formative or summative. Several curriculum outcomes call for displaying ideas, data, conclusions, and the results of practical or literature research. These can be in written form for display or for direct teacher assessment. Whether an activity/product is part of learning or a final statement, students should know the expectations for the exercise and the rubric by which it will be assessed. Written assignments and tests can be used to assess knowledge, understanding, and application of concepts. They are less effective in assessing skills, processes, and attitudes. The purpose of the assessment should determine what form of paper and pencil exercise is used.

Presentation
This science curriculum includes outcomes that require students to analyse and interpret information; identify relationships among science, technology, society, and environment; to be able to work in teams; and communicate information. Although the process can be time consuming, these activities are best displayed and assessed through presentations. These can be given orally, in written/pictorial form, by project summary (science fair), or by using electronic systems such as video or computer software. Whatever the level of complexity or format used, it is important to consider the curriculum outcomes as a guide to assessing the presentation. The outcomes indicate the process, concepts, and context for which and about which a presentation is made.

Portfolio
Portfolios offer another option for assessing student progress in meeting curriculum outcomes over a more extended period of time. This form of assessment allows the student to be central in the process. Decisions about the portfolio and its contents can be made by the student. What is placed in the portfolio, the criteria for selection, how the portfolio is used, how and where it is stored, and how it is evaluated are some of the questions to consider when planning to collect and display student work in this way. The portfolio should provide a long-term record of growth in learning and skills. This record of growth is important for individual reflection and self-assessment, but it is also important to share with others. For many students it is exciting to review a portfolio and see the record of development over time.
The science curriculum is based on an outcomes framework that includes statements of essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. The general, key-stage, and specific curriculum outcomes reflect the pan-Canadian Common Framework of Science Learning Outcomes K to 12. The diagram below provides the blueprint of the outcomes framework.

**Outcomes Framework**

![Diagram of the outcomes framework](image)

**Curriculum Outcomes Framework**

**Overview**

The science curriculum is based on an outcomes framework that includes statements of essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. The general, key-stage, and specific curriculum outcomes reflect the pan-Canadian Common Framework of Science Learning Outcomes K to 12. The diagram below provides the blueprint of the outcomes framework.
Essential Graduation Learnings

Essential graduation learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the essential graduation learnings will prepare students to continue to learn throughout their lives. These learnings describe expectations not in terms of individual school subjects but in terms of knowledge, skills, and attitudes developed throughout the curriculum. They confirm that students need to make connections and develop abilities across subject boundaries, and be ready to meet the shifting and ongoing opportunities, responsibilities, and demands of life after graduation. The essential graduation learnings are the following:

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

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

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

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

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

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

The general curriculum outcomes form the basis of the outcomes framework. They also identify the key components of scientific literacy. Four general curriculum outcomes have been identified to delineate the four critical aspects of students’ scientific literacy. They reflect the wholeness and interconnectedness of learning and should be considered interrelated and mutually supportive.

Science, Technology, Society, and the Environment

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

Skills

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

Knowledge

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

Attitudes

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

Key-Stage Curriculum Outcomes

Key-stage curriculum outcomes are statements that identify what students are expected to know, be able to do, and value by the end of grades 3, 6, 9, and 12 as a result of their cumulative learning experiences in science. The key-stage curriculum outcomes are from the Common Framework for Science Learning Outcomes K to 12.

Specific Curriculum Outcomes

Specific curriculum outcome statements describe what students are expected to know and be able to do at each grade level. They are intended to help teachers design learning experiences and assessment tasks. Specific curriculum outcomes represent a framework for assisting students to achieve the key-stage curriculum outcomes, the general curriculum outcomes, and ultimately, the essential graduation learnings. Specific curriculum outcomes are organized in units for each grade level.
Attitude Outcomes

It is expected that the Atlantic Canada science program will foster certain attitudes in students throughout their school years. The STSE, skills, and knowledge outcomes contribute to the development of attitudes, and opportunities for fostering these attitudes are highlighted in the Elaborations—Strategies for Learning and Teaching sections of each unit.

Attitudes refer to generalized aspects of behaviour that teachers model for students by example and by selective approval. Attitudes are not acquired in the same way as skills and knowledge. The development of positive attitudes plays an important role in students’ growth by interacting with their intellectual development and by creating a readiness for responsible application of what students learn.

Since attitudes are not acquired in the same way as skills and knowledge, outcome statements for attitudes are written as key-stage curriculum outcomes for the end of grades 3, 6, 9, and 12. These outcome statements are meant to guide teachers in creating a learning environment that fosters positive attitudes.

The following pages present the attitude outcomes from the pan-Canadian Common Framework of Science Learning Outcomes K to 12 for the end of grade 12.
Common Framework of Science Learning Outcomes K to 12
Attitude Outcome Statements

By the end of grade 12, it is expected that students will be encouraged to

<table>
<thead>
<tr>
<th>Appreciation of Science</th>
<th>Interest in Science</th>
<th>Scientific Inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not</td>
<td>439 show a continuing and more informed curiosity and interest in science and science-related issues</td>
<td>442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations</td>
</tr>
<tr>
<td>437 appreciate that the applications of science and technology can raise ethical dilemmas</td>
<td>440 acquire, with interest and confidence, additional science knowledge and skills using a variety of resources and methods, including formal research</td>
<td>443 use factual information and rational explanations when analysing and evaluating</td>
</tr>
<tr>
<td>438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds</td>
<td>441 consider further studies and careers in science- and explore where further science- and technology-related fields</td>
<td>444 value the processes for drawing conclusions</td>
</tr>
</tbody>
</table>

**Evident when students, for example,**

- consider the social and cultural contexts in which a theory developed
- use a multi-perspective approach, considering scientific, technological, economic, cultural, political, and environmental factors when formulating conclusions, solving problems, or making decisions on STSE issues
- recognize the usefulness of being skilled in mathematics and problem-solving
- recognize how scientific problem solving and the development of new technologies are related
- recognize the contribution of science and technology to the progress of civilizations
- carefully research and openly discuss ethical dilemmas associated with the applications of science and technology
- show support for the development of information technologies and science as they relate to human needs
- recognize that western approaches to science are not the only ways of viewing the universe
- consider the research of both men and women
- conduct research to answer their own questions
- recognize that part-time jobs require science- and technology-related knowledge and skills
- maintain interest in or pursue further studies in science
- recognize the importance of making connections between various science disciplines
- explore and use a variety of methods and resources to increase their own knowledge and skills
- are interested in science and technology topics not directly related to their formal studies
- explore where further science- and technology-related studies can be pursued
- are critical and constructive when considering new theories and techniques
- use scientific vocabulary and principles in everyday discussions
- readily investigate STSE issues

**Evident when students, for example,**

- insist on evidence before accepting a new idea or explanation, and ask questions and conduct research to confirm and extend their understanding
- criticize arguments based on the faulty, incomplete, or misleading use of numbers
- recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen
- expend the effort and time needed to make valid inferences
- critically evaluate inferences and conclusions, cognizant of the many variables involved in experimentation
- critically assess their opinion of the value of science and its applications
- criticize arguments in which evidence, explanations, or positions do not reflect the diversity of perspectives that exist
- insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position taken can be judged
- seek new models, explanations, and theories when confronted with discrepant events or evidence
Common Framework of Science Learning Outcomes K to 12

Attitude Outcome Statements (continued)

By the end of grade 12, it is expected that students will be encouraged to

<table>
<thead>
<tr>
<th>Collaboration</th>
<th>Stewardship</th>
<th>Safety in Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas</td>
<td>446 have a sense of personal and shared responsibility for maintaining a sustainable environment</td>
<td>449 show concern for safety and accept the need for rules and regulations</td>
</tr>
<tr>
<td>Evident when students, for example,</td>
<td>447 project the personal, social, and environmental consequences of proposed action</td>
<td>450 be aware of the direct and indirect consequences of their actions</td>
</tr>
<tr>
<td>• willingly work with any classmate or group of individuals regardless of their age, gender, or physical and cultural characteristics</td>
<td>448 want to take action for maintaining a sustainable environment</td>
<td>Evident when students, for example,</td>
</tr>
<tr>
<td>• assume a variety of roles within a group, as required</td>
<td></td>
<td>• read the labels on materials before using them, interpret the WHMIS symbols, and consult a reference document if safety symbols are not understood</td>
</tr>
<tr>
<td>• accept responsibility for any task that helps the group complete an activity</td>
<td></td>
<td>• criticize a procedure, a design, or materials that are not safe or that could have a negative impact on the environment</td>
</tr>
<tr>
<td>• give the same attention and energy to the group’s product as they would to a personal assignment</td>
<td></td>
<td>• consider safety a positive limiting factor in scientific and technological endeavours</td>
</tr>
<tr>
<td>• are attentive when others speak</td>
<td></td>
<td>• carefully manipulate materials, cognizant of the risks and potential consequences of their own actions</td>
</tr>
<tr>
<td>• are capable of suspending personal views when evaluating suggestions made by a group</td>
<td></td>
<td>• write into a laboratory procedure safety and waste-disposal concerns</td>
</tr>
<tr>
<td>• seek the points of view of others and consider diverse perspectives</td>
<td></td>
<td>• evaluate the long-term impact of safety and waste disposal on the environment and the quality of life of living organisms</td>
</tr>
<tr>
<td>• accept constructive criticism when sharing their ideas or points of view</td>
<td></td>
<td>• use safety and waste disposal as criteria for evaluating an experiment</td>
</tr>
<tr>
<td>• criticize the ideas of their peers without criticizing the persons</td>
<td></td>
<td>• assume responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials in a safe place</td>
</tr>
<tr>
<td>• evaluate the ideas of others objectively</td>
<td></td>
<td>• seek assistance immediately for any first-aid concerns such as cuts, burns, or unusual reactions</td>
</tr>
<tr>
<td>• encourage the use of procedures that enable everyone, regardless of gender or cultural background, to participate in decision making</td>
<td></td>
<td>• keep the work station uncluttered, with only appropriate lab materials present</td>
</tr>
<tr>
<td>• contribute to peaceful conflict resolution</td>
<td></td>
<td>• encourage the use of a variety of communication strategies during group work</td>
</tr>
<tr>
<td>• encourage the use of a variety of communication strategies during group work</td>
<td></td>
<td>• share the responsibility for errors made or difficulties encountered by the group</td>
</tr>
<tr>
<td>• share the responsibility for errors made or difficulties encountered by the group</td>
<td></td>
<td>• undertake responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials in a safe place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• seek assistance immediately for any first-aid concerns such as cuts, burns, or unusual reactions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• keep the work station uncluttered, with only appropriate lab materials present</td>
</tr>
</tbody>
</table>
Specific curriculum outcomes are organized in sections in this curriculum guide. Suggestions for learning, teaching, assessment, and resources are provided to support student achievement of the outcomes. Suggested times for each topic are also provided. Although Applied Science 701A is 110 hours (~90 classes) in duration, the cumulative topic time allocated is 90 hours (~74 classes), or 45 hours (~37 classes) per term. The remaining 10 hours each term allows for summative assessment considerations and robot performance.

The order in which the sections appear in this guide is meant to suggest a sequence. In some cases, the rationale for the recommended sequence is related to the conceptual flow across the year. Some units or certain aspects of units may also be combined or integrated. This is one way of assisting students as they attempt to make connections across topics in science or between science and the real world.

The numbering system used is from the pan-Canadian document:

- 100s—Science-Technology-Society-Environment (STSE) outcomes
- 200s—Skills outcomes
- 300s—Knowledge outcomes
- 400s—Attitude outcomes (see pages 14-16)

These code numbers appear in brackets after each specific curriculum outcome (SCO).
The Four-Column Spread  

All units have a two-page layout of four columns as illustrated below. In some cases, the four-column spread continues to the next two-page layout. Outcomes are grouped by a topic indicated at the top of the left page.

**Two-Page, Four-Column Spread**

<table>
<thead>
<tr>
<th>Page One</th>
<th>Page Two</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic</strong></td>
<td><strong>Outcomes</strong></td>
</tr>
<tr>
<td><strong>Students will be expected to</strong></td>
<td></td>
</tr>
<tr>
<td>• Specific curriculum outcome based on the pan-Canadian outcomes (outcome number)</td>
<td></td>
</tr>
<tr>
<td>• Specific curriculum outcome based on the pan-Canadian outcomes (outcome number)</td>
<td></td>
</tr>
</tbody>
</table>
**Column One: Outcomes**

The first column provides the specific curriculum outcomes. These are based, in part, on the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*. The statements involve the Science-Technology-Society-Environment (STSE), skills, and knowledge outcomes indicated by the outcome number(s) that appear(s) in parentheses after the outcome. It should be noted that select outcomes contain a list of directives to further delineate the outcome for instruction and assessment purposes. Select STSE and skills outcomes have been written in a context that shows how these outcomes should be addressed. Furthermore, the 300 level knowledge outcomes are specific to Prince Edward Island and are not reflected in the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*.

Specific curriculum outcomes have been grouped by topic. Other groupings of outcomes are possible and in some cases may be necessary in order to take advantage of local situations. The grouping of outcomes provides a suggested teaching sequence. Teachers may prefer to plan their own teaching sequence to meet the learning needs of their students.

Column one and column two define what students are expected to learn, and be able to do.

**Column Two: Elaborations—Strategies for Learning and Teaching**

The second column may include elaborations of outcomes listed in column one, and describes learning environments and experiences that will support students’ learning.

The strategies in this column are intended to provide a holistic approach to instruction. In some cases, they address a single outcome; in other cases, they address a group of outcomes.

**Column Three: Tasks for Instruction and/or Assessment**

The third column provides suggestions for ways that students’ achievement of the outcomes could be assessed. These suggestions reflect a variety of assessment techniques and materials that include, but are not limited to, informal/formal observation, performance, journal, interview, paper and pencil, presentation, and portfolio. Some assessment tasks may be used to assess student learning in relation to a single outcome, others to assess student learning in relation to several outcomes. The assessment item identifies the outcome(s) addressed by the outcome number in brackets after the item.

**Column Four: Resources/Notes**

This column provides an opportunity for teachers to make note of useful resources.
### Career Profile
- identify and describe science- and technology-based careers related to this course (117-7)
- identify possible areas of further study related to science and technology (117-8)

### Energy Sources
- explain the importance of peer review in the development of scientific knowledge (114-5)
- construct arguments to support a decision or judgment, using examples and evidence and recognizing various perspectives (118-6)
- propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability (118-10)
- use library and other research tools to collect information on a selected energy topic (213-6)
- select and integrate information from various print and electronic sources or from several parts of the same source (213-7)

### Introduction to Robotics
- identify and describe the basic components of a robot and its function (300-1)
- work co-operatively with team members to construct and test a tumbler robot, and troubleshoot problems as they arise (214-14/215-6 a)
- identify and describe the basic components of robotics subsystems (300-2)

### Building a Protobot
- identify and describe the components of an engineering design process (300-3)
- work co-operatively with team members to construct and test a protobot, and troubleshoot problems as they arise (214-14/215-6 b)
- describe and evaluate, using scientific principles, the design of the arm assembly and/or gripper to determine how it may be modified to perform a particular home function using scientific principles (116-6/214-16)

### Microcontroller and Transmitter
- explain how RF signals are transmitted and describe factors that affect their transmission (300-17)
- configure a transmitter and receiver effectively and accurately to control a robot in arcade-style and tank-style propulsion configurations (213-3a)
- evaluate the design and function of arcade-style and tank-style propulsion in terms of ability to control straight-line and turning motion, and speed (118-3a)
- analyse quantitatively the relationship between speed, distance and time for RF signals (300-4)

### Speed, Power, Torque, and DC Motors
- qualitatively describe the relationships among speed, acceleration, force, torque, work, and power (300-5)
- work co-operatively with team members to construct and test a simple winch, and troubleshoot problems as they arise (214-14/215-6 c)
- quantitatively and qualitatively analyse problems involving stall torque and free speed of a motor (300-6)
- quantitatively and qualitatively analyse problems involving Newton’s second law (300-7)

### Gears, Chains, and Sprockets
- quantitatively analyse problems involving gear ratio (300-9)
- identify and describe gear types (300-10)
- qualitatively describe the relationship between gearing, pulley free speed, and power (300-8)
- evaluate the role of continued testing in the development and improvement of materials used in the construction of prototypes (114-3)

### Advanced Gears
- evaluate the design of a differential and the way it functions on the basis of identified criteria, such as its effect on a drivetrain and impact on everyday life and safety (118-3a)
- work co-operatively with team members to construct and test a steerable robot containing a differential, and troubleshoot problems as they arise (214-14/215-6 d)
Section Overviews/Specific Curriculum Outcomes

Friction and Traction
- compare static and kinetic friction and identify the factors that affect traction (300-11)
- identify and correct practical problems in the way a robot functions to maximize traction (214-13)

Drivetrain Design and Tank Tread Drive
- describe how turning scrub and turning torque affect a robot’s ability to turn, and how these quantities can be altered to maximize torque and minimize scrub (300-12)
- describe and evaluate the design of a drivetrain to determine how it may be modified to perform a particular function using scientific principles related to turning scrub, turning torque, and traction (116-6/214-16)
- work co-operatively with team members to construct and optimize a drivetrain design in consideration of factors related to turning torque and scrub, and troubleshoot problems as they arise (214-14/215-6 e)
- calculate and compare the theoretical and experimental speed of a drivetrain design, and qualitatively account for differences (300-13)

Object Manipulation, Rotating Joints, and Linkages
- describe and evaluate the design of various types of object manipulators (300-14)
- describe and evaluate the design of rotating joints and linkages (300-15)
- work co-operatively with team members to construct and test a design involving a manipulator, rotating joints, and linkages, and troubleshoot problems as they arise (214-14/215-6f)

Bumper and Limit Switches
- describe the functions of a bumper switch and a limit switch, and identify their possible uses (300-16)
- configure a transmitter and receiver to effectively and accurately use switches to assist in the control of robot, or robot component, movement (213-3b)

Final Project
- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (214-15)
- work co-operatively with team members to construct and test a robot design, using components conducive to completing a predetermined task, and troubleshooting problems as they arise (214-14/215-6 h)
- communicate the results of a scientific or technological endeavour, using appropriate language and conventions (114-9)
Applied Science 701A
Curriculum Sections
Career Profile

~2 Classes

Outcomes

Students will be expected to

- identify possible areas of further study related to science and technology (117-8)
- identify and describe science-and technology-based careers related to this course (117-7)

Elaborations—Strategies for Learning and Teaching

The outcomes addressed in the “Career Profile” and “Energy Sources” sections (pp.24-27) are project-related and can be addressed at any time throughout this course. The section entitled “Student Reflection, Skills Portfolio, Engineering Notebook” (pp. 28, 29) contains outcomes that are expected to be addressed continuously throughout this course. It is recommended that all remaining curriculum guide sections be addressed in order as they appear.

Specific curriculum outcomes 117-7 and 117-8 can be addressed by providing students with an opportunity to create a career profile by researching a career related to the science that they are studying.

The career profile can take on a variety of formats, such as a Web page, podcast, or poster. In the profile, the students should

- describe the career (duties, responsibilities, time commitment);
- explain how the career is relevant to society;
- identify the educational requirements;
- identify key skills that are required to be successful at this career;
- discuss the upward mobility (What might this career lead to?);
- provide a salary range;
- identify corporations that currently provide employment in this career;
- provide a current job posting for this career;
- identify factors that may affect future demand;
- contact someone currently employed in this career and choose one of the following options:
  - provide a vocal recording of his/her comments and answers to your questions;
  - provide a written recording of his/her comments and answers to your questions;
  - invite the contact to be a guest speaker for the class.
Career Profile
~2 Classes

Tasks for Instruction and/or Assessment

Performance

- Research a career related to this course that you find interesting. Use your imagination - engineering technician, automobile design, machinist, electronics, radio control, forestry, aerospace (NASA) - or simply perform a search on the Internet for “careers.” Create a career profile that describes the career and identifies how it is relevant to society. Identify the educational requirements, knowledge and skills required, salary range, present and potential future demand. Contact someone currently working in this career to gather additional information. (117-7, 117-8)

Resources/Notes

Appendix A
Profile Project
Career Profile Rubric

Career Database/Labour Market Information (Web sites)
Service Canada (Job Futures)
http://www.jobfutures.ca/

Service Canada (Labour Market Information)
www.labourmarketinformation.ca

Public Service Commission of Canada
http://www.psc-cfp.gc.ca/centres/emple.htm
http://www.careerbuilder.ca

Labour Market Information (HRSDC)

Interprovincial Standards Canada (“Red Seal” Program)
http://www.red-seal.ca/

Career Cruising
http://www.careercruising.com/
Energy Sources
~5 Classes

Outcomes

Students will be expected to

- propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability (118-10)

- use library and other research tools to collect information on a selected energy topic (213-6)

- select and integrate information from various print and electronic sources or from several parts of the same source (213-7)

- explain the importance of peer review in the development of scientific knowledge (114-5)

- construct arguments to support a decision or judgment, using examples and evidence and recognizing various perspectives (118-6)

Elaborations—Strategies for Learning and Teaching

Specific curriculum outcomes 118-10, 213-6, and 213-7 can be addressed by providing students with an opportunity to engage, individually or collaboratively, in a research project that would require them to use print and electronic resources to research, select, and integrate information on an energy source.

Students could be asked to select an energy source of interest; discuss the viability of its long-term use; consider from an array of perspectives (e.g., health, economics, policy, and the environment) the risks and benefits; and give a brief history of the subject. Sustainability and other issues may be considered.

Energy sources that could be considered include nuclear, wind, hydrogen, landfill gas, waste, hydro, coal, petroleum (oil), natural gas, passive solar, photovoltaic, biomass, tidal, wave, geothermal, and ethanol.

Students should be asked to present their energy projects to the class. Class presentations will provide opportunities for students to use evidence to construct arguments in support of decisions they have made about an energy source.

Through questioning, students will be exposed to various other perspectives and, as a result, will be expected to better appreciate the importance of peer review in the development of scientific knowledge.
Energy Sources
~5 Classes

Tasks for Instruction and/or Assessment

Performance
• Research an energy source of interest. Discuss the viability of long-term use of the energy source, along with the risks and benefits, as viewed from different perspectives (health, economics, and the environment). Provide a brief history of your subject. Use the instructions/questions below to guide your research:
1. Describe your energy source.
2. Identify the possible uses of your energy source.
3. Provide a brief history of your energy source.
4. What is the usable lifetime (sustainability) of your energy source?
5. Outline the process of your energy source's development and transfer.
6. What are some advantages of your energy source?
7. What are some disadvantages of your energy source?
8. Identify various careers associated with the production and transmission of your energy source. (118-10, 213-6, 213-7)

Presentation
• Prepare an electronic multimedia presentation to assist in communicating your information on an energy source of interest. (114-5, 118-6)

Paper and Pencil
• Identify the possible uses of an energy source presented in your class. Describe the two most pertinent advantages and disadvantages of the energy source in a Prince Edward Island context. (114-5, 118-6)
• Of the energy sources presented, which do you believe are most suitable for use in Prince Edward Island. Support your decision with the evidence that was presented or discussed. (114-5, 118-6)

Resources/Notes

Appendix B
Energy Project Description
Energy Presentation Rubric
Energy Presentation Report Form
Energy Project Sign-up Sheet
### Student Reflection, Skills Logbook, Engineering Notebook

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations—Strategies for Learning and Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be expected to</td>
<td></td>
</tr>
<tr>
<td>• evaluate individual and group processes used in planning, problem solving, decision making, and completing a task (215-7)</td>
<td>The outcomes addressed in the “Student Reflection, Skills Portfolio, Engineering Notebook” (pp. 28-29) section are expected to be addressed continuously throughout this course. Most of the activities in Science 701A involve team collaboration during which student teams engage in planning, problem solving, decision making, and completing a task. Students should be asked periodically (e.g., quarterly) to explicitly evaluate their participation and contribution to this process. Similarly, students should be provided with the opportunity to assess their peers. It is recommended that self- and peer-assessment rubrics be provided to students at the beginning of the course. Furthermore, it is recommended that students be involved in the construction of these rubrics so that they will have ownership and a better awareness of the expectations. Teachers should conduct formal interviews with each student to reflect upon self- and peer-assessments, discuss strengths, and identify strategies for personal growth.</td>
</tr>
<tr>
<td>• analyse the knowledge and skills acquired in their study of science, to identify areas of further study related to science and technology (117-9)</td>
<td>Students will be required to maintain a skills logbook of acquired and desired skills. The logbook could be collected several times (quarterly reporting periods) throughout the duration of this course. For each reporting period, students should consult the Conference Board of Canada’s Employability Skills 2000+ and select from each category (fundamental skills, teamwork skills, personal management skills) two skills that they have acquired, and two skills that they desire. It is expected that students add entries to their logbooks each week, and submit their logbooks for assessment quarterly. For each of the six acquired skills reported quarterly, students must provide an example of something they have said or done that can be used, in part, as evidence that they possess the selected skill.</td>
</tr>
<tr>
<td>• select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results (215-2)</td>
<td>Science 701A provides numerous opportunities for students to communicate ideas, plans, and results of experimentation. Students are expected to use a variety of modes of representation (numeric, symbolic, graphical, linguistic) to communicate effectively and efficiently. Teachers may consider having students maintain an engineering notebook as a means of communicating their ideas/plans and reflecting on past modes of representation.</td>
</tr>
</tbody>
</table>
# Student Reflection, Skills Logbook, Engineering Notebook

## Tasks for Instruction and/or Assessment

### Portfolio

- Identify six skills (two from each category in *Employability Skills 2000+*) that you feel you have developed. Directly below each recorded skill identify something you have said or done that can be used, in part, as evidence that you possess that skill. Start each of your supporting statements as follows: *This skill is evident, for example, when I ...* (117-9)

- Identify six skills (two from each category in *Employability Skills 2000+*) that you would like to improve upon. Record the identified skills in the appropriate location by starting each with the following: *I intend to work on improving my ability to ...* (117-9)

### Paper and Pencil

- Record in your engineering notebook ideas and plans using several modes of communication (numeric, symbolic, graphical, linguistic). (215-2)

- Reflect on the entries in your engineering notebook. Were there entries that communicated ideas more effectively than others? Explain. (215-2)

### Journal

- Evaluate your and your group’s effectiveness in planning, problem solving, decision making, and completing a task. Identify your and your team strengths, and define areas in which you and your team can be more effective. (215-7)

## Resources/Notes

- Appendix C
- Skills Logbook Project
- *Employability Skills 2000+*
### Introduction to Robotics

~5 Classes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations—Strategies for Learning and Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be expected to</td>
<td>As an introduction, student groups can be given a variety of pictures of mechanical devices, some considered robots and others not. The group task would be to review the pictures and identify which image(s) they believe to be robots. The groups can then create an operational definition of a robot which can be shared with the class. Students are expected to identify the basic components of a robot, and their functions. These include the body, control system, CPU, and output devices (behaviour).</td>
</tr>
<tr>
<td>• identify and describe the basic components of a robot and its function (300-1)</td>
<td></td>
</tr>
<tr>
<td>• identify and describe the basic components of robotics subsystems (300-2)</td>
<td>Each part involved in the construction of a robot falls into one of six categories, or subsystems. The subsystems include structure, motion, power, sensor, logic, and control. Students are expected to identify and describe the six categories of robot subsystems and the parts associated with each. To assist in addressing this outcome and in managing resources, student teams could create a parts inventory. This activity may also help clarify the functions of the individual components of the robot subsystems.</td>
</tr>
<tr>
<td>• work co-operatively with team members to construct and test a tumbler robot, and troubleshoot problems as they arise. (214-14/215-6 a)</td>
<td>This is the first opportunity for many students to construct a robot. Students should be provided with explicit instructions and diagrams to assist in the construction, so that they have exposure to proper design techniques. Furthermore, this guided activity will assist in building student confidence in constructing future robots. The first robot construction (VEX Tumbler Robot) will consist of a basic square chassis design with arcade-style (single joystick control) propulsion involving one motor per tire. Constructing this basic robot should provide students with an opportunity to work on team dynamics - assigning a group task, sharing team responsibilities, and troubleshooting problems as they arise.</td>
</tr>
<tr>
<td></td>
<td>Please Note: It is very easy for students to mistakenly use VEX Servos instead of VEX Motors, as they look identical. It is recommended that all VEX Servos be labelled with bright permanent markings.</td>
</tr>
</tbody>
</table>
# Introduction to Robotics

~5 Classes

## Tasks for Instruction and/or Assessment

### Performance / Journal
- Create an inventory of the robot components provided by your teacher by first organizing the components into subsystem categories. In your engineering notebook, briefly describe the function of each component. (300-2)

### Performance
- Construct a basic radio-controlled robot consisting of a square chassis design with arcade-style propulsion involving one motor per tire. (214-14/215-6 a)
- Test the functioning of your robot by having it complete an obstacle course. Challenge another team to a time trial, or have both robots compete simultaneously on a common playing surface to determine which can complete the assigned task first. (214-14/215-6 a)

### Paper and Pencil
- Given a variety of devices, or photographs of devices, identify which you would consider to be a robot, and which you would not. Support your decision by identifying those devices which contain all basic robot components. (300-1)

## Resources/Notes

- Student Resource (SR): Unit 1
  - Unit 1: pp. 62-84

- Unit 1: pp. 62-84

- Unit 1: pp. 62-86
# Building a Protobot

## Outcomes

*Students will be expected to*

- identify and describe the components of an engineering design process (300-3)
- work co-operatively with team members to construct and test a protobot, and troubleshoot problems as they arise (214-14/215-6 b)
- describe and evaluate, using scientific principles, the design of the arm assembly and/or gripper to determine how it may be modified to perform a particular home function using scientific principles (116-6/214-16)

## Elaborations — Strategies for Learning and Teaching

When designing and building any device it is important to clearly identify the purpose of the design, research existing designs, evaluate prototypes, and consider other relevant variables. Students should be expected to identify and describe the components of an engineering design process. Although the components of an engineering design process may vary from source to source, they usually include the following steps: (a) identifying a need; (b) defining the problem to be solved; (c) gathering information; (d) conducting research; (e) finding alternate solutions; (f) analysing and testing possible solutions; (g) building; and (h) communicating.

Teachers can use this time to introduce students to Google SketchUp, which they can use to complete sketches and drawings as part of the engineering design process.

Students have experience in assembly of a basic robot chassis with arcade-style propulsion. Students are now expected to build on this prior learning by creating a robot with basic tank-style (double joystick controls) propulsion and an arm assembly with a gripper for object manipulation. It is expected that students be provided with explicit instructions and diagrams to assist in the construction, so that they continue to have exposure to proper design techniques.

A very significant part of an engineering design process requires the designer to evaluate a design, find alternate solutions, and analyse and test possible solutions. Students will be required to describe and evaluate the design of the protobot arm assembly and/or gripper to determine how it may be modified to perform a particular home function. Variables to consider include the weight of the objects to be manipulated, how high the arm needs to reach, the size of the objects, robot cost, etc.

Please Note: A limit switch is introduced in the protobot build phase. Consequently, teachers at this time may want to address the outcomes from the “Bumper and Limit Switch” section (pp. 48-49) of the curriculum guide. It is recommended that students incorporate limit switches in their designs to prevent damage to the servos, motors, and other robot components.
# Building a Protobot

~6 Classes

## Tasks for Instruction and/or Assessment

<table>
<thead>
<tr>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Describe how the engineering design process could be used to design a robot to perform a task of your choice. Present your engineering design process to the class. (300-3)</td>
</tr>
<tr>
<td>• Describe how the engineering design process could be used to design the protobot. (300-3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Construct a basic radio-controlled robot with tank-style propulsion and an arm assembly with a gripper for object manipulation. (214-14/215-6 b)</td>
</tr>
<tr>
<td>• Test the functioning of your robot by having it collect a variety of tennis balls and place them in a container. Challenge another team to a time trial, or have both robots compete simultaneously on a common playing surface to determine which can complete the assigned task first. (214-14/215-6 b)</td>
</tr>
<tr>
<td>• Using Google SketchUp, reassemble an existing model that has been disassembled by your teacher.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper and Pencil</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Describe how the arm of your protobot can be modified to perform another function of your choice. Evaluate your design based on criteria that you have developed. (116-6, 214-16)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resources/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Resource: Unit 3</td>
</tr>
<tr>
<td>Unit 3: pp. 6-19</td>
</tr>
<tr>
<td>Unit 3: pp. 40-88</td>
</tr>
<tr>
<td>Unit 3: pp. 89-90</td>
</tr>
</tbody>
</table>
# Microcontroller and Transmitter

~6 Classes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations—Strategies for Learning and Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be expected to</td>
<td>Students are expected to explain in basic terms how radio frequency (RF) signals are transmitted. To facilitate the conceptualization of the crystal resonance frequency between the transmitter and receiver, a trumpet (or tuning fork) can be used to generate a sound frequency near a drum of the same resonance frequency. Students can then observe that an audible sound will result from the drum resonance that was induced by the trumpet (or tuning folk) frequency that was transmitted. Students should be provided with an opportunity to test drum resonance when transmitting alternate frequencies. Furthermore, students should be provided with an opportunity to test the effect of horizontal and vertical transmission from a transmitter antenna, and antenna length, on transmission distance.</td>
</tr>
<tr>
<td>• explain how RF signals are transmitted and describe factors that affect their transmission (300-17)</td>
<td>Students have experience with both arcade-style and tank-style propulsion, with separate robots and motor configurations. Outcomes 231-3a and 118-3a will be addressed as a group by providing students with the opportunity to activate both tank-style and arcade-style propulsion using the same motor configuration. While activating and testing the configurations, students should evaluate the design and function of arcade-style and tank-style propulsion in terms of ability to control straight-line and turning motion, and speed.</td>
</tr>
<tr>
<td>• configure a transmitter and receiver effectively and accurately to control a robot in arcade-style and tank-style propulsion configurations (213-3a)</td>
<td>The concept of distance, speed, and time will be recurring in this course. The initial context for analysing this relationship was radio frequency signals which travel at the speed of light (~3x10^8 m/s; ~3x10^5 km/s). To develop the relationship between distance, speed, and time, students could be asked questions such as, “If you travel at 100 km/h, how far will you travel in 5 hours?” and “If you travel 200 km in 4 hours, what was your average speed?” Once the relationship is developed, students should be expected to manipulate and solve for any variable in the distance-speed-time formula (d=vt).</td>
</tr>
<tr>
<td>• evaluate the design and function of arcade-style and tank-style propulsion in terms of ability to control straight-line and turning motion, and speed (118-3a)</td>
<td>Students must pay particular attention to the units of measure for speed so that corresponding variables (distance, time) are used with appropriate units. Furthermore, students should be expected to convert between units of measure for any variable so that the speed, distance, time formula can be appropriately manipulated.</td>
</tr>
<tr>
<td>• analyse quantitatively the relationship between speed, distance, and time for RF signals (300-4)</td>
<td></td>
</tr>
</tbody>
</table>
Microcontroller and Transmitter
~6 Classes

Tasks for Instruction and/or Assessment

Performance

- Perform an experiment to test the effects of horizontal and vertical transmission from a transmitter antenna, and antenna length, on transmission distance. (300-17)

- Configure a transmitter to function in arcade-style and in tank-style. (213-3a)

- Configure a transmitter to reverse motor direction. (213-3a)

Journal

- In your engineering notebook, describe how you would explain to a student in grade 9 how RF signals are transmitted. (300-14)

Paper and Pencil

- Describe the difference between arcade- and tank-style propulsion. Evaluate these configuration styles by first creating a list of advantages and disadvantages of each. (118-3a)

- Describe how to configure arcade- and tank-style propulsion on the transmitter and receiver. (213-3a)

- Explain why there can be more motor ports (eight ports) than transmitter channels (six channels). (213-a, 118-3a)

- How long would it take for a signal travelling at the speed of light (300 000 km/s) to travel 500 km? to travel from the Sun to Earth (150 000 000 km). (300-4)

- If it takes a signal travelling at the speed of light (300 000 km/s) 15 seconds to reach its destination, how far did it travel? (300-4)

Resources/Notes

Student Resource: Unit 4

Internet: How Signals are Sent
www.education.rec.ri.cmu.edu/roboticscurriculum/vex_online/lessons/remote_control/lesson.html
Speed, Power, Torque, and DC Motors

~3 Classes

Outcomes

Students will be expected to

- qualitatively describe the relationships among speed, acceleration, force, torque, work, and power (300-5)

- work co-operatively with team members to construct and test a simple winch, and troubleshoot problems as they arise (214-14/215-6 c)

- quantitatively and qualitatively analyse problems involving stall torque and free speed of a motor (300-6)

- quantitatively and qualitatively analyse problems involving Newton's second law (300-7)

Elaborations—Strategies for Learning and Teaching

Students may have used the terms speed, acceleration, force, torque, work, and power at various times. But often the common use of a term is vastly different from its technical definition. For instance, power is often misused in place of energy. Student should be able to qualitatively describe these terms and the relationships among them.

Two important quantities of a motor are free speed and stall torque. Students should be provided with an opportunity to measure these quantities by building a test stand (e.g., simple winch). A winch can easily be created with chassis rails, a tank tread sprocket (with treads), a motor, and a drive shaft. Once the winch is assembled, students are expected to determine the free speed and stall torque of their motor. The reporting units can vary. Rotations per minute (rpm) can be used to report free speed. Stall torque can be calculated and reported as in lbs, ft lbs, and/or N m.

When building moving components, the designer has to consider torque, force, mass, and their effects on acceleration. Students are expected to qualitatively describe and calculate the effect of force and mass on an object's acceleration, using Newton's second law (F_{net}=ma).

This outcome provides a nice segue into the following section, which addresses how force and speed can be altered using gears, chains, and sprockets.
# Speed, Power, Torque, and DC Motors

~3 Classes

## Tasks for Instruction and/or Assessment

**Performance**

- Assemble a simple winch. Determine the stall torque of a VEX motor by recording measurements of pulley radius and collecting corresponding force data using a force sensor. (214-14/215-6 c)

- Using the simple winch you assembled, determine the free speed (rpm) of a VEX motor. (214-14/215-6 c)

**Journal**

- In your engineering notebook, qualitatively describe the relationships among speed, acceleration, force, torque, work, and power. Provide concrete examples and/or diagrams to clarify explanations. (300-5)

**Paper and Pencil**

- The radius of a pulley attached to a motor of a winch is 1.5 inches. If the motor has a stall torque of 5.3 in lbs, calculate the minimum weight to stall the motor. (300-6)

- What is the free speed (rpm) of a motor that has a pulley attached to the primary axle that is rotating at 75 revolutions in 45 minutes? (300-6)

- What would happen to the upward acceleration of a mass on a cable if the mass were doubled? Explain. (300-7)

- How much force would need to be applied to accelerate a 200 kg cart at a rate of 1m/s² (assume no friction)? (300-7)

## Resources/Notes

- Student Resource: Unit 5
  Unit 5: pp. 8-9

- Unit 5: pp. 29-39
- Internet: Stall Torque
  [www.education.rec.ri.cmu.edu/roboticscurriculum/vex_online/lessons/stall_torque/lesson.html](http://www.education.rec.ri.cmu.edu/roboticscurriculum/vex_online/lessons/stall_torque/lesson.html)

- Unit 5: p. 41
# Gears, Chains, and Sprockets

~4 Classes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations—Strategies for Learning and Teaching</th>
</tr>
</thead>
</table>
| Students will be expected to:  
- identify and describe gear types (300-10)  
- quantitatively analyse problems involving gear ratio (300-9)  
- qualitatively describe the relationship between gearing, pulley free speed, and power (300-8)  
- evaluate the role of continued testing in the development and improvement of materials used in the construction of prototypes (114-3) | Gears play an important role in controlling power transmission. Gears can change the direction of power, amount of force, and speed of rotation. To accomplish this a variety of gear types are used. Students should be familiar with the following gear types, and their associated roles: spur, bevel, worm, rack, and idler.  
In order to quantitatively analyse problems involving gear ratio, students must first be aware of the meaning of “driving gear” and “driven gear,” as well as the gear ratio reporting convention (driven gear : driving gear). Student should be able to calculate the theoretical speed and torque as a result of gear ratio. Furthermore, students are expected to identify whether there will be a speed increase and torque decrease (or vice versa) when the driven gear is larger (or smaller) than the driving gear.  
Students should have an opportunity to test the effects of gear ratio on speed and power. For example, students can modify the design of their previously constructed winch to facilitate gear ratio changes and data collection. Students should qualitatively describe and calculate the expected values of speed and power and compare results to the actual values obtained through experimentation. Reflecting on their data (i.e., the differences between the actual and expected values), and in consideration of other design issues, students should evaluate the role of continued testing in the development and improvement of materials used in the construction of prototypes. For example, students should test the effect of load on the free speed of a motor. Furthermore, students should evaluate other characteristics (e.g., strength, weight, inertness) of the materials used in the design in terms of durability, strength, volume, weight, etc. |
Gears, Chains, and Sprockets
~4 Classes

### Tasks for Instruction and/or Assessment

**Performance**

- Modify the simple winch that you created in the previous section to permit multiple gear ratio adjustments. Using the stall torque and free speed data for your VEX motor, determine the theoretical free speed and power of the final parallel axle for each gear ratio used. Compare the theoretical speed and power calculated to the actual speed and power obtained through experimentation, and account for differences. (300-10, 300-9, 300-8, 114-3)

**Journal**

- Given a 12-tooth and a 36-tooth spur gear, explain (qualitatively) the effect on pulley free speed and torque when the 12-tooth gear is the (1) driving gear, (2) driven gear. (300-8)

**Pencil and Paper**

- Do idler gears change the direction of motion and speed, direction of motion only, or speed only? Explain. (300-10)

- Describe the relative direction of rotation resulting from the meshing of two spur gears. (300-10)

- A 12-tooth spur gear is meshed with a 60-tooth spur gear on a parallel axle. When they turn, which has the higher rpm? (300-9, 300-10)

- Describe the change in the axis of rotation that occurs when two bevel gears mesh. (300-10)

- A 12-tooth spur gear (driving gear) is meshed with an 84-tooth spur gear (driven gear) on a parallel axle. Calculate the gear ratio. (300-9)

---

**Resources/Notes**

- Student Resource: Unit 6
  - Unit 6: pp. 7-18
  - Unit 7: pp. 9-11
  - Unit 6: pp. 10-18

- Internet: Gear Ratios and Speed
  - www.education.rec.ri.cmu.edu/roboticscurriculum/vex_online/lessons/gearbox/lesson.html
  - Unit 6: pp. 10-18, 53-60
Advanced Gears
~3 Classes

Outcomes

Students will be expected to

- evaluate the design of a differential and the way it functions on the basis of identified criteria, such as its effect on a drivetrain and impact on everyday life and safety (118-3a)

- work co-operatively with team members to construct and test a steerable robot containing a differential, and troubleshoot problems as they arise (214-14/215-6 d)

Elaborations—Strategies for Learning and Teaching

In the previous unit students learned about various gear types, such as spur, bevel, worm, rack, and idler gears. In this unit students have the opportunity to study how a specific arrangement of spur, bevel, and idler gears forms a very important component of an automobile drivetrain know as the differential. Students are expected to evaluate the design of a differential and the way it functions with respect to its effect on the drivetrain and its impact on everyday life and safety.

At this point students have experienced variations of a drivetrain design involving fixed axles. They should be provided with an opportunity to construct and test a chassis design containing a rear differential drivetrain with a front-end steering mechanism. Time permitting, students may consider designing and constructing alternate steering mechanisms, such as a rack-and-pinion design.

Teams should be reminded of their final team project (robot competition) so they can reflect on and plan propulsion and steering mechanisms for the competition and consider designs that permit gear ratio adjustments.
Advanced Gears
~3 Classes

Tasks for Instruction and/or Assessment

Performance

• Construct a robot with a rear differential drivetrain and front-end steering. (214-14/215-6 d)

• Test the functioning of your robot by having it complete an obstacle course. Challenge another team to a time trial, or have both robots compete simultaneously on a common playing surface to determine which can complete the assigned task first. (214-14/215-6 d)

Paper and Pencil

• Explain how a differential functions and how it affects the drivetrain of an automobile. (118-3)

• Explain how a differential affects the steering of an automobile and explain the importance of this technology in society. (118-3)

Resources/Notes

Student Resource: Unit 7
Unit 7: pp. 12-14

Unit 7: pp. 29-53
# Friction and Traction

## Outcomes

Students will be expected to

- compare static and kinetic friction and identify the factors that affect traction (300-11)

- identify and correct practical problems in the way a robot functions to maximize traction (214-13)

## Elaborations—Strategies for Learning and Teaching

Teachers could begin this unit by asking students how traction can be increased. From their discussion, the factors affecting traction may be identified. This activity would lead into an introduction to frictional forces and the two factors affecting friction (normal force and coefficient of friction). As an introduction to the two types of frictional forces (kinetic, static), students can be invited to comment on the amount of force required to move a stationary box from rest versus the amount of force required to keep the same box sliding at a constant speed. Deciding whether to create a robot whose drivetrain accelerates very quickly versus one which accelerates more slowly, but with greater torque, is situationally dependent. The slower, greater torque argument is one that considers the difference between static and sliding friction. The decision to accelerate more quickly (spinning tires) takes static and sliding friction into consideration, and potentially Newton's third law (tire pushes many little pieces of dirt with a lot of force... many little pieces of dirt push tire forward with a lot of little forces).

The engineering design process described in unit 2 identified finding alternate solutions, analysing possible solutions, and designing, testing, and evaluating the best solution as three explicit components. Consequently, students should be engaged in an activity that permits them to alter the stance, tire type, and the gear ratio between the motor and differential drive of their previously designed robot for the purpose of a “tractor pull” competition. As part of the competition, students could be asked to communicate the adjustments made to their robot. This communication component, also part of the engineering design process, is necessary for the advancement of technology transfer. It is important that students develop an understanding of the importance of communication, collaboration, and partnerships in scientific and technological development.
## Friction and Traction

~6 Classes

<table>
<thead>
<tr>
<th>Tasks for Instruction and/or Assessment</th>
<th>Resources/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance</strong></td>
<td></td>
</tr>
<tr>
<td>• Using a force sensor and a block (e.g., wood, plastic), determine which of the following requires more force: moving the block from rest, or keeping the block moving at a constant speed. (300-11)</td>
<td>Student Resource: Unit 8 Unit 8: pp. 9-13, 38-40</td>
</tr>
<tr>
<td>• Using a force sensor, various masses, and two blocks (each with a different surface texture), determine, through experimentation, factors that affect frictional force. (300-11)</td>
<td></td>
</tr>
<tr>
<td><strong>Performance / Presentation</strong></td>
<td>Unit 8: pp. 27-37</td>
</tr>
<tr>
<td>• Modify the traction, weight, and stance of your robot (built for the previous section) to compete in a “tractor pull” type of activity. Communicate your modification to the class. (214-13)</td>
<td></td>
</tr>
<tr>
<td>• Test the functioning of your modified robot by having it compete in a “tractor pull.” (214-13)</td>
<td></td>
</tr>
</tbody>
</table>
### Outcomes

**Students will be expected to**

- describe how turning scrub and turning torque affect a robot's ability to turn, and how these quantities can be altered to maximize torque and minimize scrub (300-12)
- describe and evaluate the design of a drivetrain to determine how it may be modified to perform a particular function using scientific principles related to turning scrub, turning torque, and traction (116-6/214-16)
- calculate and compare the theoretical and experimental speeds of a drivetrain design, and qualitatively account for differences (300-13)
- work co-operatively with team members to construct and optimize a drivetrain design in consideration of factors related to turning torque and scrub, and troubleshoot problems as they arise (214-14/215-6 e)

### Elaborations—Strategies for Learning and Teaching

Friction plays an important role in determining the type of drivetrain, stance, and traction to use in a robot design. Determining the drivetrain type, chassis design (stance), and traction type is situationally dependent. In order to make informed decisions regarding these components of a robot design, students need to develop an understanding of turning torque and turning scrub, and their interrelationship. Students should describe how turning scrub and turning torque affect a robot's ability to turn, and how these quantities can be altered to maximize torque and minimize scrub. Students are expected to describe and evaluate the benefit, or purpose, of using one drivetrain design over another - using scientific principles related to turning scrub, turning torque, and traction.

Student were introduced to distance, speed, and time in unit 4 (radio frequencies) and again in unit 6 (gear ratio, speed, power). Students are expected to select and build a chassis design, calculate the theoretical robot speed (using motor free speed, gear ratio, tire circumference) and actual speed, and explain the differences. *This may be an appropriate time to have student groups consider reviewing the final project requirements. The chassis they decide to build in order to calculate and measure speed could also serve as the chassis for the final project. Furthermore, their calculations involving gear ratios, theoretical speed, and actual speed can be used to fulfil the requirements of the final project.*

Students should be provided with an opportunity to construct a skid steer drivetrain containing variable wheelbase length adjustments. Students should test the turning ability of their robot at various wheelbase lengths by measuring turning radius. They should determine the optimum wheelbase length in consideration of other fixed robot variables and the operational environment (robot width, tire type, floor surface, etc.). They should explain their results in relation to their knowledge of turning torque and scrub. A common type of skid steer drivetrain is known as a tank tread drive. Tank tread drives are very popular for purposes such as traversing or excavating rough terrain. However, tank tread drives have a significant amount of turning scrub. Students should be provided with an opportunity to create a chassis containing a tank tread drive and to modify the design for a particular purpose.
Drivetrain Design and Tank Tread Drive
~12 Classes

Tasks for Instruction and/or Assessment

Performance

- Construct a robot with a chassis design which permits wheel base and stance adjustments. Adjust the stance and wheel base of your chassis in order to observe the effect of these changes on turning torque and turning scrub. Document your findings in your engineering notebook. (214-14/215-6 e)
- Measure the turning radius of your different chassis designs and explain their results in relation to your knowledge of turning torque and scrub. (300-12)
- Construct a robot with a tank tread drivetrain that is capable of climbing over 5 cm-high obstacles. (214-14/215-6 e)
- Test the functioning of your robot by having it complete an obstacle course. Challenge another team to a time trial, or have both robots compete simultaneously on a common playing surface to determine which can complete the assigned task first. (214-14/215-6 e)
- Construct a robot chassis (perhaps the chassis you wish to use in the final project) for the purpose of calculating actual and experimental robot speeds. In consideration of the VEX motor free speed data and chassis gear ratio determined from the drivetrain, calculate the robot’s theoretical speed. Using a measuring device and timer (or motion sensor), determine the robot’s actual speed. Compare the actual and theoretical speeds and account for differences. (300-13)

Paper and Pencil / Presentation

- Explain how turning scrub and turning torque are affected by wheel base and stance. (300-12, 116-6, 214-16)
- A balance among turning scrub, turning torque, and traction must always be considered in chassis design. Describe the balance among turning scrub, turning torque, and traction in the design of a bulldozer, and compare it with that of a golf cart? Why do these two devices have such drastic differences in the balance between turning scrub, turning torque, and traction? (300-12, 116-6, 214-16)
- Explain how a tank tread design may be adjusted to improve climbing ability? (214-14/215-6 e)
- Explain how a tank tread design is optimal for traversing sandy or muddy terrain (as compared to wheeled vehicles). (214-14/215-6 e, 116-6, 214-16)

Resources/Notes

Student Resource: Units 9,10,11
Unit 9: pp. 7-13, 25-47
Unit 10: pp. 7-10, 27-30
Unit 9: pp. 7-13, 25-47
Unit 11: pp. 6-12, 19-34
Object Manipulation, Rotating Joints, and Linkages

Outcomes

Students will be expected to

- describe and evaluate the design of various types of object manipulators (300-14)
- describe and evaluate the design of rotating joints, and linkages (300-15)
- work co-operatively with team members to construct and test a design involving a manipulator, rotating joints, and linkages, and troubleshoot problems as they arise (214-14/215-6f)

Elaborations—Strategies for Learning and Teaching

The outcomes addressed in the “Object Manipulation, Rotating Joints, and Linkages” section (pp. 46-47) are to be incorporated into the final project.

Students should be exposed to various types of object manipulators, such as the plow, scoop, and grabber. They should evaluate each type based on its design purpose and effectiveness. Furthermore, students are expected to describe the three basic types of degrees of freedom.

In consideration of the final team project, students should evaluate various designs to determine which is best for their robot. In their evaluation they should consider the required manipulator type, degrees of freedom, joint load, joint speed, and linkages.

Once student teams have evaluated the type of manipulator, linkages, degrees of freedom, joint load, and speed required for the final project (competition), they should begin to construct and test the prototype. Students may have to reconfigure the chassis to accommodate their design and troubleshoot problems as they arise.

Note: At this point students can begin testing the effectiveness of their robot against the competition criteria, and adjusting the robot design accordingly. They may want to consider how autonomous design features (bumper and limit switches) may contribute to the operation of their robot. Bumper and limit switches are addressed in the next section.
Object Manipulation, Rotating Joints, and Linkages

Tasks for Instruction and/or Assessment

Performance

- Construct an object manipulator and associated linkages in consideration of the degrees of freedom, joint load, and joint speed required for your robot to compete in the final class project.

Paper and Pencil

- Identify examples of each of the three types of object manipulators (plow, scoop, and friction grabber) that you have seen in your community. For each, explain how the design is appropriate for its function. (300-14)

- Describe the role of gears in the design of object manipulators. Provide an example. (300-14, 300-15)

- Object manipulators are attached to the body of a device through the use of various arrangement of linkages. Select one of the devices above and comment on the effect of the linkage arrangement on joint load and speed. (300-15)

- Describe what is meant by “degrees of freedom” in rotating joints and linkages. Select a device and describe the number of degrees of freedom associated with the joints and linkages involved. (300-15)

- Calculate the maximum load you want to apply to your VEX motor. Determine the gear required to achieve the load and the resulting joint speed. (300-15)

Resources/Notes

Student Resource:
Unit 12: pp. 5-9, 20
Unit 13: pp. 6-12, 29-30
Unit 15: pp. 7-12, 27-28

Unit 12: pp. 15-19
Unit 13: pp. 22-28
Unit 15: pp. 23-26
# Bumper and Limit Switches

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations—Strategies for Learning and Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be expected to describe the functions of a bumper switch and a limit switch, and identify their possible uses (300-16)</td>
<td>The outcomes addressed in the “Bumper and Limit Switches” section (pp. 48-49) are to be incorporated into the final project.</td>
</tr>
<tr>
<td>Students are expected to configure a transmitter and receiver to effectively and accurately use switches to assist in the control of robot, or robot component, movement (213-3b)</td>
<td>To introduce the topic of limit and bumper switches, students could be asked to look carefully at the design of a robot to identify moving components (linkages) that can potentially cause damage. They should be reminded that damage may only occur as a result of prolonged contact and that the damage may not only exist at the point of contact (structural damage) but may also exist at the source of motion (motor) as a result of impact or prolonged exposure to loads.</td>
</tr>
</tbody>
</table>

Students should be introduced to bumper and limit switches, and be expected to describe their functions and identify possible uses. 

**Note:** Refer to the VEX Inventor’s Guide for more information on the functioning of bumper and limit switches.

In consideration of the final group project (robot competition), student groups may want to determine how limit and/or bumper switches can be used effectively in their robot design. They should then incorporate the switches in the robot build phase.
## Bumper and Limit Switches

### Tasks for Instruction and/or Assessment

**Performance/Journal**

- Identify where limit and bumper switches should be added to your final project robot. In your engineering notebook, explain the purpose for the inclusion of these switches in your robot design. Incorporate the switches in your robot and configure the transmitter and receiver to allow the switches to function as intended. (213-3b, 300-16)

- Test the functioning and efficiency of your switches by having your robot perform a task with the switches disconnected, then connected. In your engineering notebook, comment on the functioning and efficiency of your robot with and without the use of switches. (213-3b, 300-16)

**Paper and Pencil**

- Describe the function and purpose of limit and bumper switches. For each switch type, provide an example of a robot, or robot component, that should contain these specialized devices. (300-16)

### Resources/Notes

- Student Resource:
  - Unit 16: pp. 7-11; pp. 22-28

- VEX Inventor’s Guide
Final Project  
~22 Classes

Outcomes

Students will be expected to

- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (214-15)
- work co-operatively with team members to construct and test a robot design, using components conducive to completing a predetermined task, and troubleshooting problems as they arise (214-14/215-6 h)
- communicate the results of a scientific or technological endeavour, using appropriate language and conventions (114-9)

Elaborations—Strategies for Learning and Teaching

These outcomes will be addressed as a group by having students engage in a culminating final project that integrates their combined knowledge and skills obtained throughout this course. It is recommended that student groups use the final project criteria as the context to study chassis speed, manipulators, rotating joints, linkages, and switches in units 10, 12, 13, 15, and 16, respectively. Student groups should be provided with the autonomy to create a unique design. Teachers are encouraged to facilitate the process by having students reflect on the design principles they have learned and continuously evaluate their design for its effectiveness in accomplishing the prescribed robot task.

The final project will involve team members working co-operatively to construct and test a robot design, using components appropriate for completing a predetermined task, and troubleshooting problems as they arise. This process will involve the consideration of alternative solutions and the identification of potential strengths and weaknesses of each.

Robots should be assessed based on their effectiveness in completing the assigned tasks. The design of the robot should be assessed in accordance with a chassis and component construction rubric (provided to students in advance). Furthermore, student teams should be assessed on the engineering design process.

In addition to the planning, construction, and robot competition, it is expected that student teams develop a slideshow presentation that documents the engineering design process which they used. Students should be provided with the presentation criteria and rubric by which they will be assessed. The criteria should involve the benefits of the particular designs chosen (e.g., chassis, manipulators, rotating joints, linkages, switches) as well as any pertinent calculations, such as theoretical/actual speeds, gear ratios, maximum loads, etc.
Final Project
~22 Classes

Tasks for Instruction and/or Assessment

Performance

- Construct and test a robot design using components capable of collecting soda cans and delivering them to an assigned location in the shortest time possible.
- While designing and constructing your robot, document the process, using the following criteria and presentation software of your choice:

  Competition Reporting Criteria
  You will be required to document (using an electronic presentation) all of the components of the engineering design process as described in unit 3.
  1. Identify a need.
  2. Define a problem to be solved.
  3. Gather information.
  4. Conduct research.
  5. Find alternative solutions.
  6. Analyse the possible solutions.
     - chassis
     - propulsion analysis
     - mechanisms/subsystems
     - chassis (sketches, pencil and/or electronic)
     - propulsion (gear reduction calculations; sketches, pencil and/or electronic)
     - components (gear reduction calculations; sketches, pencil and/or electronic)
  8. Build (illustrated via photograph).
  9. Communicate (using presentation software).

Presentation

- Prepare and present a ten-minute presentation for your class on the engineering design process used for the construction of your robot. Include an introduction, conclusion, and references in addition to the components outlined by your teacher.

Resources/Notes

Direct Contributions from Units 12, 13, 15, 16, 17

Appendix D

Final Project Description
- Engineering Design
- Component/Chassis Construction
- Oral Presentation
- Robot Performance

(214-14, 214-15, 215-6)
Project: Career Profile

The objective of this project is to allow you to explore a variety of careers and create a career profile (Web page or poster) to share your findings and enthusiasm with your classmates. The career profile must fulfill the criteria stated below. It is my intention that you will be exposed to a variety of careers via your own research and the research and profiles provided by your classmates.

This is a unique opportunity to create a project of your own design... take pride in your work and enjoy!

Career Profile Criteria

1. You must search for a course-related CAREER that you find interesting. Use your imagination - engineering technician, automobile design, machinist, electronics, radio control, forestry, aerospace (Canadian Space Agency) - or simply perform a search on the Internet for “careers.” I provided a list of sites to surf if you are having difficulty.

2. For your career profile, you must
   A. describe the career (duties, responsibilities, time commitment);
   B. explain how the career is relevant to society;
   C. identify the educational requirements;
   D. identify key skills that are required to be successful at this career;
   E. discuss upward mobility (what might this career lead to?);
   F. provide a salary range;
   G. identify at least 3 corporations that currently provide employment in this career;
   H. provide a current job posting for this career;
   I. identify factors that may affect future demand (you must be able to substantiate your factors with facts);
   J. contact someone currently employed in this career and choose one of the following options:
      i. provide a vocal recording of his/her comments and answers to your questions;
      ii. provide a written recording of his/her comments and answers to your questions;
      iii. have your contact speak to your class (I must be notified of your intention to provide a guest speaker prior to your making the necessary arrangements).

Please Note: The individual whom you wish to contact and the associated questions you wish to ask must be identified and communicated to me prior to making contact.
2. continued...

K. include graphics to provide clarity or enhance the contents of the career profile;

L. attach references (use the appropriate format associated with each reference type);

M. acknowledge those who have assisted you with information or have provided guidance.

Below you will find a list of Internet sites that may assist you in locating a career of interest. Note: Web sites and URLs are not static. The links below may no longer be valid.

**Career Databases / Labour Market Information (Web sites)**

Public Service Commission of Canada  
http://www.psc-cfp.gc.ca/centres/empl_e.htm

http://www.careerbuilder.ca

Service Canada (Job Futures)  
http://www.jobfutures.ca/

Service Canada (Labour Market Information)  
www.labourmarketinformation.ca

HRSDC (Human Resources and Skills Development Canada)  
Home page (HRSDC)  
http://www.hrsdc.gc.ca/

Labour Market Information (HRSDC)  

Interprovincial Standards Canada (“Red Seal” Program)  
http://www.red-seal.ca/

Career Cruising  
http://www.careercruising.com/  
(Get a username and password from your teacher)
<table>
<thead>
<tr>
<th>Career Profile</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student shows a full understanding of the topic.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student shows a good understanding of the topic.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student shows a good understanding of parts of the topic.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student does not seem to understand the topic very well.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All facts in presentation are accurate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>99-90% of facts are accurate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>89-80% of facts are accurate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fewer than 80% of facts are accurate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Graphics and Pictures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphics go well with text and there is a good mix of text and graphics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphics go well with text, but there are so many that they distract from the text.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphics go well with text, but there are too few and the presentation seems text heavy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphics do not go with the text or appear to be randomly chosen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Spelling, Grammar and Organization</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There are no spelling or grammatical errors.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentation is very well organized.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There are minor spelling or grammatical errors, but presentation is well organized.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There are multiple spelling or grammatical errors OR the presentation lacked organization.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There are multiple spelling and grammatical errors. Presentation lacked organization.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assignment is of very good quality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assignment is of good quality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assignment is of fair quality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assignment is of very poor quality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Works Cited</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There are more than two sources, cited correctly.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sources used, but not cited properly.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only one source is used.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No works are cited.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of Questions Asked</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Five or more questions were asked.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four questions were asked.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three questions were asked.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fewer than three questions were asked.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Relevance of Questions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All questions are relevant and give insight into the career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some questions are relevant and give insight into the career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some questions are relevant, but give little insight into the career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questions are not relevant and do not give insight into the career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Creativity of Questions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All questions are creative and provide information not easily found in research.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some questions are creative and provide information not easily found in research.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A few questions are creative and provide information not easily found in research.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questions lack creativity and do not provide information that can’t be easily found from other sources.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mark  /36
APPENDIX B
Project: Energy Presentation

Task

Select an energy source of interest. Discuss the viability of long-term use; the risks and benefits, as viewed from different perspectives (e.g., health, economics, environment); and the history of the energy source. Add other pertinent information as called for in the criteria below.

You are permitted to work individually or with a partner. Prepare an electronic multimedia presentation to assist in communicating the results of your project.

Energy Presentation Criteria

Use the following questions/instructions to guide your research and presentation:

- Describe your energy source.
- Identify the possible uses of your energy source.
- Describe the history of your energy source.
- What is the usable lifetime (sustainability) of your energy source?
- Outline the process of your energy source’s development and the energy transfer.
- What are some advantages of your energy source?
- What are some disadvantages of your energy source?
- Identify various careers associated with the production and transmission of your energy source.

Energy Presentation Logistics and Assessment

- Presentation to include all criteria listed above, and references
- Presentation duration to be 10-20 minutes, including questions
- Presentation to be assessed in accordance with the attached oral presentation rubric

Energy Source Examples

Nuclear, Hydrogen, Landfill Gas, Waste, Hydro, Coal, Petroleum (Oil), Natural Gas, Passive Solar, Photovoltaic, Biomass, Tidal, Wave, Geothermal, Ethanol

Assessment/Evaluation

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation</td>
<td>40%</td>
</tr>
<tr>
<td>Notes</td>
<td>20%</td>
</tr>
<tr>
<td>Test</td>
<td>40%</td>
</tr>
</tbody>
</table>

(delivery and content of slideshow - see presentation rubric)

(notes taken on presentations)

(students will be allowed to use their notes)
<table>
<thead>
<tr>
<th>Category</th>
<th>4 Marks</th>
<th>3 Marks</th>
<th>2 Marks</th>
<th>1 Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery</td>
<td>Speaker’s voice is strong and clear. Speaker conveys confidence about the topic. Excellent eye contact.</td>
<td>Good speaking voice. Speaker is in command of topic. Good eye contact.</td>
<td>Clarity of speech is uneven. Speaker is not completely sure of topic. Limited or sporadic eye contact.</td>
<td>Control of speaking tone, clarity, and volume is not evident. Speaker does not convey interest. No eye contact.</td>
</tr>
<tr>
<td>Topic Coverage</td>
<td>All 8 points are adequately covered.</td>
<td>6-7 points are adequately covered. Other points mentioned but not covered.</td>
<td>4-5 points are adequately covered. Other points mentioned but not covered.</td>
<td>Fewer than 4 of the 8 points are covered in sufficient detail.</td>
</tr>
<tr>
<td>Number of Slides</td>
<td>There are more than 10 slides.</td>
<td>There are 9-10 slides.</td>
<td>There are 7 to 8 slides.</td>
<td>There are fewer than 7 slides.</td>
</tr>
<tr>
<td>Content Accuracy</td>
<td>All content throughout the presentation is accurate. There are no factual errors.</td>
<td>Most of the content is accurate, but there is one piece of information that may be inaccurate.</td>
<td>The content is generally accurate, but one piece of information is clearly flawed or inaccurate.</td>
<td>Content is typically confusing or contains more than one factual error.</td>
</tr>
<tr>
<td>Spelling and Grammar</td>
<td>Presentation has no misspellings or grammatical errors.</td>
<td>Presentation has 1or 2 misspellings, but no grammatical errors.</td>
<td>Presentation has 1 or 2 grammatical errors, but no misspellings.</td>
<td>Presentation has more than 2 grammatical and/or spelling errors.</td>
</tr>
<tr>
<td>Originality</td>
<td>Presentation shows considerable originality and inventiveness. The content and ideas are presented in a unique and interesting way.</td>
<td>Presentation shows some originality and inventiveness. The content and ideas are presented in an interesting way.</td>
<td>Presentation shows an attempt at originality and inventiveness on 1 or 2 slides.</td>
<td>Presentation is a rehash of other people’s ideas and/or graphics and shows very little attempt at original thought.</td>
</tr>
<tr>
<td>Use of Graphics</td>
<td>All graphics are attractive (size and colours) and support the theme/content of the presentation.</td>
<td>A few graphics are not attractive, but all support the theme/content of the presentation.</td>
<td>All graphics are attractive but a few do not support the theme/content of the presentation.</td>
<td>Several graphics are unattractive and detract from the content of the presentation.</td>
</tr>
<tr>
<td>Graphic Sources</td>
<td>All graphics have been properly cited.</td>
<td>Some graphics have been cited.</td>
<td>Few graphics have been cited.</td>
<td></td>
</tr>
<tr>
<td>Background</td>
<td>Background does not detract from text or other graphics. Choice of background is consistent from slide to slide, and is appropriate for the topic.</td>
<td>Background does not detract from the text or other graphics.</td>
<td>Background makes it difficult to see text, or competes with other graphics on the page.</td>
<td></td>
</tr>
<tr>
<td>Sources</td>
<td>5 or more sources are used and identified.</td>
<td>2 to 4 sources are used and identified.</td>
<td>A single source is used throughout the presentation.</td>
<td></td>
</tr>
<tr>
<td>Organization of Slide Show</td>
<td>Slideshow is well organized, and contains a cover slide. All points are covered. Slides identify sources.</td>
<td>Slideshow is organized, but is lacking some of the components.</td>
<td>Slideshow is unorganized, with little structure, and is hard to follow. Very few of the necessary components are present.</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL**
## Energy Source Sign-Up Sheet

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Student Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td><em>Wendy Green, Jack Mills, Turner North</em> (SAMPLE)</td>
</tr>
<tr>
<td>Nuclear</td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td></td>
</tr>
<tr>
<td>Landfill Gas</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td></td>
</tr>
<tr>
<td>Hydro</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td></td>
</tr>
<tr>
<td>Petroleum (Oil)</td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
</tr>
<tr>
<td>Passive Solar</td>
<td></td>
</tr>
<tr>
<td>Photovoltaic</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td></td>
</tr>
<tr>
<td>Tidal</td>
<td></td>
</tr>
<tr>
<td>Wave</td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Energy Presentations

### Report Form

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>________________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Members</td>
<td>________________________________</td>
</tr>
</tbody>
</table>

| Description | ________________________________ |
| Uses        | ________________________________ |
| History     | ________________________________ |
| Sustainability | ________________________________ |
| Energy Transfer | ________________________________ |
| Pros/Advantages | ________________________________ |
| Cons/Disadvantages | ________________________________ |
| Careers     | ________________________________ |
APPENDIX C
Project: Skills Portfolio

Overview

The Skills Portfolio is an ongoing project that will be assessed four times throughout this course (end of units 4, 8, 12, and 16). Attached is a copy of *Employability Skills 2000+*, a document that was created by the Conference Board of Canada. It outlines three categories of skills (Fundamental Skills, Teamwork Skills, Personal Management Skills) that the Conference Board believes are necessary to participate and progress in today’s dynamic world of work.

Task

You will be required to maintain a skills logbook (e.g., 3-hole duo-tang). The logbook will consist of report sheets (*Acquired Skills, Desired Skills*) containing categories labelled *Fundamental Skills, Teamwork Skills, and Personal Management Skills* (see attached). It is expected that you will add entries to your logbook each week, and submit your logbook for assessment quarterly.

For each reporting period, complete the following tasks:

1. Identify **six** skills (two items from each category in *Employability Skills 2000+*) that you believe you have mastered.

2. Directly below each recorded skill, give an example of something you have said or done that can be used, in part, as evidence that you have mastered that skill. Start each of your supporting statements as follows:

   **This skill is evident, for example, when I ...**

3. Identify six skills (two items from each category in *Employability Skills 2000+*) that you would like to improve upon.

4. Record the identified skills in the appropriate location, starting each in the following way:

   **I intend to work on improving my ability to ....**

   When completing the above statement, adjust the wording of the skill accordingly.

**Please Note:** Items on your list for #4 in one reporting period may be used in your list for #1 in subsequent reporting periods.

Skills Portfolio Assessment

The Skills Portfolio will be assessed for completeness, grammar/spelling, and appropriateness of the supporting statements provided.
**Employability Skills 2000+**

**Employability Skills 2000+** were developed by members of The Conference Board of Canada’s Employability Skills Forum and the Business and Education Forum on Science, Technology and Mathematics.

AIESEC Canada Inc.
Alberta Human Resources and Employment
Alberta Learning
Association of Colleges of Applied Arts and Technology of Ontario
Association of Canadian Community Colleges
Automotive Parts Manufacturers’ Association
Bank of Montreal
Bow Valley College
British Columbia Centre for Applied Academics
British Columbia Ministry of Education
Canada Post Corporation
Canadian Forces Recruiting Services Headquarters
Canadian Labour Force Development Board
Canadian Microelectronics Corporation
CAREERS: The Next Generation Foundation
Central Nova Industry Education Council
Conseil des écoles catholiques de langue française du Centre-Est — Ontario
CORCAN—Correctional Service Canada
Crain-Drummond Inc.
Dufferin-Peel Catholic District School Board—Ontario
Durham District School Board—Ontario
Elta Stegeley and Associates, Inc.
Hewlett-Packard (Canada) Ltd.
Human Resources Development Canada
Imperial Oil Limited
Imperial Oil National Centre for Mathematics, Science and Technology Education
Industry Canada
Investors Group Inc.
J.D. Irving, Limited
Keyano College
Let’s Talk Science
McGraw-Hill Ryerson Limited
Memorial University of Newfoundland
Mount Royal College
New Brunswick Department of Education
NetZero Networks
Ontario Ministry of Education
Ottawa Centre for Research and Innovation
Peace River South—School District No. 59—British Columbia
Peel District School Board—Ontario
Royal Bank of Canada
Saskatchewan Institute of Applied Science and Technology
Seneca College of Applied Arts and Technology
Shad International
Skills Canada—Ontario
Southwest Regional School Board—Nova Scotia
Statistics Canada
Syncrude Canada Ltd.
Software Human Resource Council Inc.
Toronto District School Board—Ontario
TransAlta Corporation
Treasury Board of Canada Secretariat
York University

**Apply Your Employability Skills at Work**

Employability Skills 2000+ are the critical skills you need in the workplace—whether you are self-employed or working for others. Employability Skills 2000+ include communication, problem solving, positive attitudes and behaviours, adaptability, working with others, and science, technology and mathematics skills.

**Apply Your Employability Skills Elsewhere in Your Life**

Employability Skills 2000+ can also be applied beyond the workplace in your daily and personal activities.

**Develop Your Employability Skills**

You can develop your Employability Skills 2000+ at home, at school, at work and in the community. Family, friends, teachers, neighbours, employers, co-workers, government, business and industry can all play a part in helping you build these skills.

**Looking for Ways to Improve Your Own Employability Skills?**

The **Employability Skills Toolkit for the Self-Managing Learner Can Help You!**

The **Employability Skills Toolkit** is a suite of practical tools designed to help you:

- know yourself and get feedback;
- identify and reflect on your skills;
- plan skills development activities;
- implement your development plans and practise your skills; and
- document and market your skills for best success.

For more information on the Toolkit or how to work with the Conference Board to produce a customized version of the Toolkit, visit the Conference Board’s Web site.

**www.conferenceboard.ca/education**

**Member Organizations**

**Employability Skills 2000+** was developed by members of The Conference Board of Canada’s Employability Skills Forum and the Business and Education Forum on Science, Technology and Mathematics.

**Communicate, manage information, use numbers, work with others, be aab**

**Employability Skills 2000+**

The skills YOU need to enter, stay in, and progress in the world of work—whether you work on your own or as part of a team.

**Employability Skills 2000+** are the employability skills, attitudes and behaviours that you need to participate and progress in today’s dynamic world of work.

The Conference Board invites and encourages students, teachers, parents, employers, labour, community leaders and governments to use **Employability Skills 2000+** as a framework for dialogue and action. Understanding and applying these skills will help you enter, stay in, and progress in the world of work.
## Employability Skills 2000+

The skills you need to enter, stay in, and progress in the world of work—whether you work on your own or as a part of a team.

These skills can also be applied and used beyond the workplace in a range of daily activities.

<table>
<thead>
<tr>
<th>Fundamental Skills</th>
<th>Personal Management Skills</th>
<th>Teamwork Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The skills needed as a base for further development</td>
<td>The personal skills, attitudes and behaviours that drive one's potential for growth</td>
<td>The skills and attributes needed to contribute productively</td>
</tr>
</tbody>
</table>

You will be better prepared to progress in the world of work when you can:

### Communicate
- read and understand information presented in a variety of forms (e.g., words, graphs, charts, diagrams)
- write and speak so others pay attention and understand
- listen and ask questions to understand and appreciate the points of view of others
- share information using a range of information and communications technologies (e.g., voice, e-mail, computers)
- use relevant scientific, technological and mathematical knowledge and skills to explain or clarify ideas

### Manage Information
- locate, gather and organize information using appropriate technology and information systems
- access, analyze and apply knowledge and skills from various disciplines (e.g., the arts, languages, science, technology, mathematics, social sciences, and the humanities)

### Use Numbers
- decide what needs to be measured or calculated
- observe and record data using appropriate methods, tools and technology
- make estimates and verify calculations

### Think & Solve Problems
- assess situations and identify problems
- seek different points of view and evaluate them based on facts
- recognize the human, interpersonal, technical, scientific and mathematical dimensions of a problem
- identify the root cause of a problem
- be creative and innovative in exploring possible solutions
- readily use science, technology and mathematics as ways to think, gain and share knowledge, solve problems and make decisions
- evaluate solutions to make recommendations or decisions
- implement solutions
- check to see if a solution works, and act on opportunities for improvement

You will be able to offer yourself greater possibilities for achievement when you can:

### Demonstrate Positive Attitudes & Behaviours
- feel good about yourself and be confident
- deal with people, problems and situations with honesty, integrity and personal ethics
- recognize your own and other people's good efforts
- take care of your personal health
- show interest, initiative and effort

### Be Responsible
- set goals and priorities balancing work and personal life
- plan and manage time, money and other resources to achieve goals
- assess, weigh and manage risk
- be accountable for your actions and the actions of your group
- be socially responsible and contribute to your community

### Be Adaptable
- work independently or as a part of a team
- carry out multiple tasks or projects
- be innovative and resourceful: identify and suggest alternative ways to achieve goals and get the job done
- be open and respond constructively to change
- learn from your mistakes and accept feedback
- cope with uncertainty

### Learn Continuously
- be willing to continuously learn and grow
- assess personal strengths and areas for development
- set your own learning goals
- identify and access learning sources and opportunities
- plan for and achieve your learning goals

### Work Safely
- be aware of personal and group health and safety practices and procedures, and act in accordance with these

You will be better prepared to add value to the outcomes of a task, project or team when you can:

### Work with Others
- understand and work within the dynamics of a group
- ensure that a team's purpose and objectives are clear
- be flexible: respect, be open to and supportive of the thoughts, opinions and contributions of others in a group
- recognize and respect people's diversity, individual differences and perspectives
- accept and provide feedback in a constructive and considerate manner
- contribute to a team by sharing information and expertise
- lead or support when appropriate, motivating a group for high performance
- understand the role of conflict in a group to reach solutions
- manage and resolve conflict when appropriate

### Participate in Projects & Tasks
- plan, design or carry out a project or task from start to finish with well-defined objectives and outcomes
- develop a plan, seek feedback, test, revise and implement
- work to agreed quality standards and specifications
- select and use appropriate tools and technology for a task or project
- adapt to changing requirements and information
- continuously monitor the success of a project or task and identify ways to improve

The Conference Board of Canada
255 Smyth Road, Ottawa
ON K1H 8M7 Canada
Tel. (613) 526-3280
Fax (613) 526-4857
Internet: www.conferenceboard.ca/education
APPENDIX D
Project: Competition (Unit 17)

Task
Your team must reflect on all of the previous mechanisms and subsystem designs in order to create a robot to place soda cans in a basket as quickly as possible (or an alternate competition described by your instructor). Although this is a timed event, you will also be competing against an opposing team on the playing surface. The activity is clearly outlined in unit 17, “Systems Integration.” In addition to planning, constructing, and competing (with your robot), your team will be responsible for developing a slideshow presentation that documents the engineering design process that you use. The criteria for the presentation are outlined below.

Competition (Unit 17) Presentation Criteria
You will be required to document (electronic presentation) all of the components of the engineering design process as described in unit 3. As you will recall, you will be required to take the following steps:

1. Identify a need.
2. Define the problem to be solved.
3. Gather information.
4. Conduct research.
5. Find alternative solutions.
6. Analyse the possible solutions.
   - Chassis
   - Propulsion analysis
   - Mechanisms/Subsystems
   - Chassis (sketches, pencil and/or electronic)
   - Propulsion (gear reduction calculations; sketches, pencil and/or electronic)
   - Components (gear reduction calculations; sketches, pencil and/or electronic)
8. Build (illustrated via photographs).
9. Communicate (using presentation software)

Presentation Logistics and Assessment
- Presentation to include an introduction, conclusion, and references
- Presentation duration to be 10 minutes, including questions
- Presentation to be assessed in accordance with the attached oral presentation rubric
- Engineering design process to be assessed in accordance with the attached engineering design rubric
- Robot design to be assessed in accordance with the attached robotics chassis and component construction rubric
- Robot performance to be assessed in accordance with the attached robotics performance rubric

This is a unique opportunity to create a project of your own design... take pride in your work and enjoy!
# Applied Science 701A
## FINAL PROJECT
### ASSESSMENT RUBRIC: ORAL PRESENTATION

<table>
<thead>
<tr>
<th>Categories</th>
<th>4 Marks</th>
<th>3 Marks</th>
<th>2 Marks</th>
<th>1 Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delivery</strong></td>
<td>Speaker’s voice is strong and clear. Speaker conveys confidence about the topic. Excellent eye contact.</td>
<td>Good speaking voice. Speaker is in command of topic. Good eye contact.</td>
<td>Clarity of speech is uneven. Speaker is not completely sure of topic. Limited or sporadic eye contact.</td>
<td>Control of speaking tone, clarity, and volume is not evident. Speaker does not convey interest. No eye contact.</td>
</tr>
<tr>
<td><strong>Introduction</strong></td>
<td>Introduction is clear and engaging, with concise thesis statement. Conclusion tied presentation together and was memorable. All sources are referenced.</td>
<td>Introduction is clear, with concise thesis statement. Conclusion tied presentation together. All sources are referenced.</td>
<td>Introduction not present, or thesis statement unclear. Conclusion does not adequately summarize presentation. Some references are missing.</td>
<td>Introduction and/or conclusion missing or ineffective. Many references are missing.</td>
</tr>
<tr>
<td><strong>Topic Coverage</strong></td>
<td>Presentation clearly articulates the identified need, problem to be solved, evidence of other possible solutions considered, and support for the design of the robot.</td>
<td>Presentation contains the identified need, problem to be solved, evidence of other possible solutions considered, and support for the design of the robot but lacks clarity.</td>
<td>Presentation lacks clarity and key components (one or two of the following: identified need, problem to be solved, evidence of other possible solutions considered, support for the design of the robot).</td>
<td>Presentation lacks clarity and several of the following components: identified need, problem to be solved, evidence of other possible solutions considered, support for the design of the robot.</td>
</tr>
<tr>
<td><strong>Content Accuracy</strong></td>
<td>All content throughout the presentation is accurate. There are no factual errors.</td>
<td>Most of the content is accurate but there is one piece of information that may be inaccurate.</td>
<td>The content is generally accurate, but one piece of information is clearly flawed or inaccurate.</td>
<td>Content is typically confusing or contains more than one factual error.</td>
</tr>
<tr>
<td><strong>Use of Graphics</strong></td>
<td>All graphics are attractive (size and colours) and support the theme/content of the presentation.</td>
<td>A few graphics are not attractive but all support the theme/content of the presentation.</td>
<td>All graphics are attractive but a few do not support the theme/content of the presentation.</td>
<td>Several graphics are unattractive and or ineffective and detract from the content of the presentation.</td>
</tr>
</tbody>
</table>

**Total:** 20
## Applied Science 701A
### FINAL PROJECT
### ASSESSMENT RUBRIC: ROBOTICS COMPONENT AND CHASSIS CONSTRUCTION

<table>
<thead>
<tr>
<th>Categories</th>
<th>4 Marks</th>
<th>3 Marks</th>
<th>2 Marks</th>
<th>1 Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chassis</strong></td>
<td>Chassis is rigid and joints are square and secure.</td>
<td>Chassis lacks some critical design components.</td>
<td>Chassis lacks many critical design components.</td>
<td>Chassis lacks most critical design components.</td>
</tr>
<tr>
<td></td>
<td>Chassis design is appropriate for the drivetrain and other components.</td>
<td>Chassis is rigid and joints are square and secure.</td>
<td>Chassis is relatively rigid but joints could be more square and secure.</td>
<td>Chassis rigidity and joints require improvement. The chassis design is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chassis design is appropriate for the drivetrain and other components,</td>
<td>Chassis design is appropriate for the drivetrain and other components,</td>
<td>not appropriately matched to the drivetrain or components. Components</td>
</tr>
<tr>
<td></td>
<td></td>
<td>but could be more efficient in design.</td>
<td>but could be more efficient in design.</td>
<td>appear to be randomly attached.</td>
</tr>
<tr>
<td><strong>Drivetrain</strong></td>
<td>Drivetrain design is excellent.</td>
<td>Drivetrain lacks some critical design components.</td>
<td>Drivetrain lacks many critical design components.</td>
<td>Drivetrain lacks most critical design components.</td>
</tr>
<tr>
<td></td>
<td>Drivetrain is securely attached to chassis. Gears are properly meshed</td>
<td>Drivetrain is securely attached to chassis. Gears are properly meshed</td>
<td>Drivetrain is securely attached to chassis. Gears could be more</td>
<td>Drivetrain could be more securely attached to chassis. Gears could be</td>
</tr>
<tr>
<td></td>
<td>and alignment is excellent.</td>
<td>and alignment is excellent.</td>
<td>properly meshed and alignment is problematic.</td>
<td>more properly meshed and alignment is problematic.</td>
</tr>
<tr>
<td></td>
<td>Design is conducive to functioning of robot in relation to scrub torque,</td>
<td>Some elements of the drivetrain are conducive to the functioning of</td>
<td>Few elements of the drivetrain are conducive to the functioning of</td>
<td>Little evidence exists to indicate that scrub torque, turning torque, and traction were considered in the drivetrain design.</td>
</tr>
<tr>
<td></td>
<td>turning torque, and traction.</td>
<td>robot in relation to scrub torque, turning torque, and traction.</td>
<td>robot in relation to scrub torque, turning torque, and traction.</td>
<td></td>
</tr>
<tr>
<td><strong>Object Manipulation and</strong></td>
<td>Object manipulator and linkage design are excellent.</td>
<td>Object manipulator and linkage design are excellent in general.</td>
<td>Object manipulator and linkage design are good. Many elements of the</td>
<td>Object manipulator and linkage design needs improvement Most elements of the design could be more appropriate for the component purpose.</td>
</tr>
<tr>
<td><strong>Linkages</strong></td>
<td></td>
<td>Some elements of the design could be more appropriate for the component purpose.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wiring / Component</strong></td>
<td>Electrical leads and component placement are excellent.</td>
<td>Electrical leads are tidy and well routed. Components could be more</td>
<td>Electrical leads could be better routed. Components could be more</td>
<td>Much more attention to the routing of electrical leads is required and components should be more strategically placed.</td>
</tr>
<tr>
<td><strong>Placement</strong></td>
<td></td>
<td>strategically placed.</td>
<td>strategically placed.</td>
<td></td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>Robot design is elegant. All components function smoothly, work well</td>
<td>Robot lacks some critical design components. Most components function</td>
<td>Robot lacks many critical design components. Some components function</td>
<td>Robot lacks most critical design components. Few components function</td>
</tr>
<tr>
<td></td>
<td>together, look as if they belong together, and are easy to modify or</td>
<td>smoothly, work well together, look as if they belong together, and are</td>
<td>smoothly, work well together, look as if they belong together, and are</td>
<td>smoothly, work well together, look as if they belong together, and are</td>
</tr>
<tr>
<td></td>
<td>replace. Efficient parts use.</td>
<td>easy to modify or replace. Efficient parts use.</td>
<td>easy to modify or replace. Parts use could be more efficient.</td>
<td>easy to modify or replace. Parts use could be more efficient.</td>
</tr>
</tbody>
</table>

Total:  / 20
<table>
<thead>
<tr>
<th>Categories</th>
<th>4 Marks</th>
<th>3 Marks</th>
<th>2 Marks</th>
<th>1 Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need Identified/ Problem Defined</td>
<td>Need for robot is clearly articulated and the problem(s) to be solved is (are) clearly defined.</td>
<td>Need for robot is clearly articulated, but the problem(s) to be solved is (are) not well defined.</td>
<td>Need for robot is not clearly articulated, and the problem(s) to be solved is (are) not well defined.</td>
<td>Need for the robot is not clearly articulated, and the problem(s) to be solved is (are) not defined.</td>
</tr>
<tr>
<td>Chassis</td>
<td>There is clear evidence of analysis of other chassis designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this chassis design over others are clearly articulated.</td>
<td>There is some evidence of analysis of other chassis designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this chassis design over others are given.</td>
<td>There is little evidence of analysis of other chassis designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this chassis design over others are given but unclear.</td>
<td>There is no evidence of analysis of other chassis designs. Sketches (pencil/electronic) of the chosen design are either not provided or unclear. Reasons for choosing this chassis design over others are not given.</td>
</tr>
<tr>
<td>Propulsion</td>
<td>There is clear evidence of analysis of other propulsion designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this propulsion design over others are clearly articulated. Gear reduction and theoretical chassis speed calculations are provided and accurate.</td>
<td>There is some evidence of analysis of other propulsion designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this propulsion design over others are given. Gear reduction and theoretical chassis speed calculations are provided, but have minor errors.</td>
<td>There is little evidence of analysis of other propulsion designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this propulsion design over others are given, but are unclear. Gear reduction and theoretical chassis speed calculations are provided, but have several errors.</td>
<td>There is no evidence of analysis of other propulsion designs. Sketches (pencil/electronic) of the chosen design are either not provided or unclear. Reasons for choosing this propulsion design over others are not given. Gear reduction and theoretical chassis speed calculations are not provided or have many errors.</td>
</tr>
<tr>
<td>Components</td>
<td>There is clear evidence of analysis of other component designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this component design over others are clearly articulated. Gear reduction calculations are provided and accurate.</td>
<td>There is some evidence of analysis of other component designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this component design over others are given. Gear reduction calculations are provided, but have minor errors.</td>
<td>There is little evidence of analysis of other component designs. Sketches (pencil/electronic) of the chosen design are provided. Reasons for choosing this component design over others are given, but are unclear. Gear reduction calculations are provided, but have several errors.</td>
<td>There is no evidence of analysis of other component designs. Sketches (pencil/electronic) of the chosen design are either not provided or unclear. Reasons for choosing this component design over others are not given. Gear reduction calculations are not provided or have many errors.</td>
</tr>
<tr>
<td>Build</td>
<td>Illustration of the sequence of the build process is excellent. Photographs are appropriate, and quality of photographs is excellent.</td>
<td>Illustration of the sequence of the build process is good. Photographs are appropriate, but quality of photographs could be improved.</td>
<td>Illustration of the sequence of the build process needs improvement. Key photographs of the process are missing, and photograph quality could be improved.</td>
<td>Illustration of the sequence of the build process is confusing. Photographs provide little insight to the intricacy/complexity of the build process. Photograph quality is poor.</td>
</tr>
</tbody>
</table>

Total: / 20
# Applied Science 701A
## FINAL PROJECT
### ASSESSMENT RUBRIC: ROBOT PERFORMANCE

<table>
<thead>
<tr>
<th>Categories</th>
<th>20 Marks</th>
<th>18 marks</th>
<th>16 Marks</th>
<th>10 Marks</th>
<th>5 Marks</th>
<th>0 Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Competition</strong></td>
<td>Robot completed competition task more efficiently than all class competitors.</td>
<td>Robot completed competition task more efficiently than all class competitors except one.</td>
<td>Robot completed competition task more efficiently than all class competitors except two.</td>
<td>Robot completed assigned task.</td>
<td>Robot completed part of task.</td>
<td>Robot did not complete any part of the assigned task. OR Robot was not completed in time for competition.</td>
</tr>
</tbody>
</table>

Total: / 20